ATOME PARAGUAY S.A.

Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

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Executive Summary

This Environmental and Social Impact Assessment (ESIA) provides the necessary elements for the analysis of the environmental and social viability of the Project corresponding to the "Free Trade Zone and Green Fertiliser Production Plant" of ATOME Paraguay S.A.

The Project has an environmental licence issued by the Ministry of Environment and Sustainable Development (MADES), but for a hydrogen and green ammonia plant. In view of the inclusion of a fertiliser production plant (Calcium Ammonium Nitrate - CAN) as part of the Project, the adjusted ESIA will be submitted to MADES to obtain a rectification of the licence, in accordance with the negotiations already held with the environmental agency.

1.0
Project Justification

The objective of the project "Free trade zone and green fertiliser (Calcium Ammonium Nitrate - CAN) production Plant" is to develop an industrial scale green fertiliser production plant (270,000 tons/year of CAN), in order to decarbonise food production by supplying Paraguay and the agricultural and food markets of the Mercosur region with sustainable alternatives.

Synthetic fertilisers have been crucial to sustaining world population growth. Without them, approximately 50% of the world's population would go hungry. However, fertiliser production and use have an environmental cost of 2.6 billion tonnes of carbon emissions per year (5% of global greenhouse gas emissions). This is more emissions than the global aviation and shipping sectors combined. As the world's population grows by 1 billion people every 10 years, the challenge is how to continue to feed the world more sustainably.

Green fertilisers are key to this, and international food and agriculture companies are starting to set aggressive targets to decarbonise their products by using sustainable fertilisers.

In this context, ATOME has identified the opportunity to produce the first zero-carbon green fertiliser in Paraguay, at a competitive cost, in the largest fertiliser importing markets in the world.

Currently 80% of the world's fertilisers are produced using ammonia synthesised from hydrogen produced from fossil fuels. ATOME proposes to produce green hydrogen using the hydropower available in Paraguay for the synthesis of ammonia through the Haber-Bosch process and green fertiliser (CAN) at the plant itself. In this way, the Project will have the capacity to displace around 600,000 tCO_2 eq/year of carbon emissions in the fertiliser sector. Considering the useful life of the Project (25 years), this impact would translate into 15,000,000 tCO_2 eq avoided.

The selection of CAN as the final product is based on the fact that it is a nitrogen-based fertiliser widely used in agriculture worldwide due to its adaptability to different types of crops, soils and climates. Furthermore, it is a stable and safe product for distribution.

NO_3^- fertilisers, such as CAN, are the most efficient and reliable source of nitrogen available and are quickly and readily available for plant uptake, providing a more consistent and reliable economic yield.

CAN can supply both fast and slow release nitrogenous nutrients to the plant. NO_3^- is readily absorbed by plants at high rates. Unlike urea or ammonium, NO_3^- is immediately available as a nutrient. NO_3^- is highly mobile in the soil and reaches the plant roots quickly. Application of nitrogen as ammonium nitrate (AN) or CAN provides a directly available nutrient supply.

The outlook for the CAN fertiliser market is favourable, with global growth at an average rate of 1.5% between 2025 and 2045, and 4.8% in Mercosur, which is the region with the highest global demand.

2.0
Project Description

The project consists of the construction and operation of a plant for the production of hydrogen (H_2), ammonia (NH_3) and green fertiliser (calcium ammonium nitrate - CAN). The Plant will be located in the locality called Puerto Sara in Surubi'y, south of the city of Villeta, Paraguay, near the eastern bank of the Paraguay River, 50 km south of the city of Asunción, next to the Villeta-Alberdi road and the SE Buey Rodeo.

The Plant will be based on the electrolysis of water for the production of H_2 and on Haber-Bosch technology for the synthesis of NH_3. Water will be taken from the Paraguay River while 220 kV electrical power will come from ANDE's Buey Rodeo electrical substation (ES), close to the Plant, fed by the Itaipú hydroelectric dam. The power supply for the plant is limited to 120 MW.

To produce CAN fertiliser, the Atome Plant will include a Nitric Acid Plant, an Ammonium Nitrate Solution Plant, and a Granulation Plant, where granulated CAN fertiliser is produced by combining the ammonium nitrate solution with water, crushed dolomite and coating agent.
Other components of the project include the following:

- 220 kV power transmission line (TL) of about 550 m in length.
- Intake, pumping and piping infrastructure for water supply from the Paraguay river to the ATOME plant and effluent discharge piping.

2.1
Plant Facilities

The *main facilities* of the production process of H_2 and NH_3 are as follows:

- Green Hydrogen Plant (H_2).
- Air Separation Unit (ASU).
- Ammonia Synthesis Unit (NH_3).
- Nitric Acid Plant (NA)
- Ammonium Nitrate Solution (ANS) Plant.
- Granulation Plant (GRAN).
- Flare System.

The *auxiliary installations* of the process, in turn, consist of:

- Raw Water Collection System.
- Pre-treatment and Raw Water Treatment Plant.
- Service Water Storage and Distribution System.
- Demineralised Water Storage System.
- Cooling System.
- Instrument and Plant Air System.
- Utility Nitrogen and Liquid Nitrogen System.
- Fire Extinguishing System.
- Wastewater Treatment Plant (WWTP).

In addition to the main and auxiliary facilities, the Plant's electrical substation and the 220 kV transmission line (TL) are also worth mentioning.

2.2
Construction aspects

The following activities are foreseen for the implementation of the project:

<u>Preliminary Services</u>

- Stake out the construction footprint.
- Delimitation of the Right Easement Strip.
- Cutting and clearing of vegetation.
- Implementation of access roads.
- Implementation of support facilities:
  - To support the construction works, the Project considers auxiliary facilities in the working environment. These facilities include machinery parking area, offices for EPC, CASALE and ATOME with the corresponding basic services (toilets, running water, septic tank, drinking water, electricity, drainage), earth and materials storage area, first aid/nursing room. The camp does not provide accommodation for workers.

Civil works

- Earthworks:
- The area of the ATOME Plant site that will need to be backfilled is about 255,000 m^2, and the height of the backfill is 0.6 m. The existing cutwater will also be backfilled. The volume of material required for backfilling is 153,000 m^3. The material for the backfill will be obtained from a gravel quarry in Surubi'y, or the method of re-filling with sand from a sediment bank in the Paraguay river will be chosen. If this option is chosen, the necessary complementary studies will be carried out. Excavations of 102,000 m^3 are planned for foundations and buildings.
- Execution of foundations.
- Execution of buildings.
- Assembly.
- Demobilisation and Site Recovery Operation and Maintenance.
- Construction Manpower, Equipment and Machinery
- 3,190,532.57 man-hours will be employed, with a peak staffing in months 21-24 of 1,020 to 1,073 people. In addition, about 40-50 workers are needed for each component of construction and assembly of the LT and the water catchment system and water and effluent pipelines.
- Workers will be transported to the work site by bus, with 8 trips per day at peak times between Asunción and the construction site.
- Equipment and machinery will be used, as well as light and heavy vehicles, including trucks for transporting fill material, containers with imported goods and oversized loads.

Timeline

The implementation of the project is estimated to last 31 months. The works and assembly are estimated to last 29 months, with pre-commissioning and testing starting in month 19, which will last 12 months. For the TL, the construction and commissioning period is estimated at 140 days (about 4.5 months).

2.3
Operation and Maintenance Aspects

Productive Capacity

H_2 Production rate	1,802.0 kg/h
N_2 production rate (for process)	8,363 kg/h
NH_3 production	10,165 kg/h
AN production (dry basis)	18,333 kg/h
Production AN (solution)	29,542 kg/h
ANS Production rate (dry basis)	23,208 kg/h
ANS Production rate (solution)	24,458 kg/h
CAN production rate	31,958 kg/h

Raw Material, Source and Quantity

Raw materials	Source	Quantity
Treated raw water	Paraguay River or Paraguay River and deep wells (for firefighting system only)	242.7 m /h^3
Ambient air	Air Separation Unit	201 ton/day
Electrical energy (hydropower)	ANDE's Buey Rodeo substation through a 220 kV TL.	Total electricity consumption = 112.9 MW.
Dolomite	Existing quarries under evaluation	173 tonnes/day

Liquid Effluents

The effluents generated in the operation of the Plant, which will be treated in the WWTP, include effluents from raw water treatment, sanitary water, oil separator effluents, non-oil network effluents, and cooling tower blowdown. Taking into account these types of effluent, the estimated average flow is 77.30 m^3/h.

Also, during O&M there will be effluents that will be treated and disposed of by authorised external managers. These are:

- NH_3 contaminated process water: 40 m^3/year.
- Process water contaminated with KOH: 150 m^3/year.
- Process water contaminated with chemical cooling additives / or water treatment: 200 m^3/year. Process water will be directed to the WWTP for homogenisation and stabilisation prior to discharge to the drainage network.
- Used oil, compressors, transformers, and motors: 60 m^3.

Solid Waste

Types and estimated quantities of waste to be generated in the operation of the Plant:

- Sludge generated in water and effluent treatment plants: 900 m^3/year.
- Rubbish (organic waste generated by plant personnel): 8,000 kg/year.
- Rubbish (solid waste generated by plant personnel): 30,000 kg/year.
- Electrical waste: 800 kg/year.
- Mechanical waste (filters, metal parts, scrap, plastics, consumables...): 5,000 kg/year.

Atmospheric Emissions and Noise During Operation

The expected atmospheric emissions from the plant's production process are:

Description	Type of emission	Operation	Flow rate (kg/h)	Composition (%Vol)
ASU	O_2-enriched air outlet	CONTINUOUS	13,200	Ambient air enriched in O_2 (90% O_2, 10% N_2, <0.5% Ar and traces of CO_2)
Electrolysis Plant	Venting of O_2 at two points	CONTINUOUS	17,820	98.5% O_2; 1.5% H_2; 4 g/ Nm^3 of H_2 O and 1 mg/Nm^3 of KOH
	H_2 vent at two points	EVENTUAL <500h/year	1,980	98.5% H_2; 1.5% O_2, 4g/ Nm^3 of H_2 O and 1 mg/ Nm^3 of KOH
Main Flare	Combustion (burning)	EVENTUAL <500h/year	29,626	**Burner + pilot:** 22.38 kg/h CO_2, 6,664.22 kg/h H_2 O, 22,920.34 kg/h N_2, 2.28 kg/h NOx, 12.42 kg/h CO, unburned 4.70 kg/h Pilot: 22.38 kg/h CO_2, 12.22 kg/h H_2 O, 89.34 kg/h N_2, 0.010 kg/NOx, 0.055 kg/h CO, unburned 0.021 kg/h
	Pilot Flame	CONTINUOUS	124	
NA abatement discharge	-	CONTINUOUS	73,929	Air with NOx 10 ppmv, NH_3 5 ppmv, N_2 O 20 ppmv
NH_3 Synthesis Unit	Process gas venting	CONTINUOUS	5	53% H_2, 43% N_2, 2% Ar and 0.3% H O_2
Secondary Flare	Combustion (burning)	EVENTUAL <500h/year	29,626	**Burner + pilot:** 22.38 kg/h CO_2, 6,664.22 kg/h H_2 O, 22,920.34 kg/h N_2, 2.28 kg/h NOx, 12.42 kg/h CO, unburned 4.70 kg/h Pilot: 22.38 kg/h CO_2, 12.22 kg/h H_2 O, 89.34 kg/h N_2 , 0.010 kg/NOx, 0.055 kg/h CO, unburned 0.021 kg/h
	Pilot Flame	CONTINUOUS (pilot)	124	
Granulation Plant	Milling discharge	CONTINUOUS	<0.629 PM_{10} 0.221 $PM_{2.5}$	Air with <37 mg/Nm^3 PM_{10} and 13 mg/Nm^3 $PM_{2.5}$
	Granulation scrubber discharge	CONTINUOUS	269,500	Air with <50 mg/ Nm^3 dust, and <50 mg/ Nm^3 NH_3
Fire-fighting system diesel generator	Diesel combustion	EVENTUAL 0h/year	1,078	71% N_2, 9.5% H_2O, 9% CO_2, 8.5% CO, 2% Ar <2500 mg/ Nm^3 NOx, <25 mg/ Nm^3 PM, <450 mg/ Nm^3 CO, <125 mg/ Nm^3 HC, SO_2 will depend on diesel S content

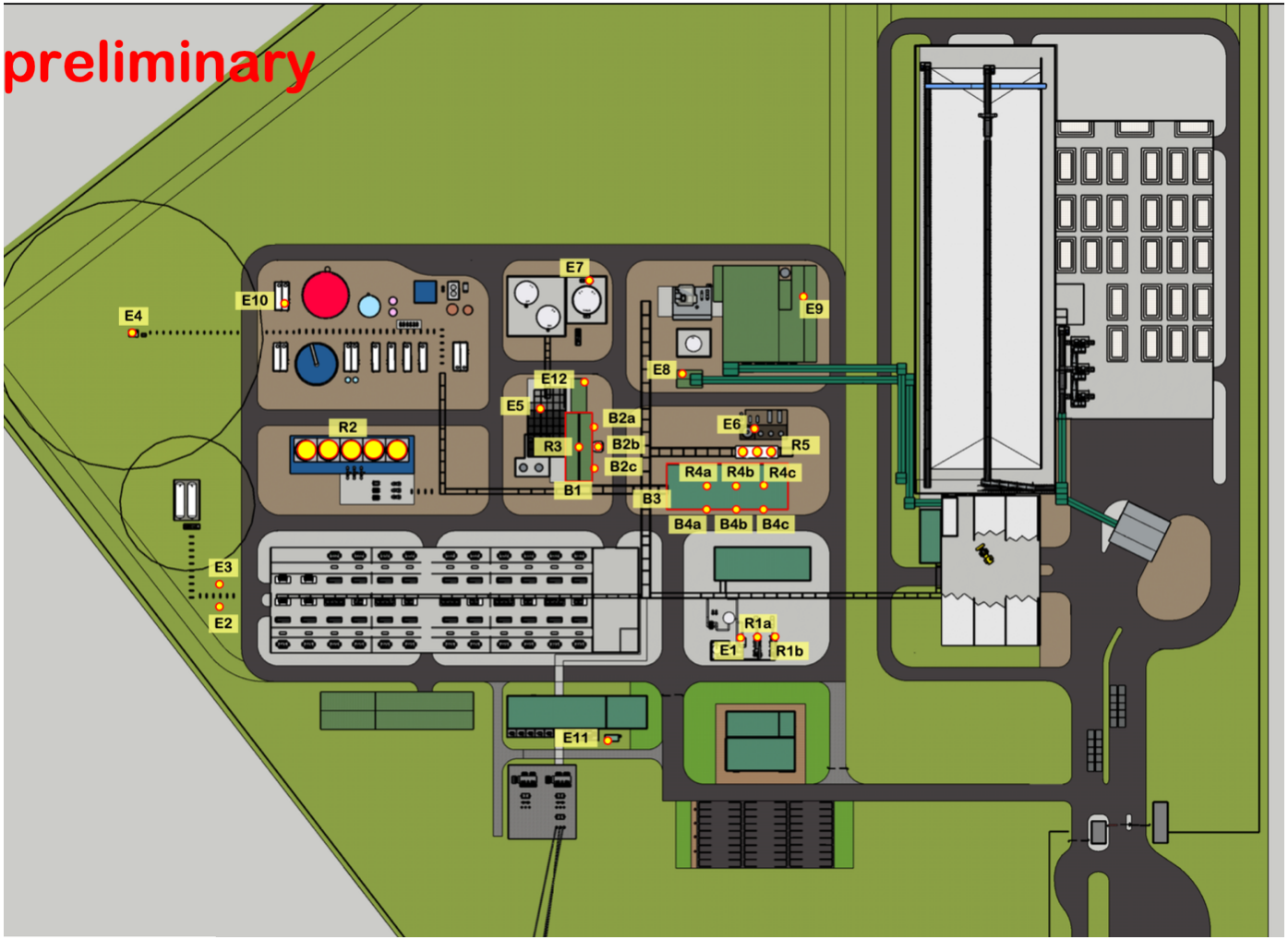
Description	Type of emission	Operation	Flow rate (kg/h)	Composition (%Vol)
Emergency generator	Diesel combustion	EVENTUAL <500h/year	1,594	71% N_2, 9.5% H_2 O, 9% CO_2, 8.5% CO, 2% Ar <2,500 mg/ Nm^3 NOx, <25 mg/ Nm^3 PM, <450 mg/ Nm^3 CO, <125 mg/ Nm^3 HC, SO_2 will depend on diesel S content
NA Plant Auxiliary Boiler Exhaust Stack	Diesel combustion	EVENTUAL <500h/year	1,078	71% N_2, 9.5% H_2 O, 9% CO_2, 8.5% CO, 2% Ar <2,500 mg/ Nm^3 NOx, <25 mg/ Nm^3 PM, <450 mg/ Nm^3 CO, <125 mg/ Nm^3 HC, SO_2 will depend on diesel S content

In terms of noise, the equipment that emits the most in the operation of the plant are:

- ASU Compressors (main and standby).
- Cooling tower (5 cells).
- Turboset.
- *Syngas* compressor and standby compressor.
- NH_3 Synthesis Unit Compressor.
- NH_3 Synthesis Unit Cooler.
- Ventilation Turboset A.
- Ventilation Turboset B.
- Building ventilation of compressors, A, B and C.

This equipment will be designed to emit a maximum noise level of 85 dBA at 1m from the equipment (distance at ground level). There will be noise reduction measures for the main equipment to comply with applicable Paraguayan and IFC noise standards.

Figure 2.3.a
Location of facilities emitting gases in operation (E1 to E12 in the Figure) and those emitting noise (R1 to R5)



Transport and Marketing of Products

The CAN fertiliser will be transported by truck to different destinations, by road and by river from the Terport port, located 33 km upstream of the plant site, and approximately 15 km along the Villeta - Alberdi road.

For the transport of the 770 tons/day of fertiliser (in big bags or bulk) to the Port, 50 truck trips (empty + loaded) are foreseen. The truck to be used is the Scania type tractor + semi-trailer with lengths of 16 m, or even less. The maximum length of this configuration is 18.15m. Transport is carried out in big bags of 1,000 kg each, totalling loads of up to 30,000 kg (30 big bags). The maximum load capacity is 33 tonnes.

Operation and Maintenance Manpower

The operation of the plant will involve operators in the different process blocks, the raw water treatment plant and the WWTP, the dispatch of products, the transmission line, and the ES of the plant (which will be operated by ANDE), as well as workers in the administrative and mechanical areas, among others. It is estimated that the following direct and indirect jobs will be generated in this phase:

- 90 permanent positions for the O&M of the plant.
- Up to 25 permanent positions in subcontracting work.
- 15 posts for the reinforcement of scheduled maintenance tasks.
- Up to 30 temporary positions for subcontracted work.

In addition, similar plants require professionals to oversee operations, such as environmental engineers, chemical and laboratory technicians, logistics and supply chain staff, managers, senior staff, HR specialists, legal, commercial, and administrative staff, among others. This translates into the creation of some 290 indirect jobs.

With the expansion of ATOME's value chain to CAN, an estimated 80 direct jobs and 584 indirect jobs will be created.

Therefore, the total number of direct workers hired in this phase is 240, of which 195 are permanent and 45 temporary. The total number of indirect jobs to be created could reach 874.

3.0
Study of Alternatives

3.1
Location Alternatives

The study of alternatives evaluated three alternatives for the location of the site for the construction of the Plant, which were compared in relation to the following environmental and social criteria and constraints:

- Availability of surface area and the format of the plots.
- Use and occupation of the land environment.

- Proximity to the Buey Rodeo Electrical Substation (ES), which would greatly reduce the length of the transmission line (TL) that would need to be constructed.
- Aspects of the physical environment, such as geology, hydrogeology, soils, relief and hydrography.
- Land cover and land use.

Alternative routes for the TL and the water and effluent pipelines were also studied, evaluating 3 alternatives for each case.

3.2
Technological and Economic Alternatives

Technological and economic alternatives were also evaluated, covering the following aspects:

- Alternative H_2 electrolysis technologies, including:
  - Pressurised Polymer Electrolyte Membrane (PEM)
  - MEP Atmospheric
  - Alkaline Pressurised
  - Alkaline Atmospheric
  - Solid Oxide Electrolyser Stack (SSEP)
  - Anion Exchange Membrane (AEM)
- Air Product Recovery Alternatives
- NH_3 Synthesis Technology Alternatives
  - Haber-Bosch
  - Electrochemical Synthesis
  - Non-Thermal Plasma Synthesis
  - Ammonia Solid State Synthesis
- CAN Storage Technology Alternatives
  - Long-term: horizontal silo and vertical silo
  - Short-term: CAN storage depot packed in big bags
- Cooling System Alternatives
  - Wet cooling system: cooling tower
  - Dry cooling system: air coolers
- Water Treatment Alternatives
  - Reverse osmosis (RO) and electrodeionisation (EDI) based water treatment plant (WTP)
  - ETA based on RO and ion exchange resin beds (CB+MB)
- Water Source Alternatives
  - Superficial
  - Underground
  - Mixed

For the Nitric Acid (NA), Ammonium Nitrate Solution (ANS) and Granulation (GRAN) production processes, no alternatives were evaluated, as those adopted in the Project are the best available in technical, environmental, and economic terms. Their detailed description is included in the Environmental and Social Impact Assessment, **Section 2.3.2**.

4.0
Diagnostics (Baseline)

4.1
Definition of Areas of Influence

Three units of analysis were defined in this study:

- Area of Indirect Influence (AII), which is a broad area where the indirect impacts of the project have reach.
- Area of Direct Influence (ADI).
- Directly Affected Area (DAA).

For the Physical and Biotic Environments, the boundary of the Surubiy Stream Basin, part of the Lower Tebicuary Hydrographic Unit (SEAM Resolution N° 376/12), was considered as the IIA. For the Socio-economic Environment, the administrative boundary of the Municipality of Villeta was considered as the study area for the baseline. However, the indirect social impacts of this project may have a more diffuse scope and go beyond this area of influence.

The Area of Direct Influence (ADI) for all media was defined as a 1 km radius buffer around the Plant area, which includes the Buey Rodeo Substation and the transmission line that will supply power to the project. Also considered is the 1 km strip (500 m on each side of the axis) around the water and effluent pipelines, the access between the plant and the export port and other accesses that will be used during construction and operation. The Directly Affected Area (DAA) constitutes the plant site, with an area of 30 ha, in addition to the easement strips of the TL (with 2.75 ha) and the pipelines (with 1.15 ha).

4.2
Physical Environment

4.2.1
Climate

The Project area is classified according to climate as Cfa, although there may be a transition, to the north, for the Aw climate. Climate type "Cf" is characterised by rainfall evenly distributed throughout the year, without a clear dry season, with the rainfall altitude of the driest month exceeding 30 mm. Climate type "Cfa", subtropical, in addition to the joint definitions already presented above, is characterised by a hot summer, in which the average temperature of the hottest month remains above 22°C.

In the region where the project is located, the Northwest, the average annual rainfall is about 600 mm, which is mainly due to the distance from the ocean. Data from the Silvio Pettirossi Airport station (Luque), located 54 km from the project area, show that for the months between July and August rainfall is less than 60 mm, reflecting the driest months. The wettest months are November and December, when averages are above 170 mm.

In terms of extreme weather events, data analysed and monitored by Paraguay's National Emergency Secretariat show that the greatest risks to the proposed project are frost, forest fires and, especially, severe storms.

4.2.2
Water Resources

4.2.2.1
Surface Water Resources

The water bodies of the AII drain towards the left bank of the Paraguay River. The most important tributaries are the Arroyo Surubiy and the Arroyo Zanja Mercedes, not located in the project's ADI and DAA.

The water catchment data for the Central District (to which the AII belongs), between the years 2019 and 2023, show a total of 7,899 records. Of this total 53.27% are for domestic use; 21.34% for drinking water system; 16.18% for other; 6.79% for industrial - washing and/or cooling; and 0.54% for industrial - raw material.

The water quality analyses carried out for the project included sampling at 3 (three) points of the Paraguay River, one of them at the place where it is estimated that water will be collected for the Project, and the other two downstream of the same, one of them being upstream and the other downstream of the possible discharge point of the treated effluents. Two sampling campaigns were carried out, campaign 1 (C1) in March and campaign 2 (C2) in June, both in the year 2023. The results were compared with the limits established by Resolution Nº 222/2002, taking into account the classification of the water bodies in the study area as Class 2.

All points showed elevated levels of total coliforms (between 24,000 and > 240,000 NMP/100mL) in C1, but only Py 2 exceeded the limit of 1,000 NMP/100 mL of faecal coliforms established in Resolution Nº 222/2022 for Class 2 waters (Art. 3º). In C2, the values of both parameters (faecal and total coliforms) decreased and there was no non-compliance with the regulations. Also related to organic parameters, it was verified that total nitrogen and total phosphorus exceeded the limits established by the legislation for Class 2 waters in C1 and C2. The extrapolation was at least 2 and 1.5 times the limit for total nitrogen and 6.8 and 2 times the limit for total phosphorus, respectively in C1 and C2. For dissolved oxygen (DO), the results did not meet the minimum limit of 5 mg/L in C1 and the concentrations were 3 times or more lower than that value. These results, associated with the presence of macrophyte banks and large amounts of algae at the collection site, as observed by the laboratory team during the campaign, are indicative of eutrophication of the water body. The team also reported observing dead fish at the site.

Despite the low DO concentrations in the water recorded at C1, the BOD in the same period, at the three sampling points, remained within the limit established in the legislation (≤ 5 mg/L), although at values close to this maximum limit, especially at PY 1 (4.7 mg/L). BOD values that comply with the maximum limits of the legislation associated with evaluated DO concentrations is due to the fact that the level of DO in water is influenced by other factors in addition to the decomposition of organic matter, such as losses to the atmosphere, respiration of aquatic organisms and oxidation of metal ions (ESTEVES, 1998). However, both parameters are

interrelated and oscillations in the DO rate lead to oscillations in the BOD concentration. Therefore, the increase in DO concentration during C2 resulted in lower BOD values than those observed in C1.

In non-conformity with the quality standards, the presence of oils and fats was also observed with concentrations between 7 and 9 mg/L in the samples of the 3 points in both campaigns. The limits for colour, aluminium and soluble iron were also not complied with in both campaigns, as well as manganese in C1. For the other parameters, the limits established by the legislation for Class 2 waters were complied with. For manganese, the non-compliant values observed in the first campaign were 3 times higher than the limit established by the Resolution and for aluminium and soluble iron, the sampled values were at least 6 and 3 times higher, respectively. It is possible that these higher concentrations reflect a characteristic of the environment, as sampling carried out in the region in previous years for another project also indicated values above the limit for these parameters, as discussed below.

4.2.3
Groundwater Resources

According to the Hydrogeological Map of the La Plata Basin (CIC; CPRM, 2015), the entire IIA and IDA are located in the hydrostratigraphic unit known as Qa - Quaternary Sediment.

The property where the Project will be installed has a deep drilled well, with a flow rate of 50,000 litres per hour, dynamic level at a depth of 22 m and a maximum depth of 96 m. The water quality analysis of the well indicated that it is mineralised and contains organic contamination. The water quality analysis of the well indicated that the water is mineralised and contains organic contamination, and can be considered non-potable, therefore, not suitable for human consumption without treatment.

In addition, water from a 3 m piezometer also existing on the property was analysed. The analysis resulted in non-compliance with MADES Resolution Nº 222/2002 for nine parameters: BOD, Dissolved Oxygen (DO), Total Nitrogen, Total Dissolved Solids, Oils and Fats, Soluble Iron, Manganese, Arsenic and Total Phosphorus.

4.2.4
Geology

The stratigraphic units found in the AII are the rocks of the Caacupé Group, located in a restricted portion of the IA, and the Quaternary Sediments, associated in the AII with sedimentary deposits, deposited in a wide belt along the Paraguay River and marking the fluvial plain.

4.2.5
Geotechnics

SPT, CPTu, DPSH and sampling in trial pits were carried out in the field and resulted in the detection of an upper layer of fine soils, mainly characterised as silty clays, up to depths of approximately 10.00 m to 15.00 m. These soils present low resistance in the first 10.00 m to 12.00 m, then with peaks in depth. From about 20.0 m onwards, in all cases, very dense silty sands are found, with no rocks present up to 40.0 m depth.

From the secondary data collected, attributes obtained in the geotechnical studies carried out in the DAA and around the Project, in addition to field observations, it was possible to identify the main problems and characteristics associated with the geological materials present. **Table 4.2.5.a** shows a summary of these potential problems and characteristics, in order to predict their behaviour, impacts and possible environmental degradation during the execution of the project, and to foresee the measures and best management practices to be adopted by the EPC contractor to avoid such potential impacts.

Table 4.2.5.a
Main problems and characteristics associated with quaternary sediments occurring in and around the ATOME plant area.

TYPES OF MATERIALS	MAIN PROBLEMS AND CHARACTERISTICS
Quaternary sediments Sand, clay, silt, and gravel lenses.	• Seasonal flooding in the Current Floodplains and occasional flooding in the Sub-recessional Floodplains. • Risk of contamination of the shallow water table. • Floods in areas with flat relief and water table suspended above clay strata. • Lateral and vertical erosion of the channel and edges during the rainy season and/or in the case of embankments, including landslides and falling soil blocks. • Possibility of precarious stability of excavation walls, mainly at depths greater than 3 m. • Low bearing capacity at points where inconsistent strata occur. • Formation of tubifications in dispersive soils. • Suppression of foundations and underground networks in case of surface dispersive soils. • Intense sedimentation of drainage channels. • Need to use borrow material in areas with dispersive soils, presence of salts and high expansion rates.

4.2.6
Geomorphology

Based on secondary information and field surveys, it was possible to identify three types of relief units along the Project's AII: hills, lowlands, and floodplains.

Almost the entire extension of the AII, including ADI/DAA, is located in lowland floodplain relief. Floodplains are mainly located at elevations below 60 m, corresponding to the current and sub-recent floodplains of the Paraguay River. The hills are elevations between 70 and 90 m, one located as an isolated body near the bed of the Surubiy Stream and another hill to the northeast

of the AII and which has continuity beyond the limits of the AII, already in the area of the District of Nueva Italia.

4.2.7
Soils

In the AII, 3 consortia and 3 soil associations were mapped: the Alfisols (*Typic Albaqualf*, *Typic Natrudalf*, *Aquic and Albaquic Paleudalf* subgroups), the Entisols (*Typic Udifluvent* and *Aquic Udifluvent* subgroups), the Ultisols (*Rhodic Paleudult* subgroup).

4.2.8
Air Quality

The air quality baseline conducted at the project site included measurements of Particulate Matter (PM) (Total Particulate Matter - TSP, Inhalable Particulate Matter - PM_{10} and Inhalable Particulate Matter - $PM_{2.5}$), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Ozone (O_3) and Nitrogen Dioxide (NO_2), regulated pollutants for which there are national and international permissible limits. The measurements were carried out in the period between 12 May and 02 June 2023, totalling between 18 and 22 measurement days for the different parameters.

The Air Quality Index (AQI) calculated taking into account the measured parameters has been maintained during the monitored period with the quality "Good", dimensionless values between 0 and 50.

Table 4.2.8. below presents the highest values obtained for each of the parameters and their comparison with the legislation.

Table 4.2.8.a
Highest values obtained in the air quality baseline

Parameter	Maximum measured value	Date	Res. SEAM 259/2015	WHO 2021
$PM_{2.5}$, 24-hour average	10.0 µg/m³	14/05/23	30 µg/m³	15 µg/m³
PM_{10}, 24-hour average	15.0 µg/m³	17, 18, 19 y 20/05/23	150 µg/m³	45 µg/m³
PTS, 24-hour average	22.53 µg/m³	19/05/23		
O_3, average 8 hours	43.19 µg/m³	24/05/23	120 µg/m³	100 µg/m³
NO_2, average 1 hour	3.76 µg/m³	25/05/23	200 µg/m³	
NO_2, average 24 hours	2.71 µg/m³	25/05/23		25 µg/m³
SO_2, half 24 hours	2.62 µg/m³	14/05/23	20 µg/m³	40 µg/m³
CO, average 8 hours	0.4 mg/m³	26/05/23	10 mg/m³	
CO, 24-hour average	0.4 mg/m³	26/05/23	4 mg/m³	4 µg/m³

As can be seen in the table, the highest results of the measured parameters are well below national and international standards, so the air quality is considered good.

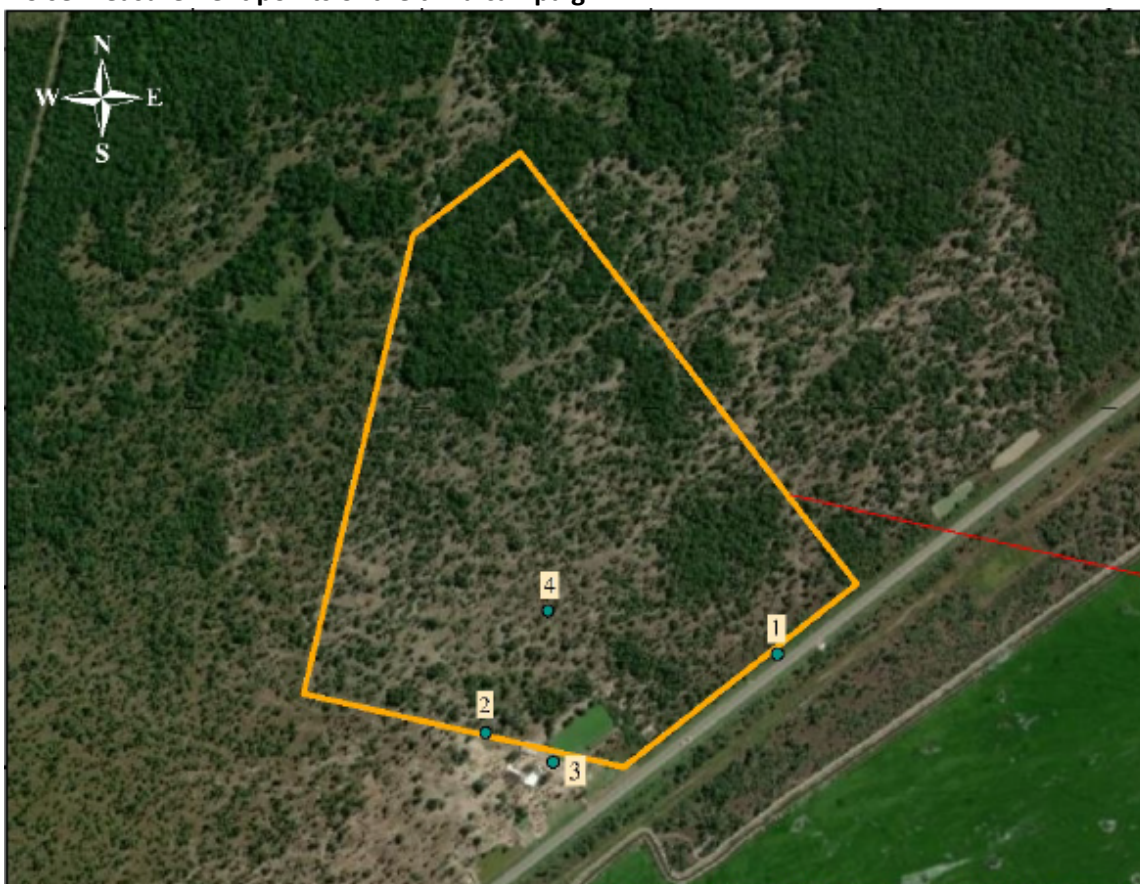
CO_2, 24-hour average, has ranged from 463.8 ppm (24/05/23) to 505.0 ppm (2/06/23). CO_2 is not regulated by SEAM Resolution 259/2015 and the WHO Guidance.

4.2.9
Noise

The noise baseline was carried out in a field campaign with measurements at four (4) points (see **Figure 4.2.9.a**) selected on the basis of land uses and noise sources, two of them at the plant boundaries (P1 at the main access and P2 at the boundary of the neighbouring property), P3 at the main access of the neighbour's house and P4 at the future location of the industry's fixed noise sources (e.g. compressors). Data collection was carried out for 20 hours continuously at the 4 measurement points. The methodology for analysing the results evaluated the hourly L-values LA_{eq}. In order to characterise the daytime and night-time periods by means of a single representative value for each period at each point surveyed, the LA_{eq} for the entire measurement period within the time slot considered for each case was considered.

At Point 1 the maximum value of $LA_{eq1hour}$ was 65.3 dBA and the minimum was 57.1 dBA. In terms of instantaneous sound levels, the maximum recorded by the sound level meter was 89.4 dB, produced by the explosion of the roof of a medium-sized cargo truck travelling along the Villeta-Alberdi road, approximately 30 metres away from where the sound level meter was located.

Figure 4.2.9.a
Noise measurement points of the third campaign



At Point 2 the highest $LA_{eq1hour}$ value was 59.9 dBA and the lowest was 56.62 dBA. The highest instantaneous sound levels were 83.6 dB and produced by equines walking towards the barn, neighing, and galloping. In addition, other values exceeding 70 dB could be attributed to other farm animals in the vicinity of the measurement point. At night and in the early hours of the morning, the barking of the dogs became a source of noise.

At Point 3 the highest $LA_{eq1hour}$ was 73.1 dBA and the lowest was 61.2 dBA. The maximum sound levels recorded by the sound level meter were related to different farm care and maintenance activities. In addition, there was a perceived contribution from mobile sources travelling at high speeds along the Villeta-Alberdi Road.

At Point 4, 63.2 dBA was the highest $LA_{eq1hour}$ and the minimum was 52.9 dBA. The highest instantaneous sound level was 80.5 dB, which is presumed to be associated with an isolated case caused by flocks of birds or mammals near the measuring equipment.

The report concludes that overall, at the 4 registration points during the 20 hours of measurement, there was a level of compliance of 81% for Law No. 1100/97. For the IFC's General Guidelines on Environment, Health and Safety, 98% compliance was recorded.

4.3
Biotic Environment

4.3.1
Vegetation and Flora

According to the 2021 Mapbiomas map, in the AII of the project, land cover is classified into natural woody vegetation (including forests and savannahs); natural non-woody vegetation, which includes natural grasslands, floodable or not, and wetlands; anthropogenic areas (mainly built-up areas) and water bodies.

Natural non-woody vegetation represents 68.23% of the AII, and woody vegetation 23.66%. However, as already mentioned, part of the natural grasslands are used for livestock, so the native vegetation in these natural habitats may be at different levels of conservation.

The mapping of vegetation cover and land use in the ADI showed that native vegetation cover predominates (65.25%), represented mainly by hydromorphic savannah (42.89% of the ADI). Semi-deciduous sub-humid forest corresponds to 22.26% of the ADI. Anthropic land uses occupy 32.36% of the ADI and include crops, pasture and silvopastoral use, asphalt and non-asphalt roads, the power substation and transmission and distribution lines, and small artificial lakes.

Similar to the ADI, the DAA of the land where the Plant will be located is mostly covered by native vegetation (99.18%), consisting mainly of hydromorphic savannah (78.76%) and forests (20.41%). In the LT easement strip, native vegetation represents only 23.73%, being 0.38% forests and 23.36% savannah. In the pipeline easement, native vegetation also predominates, occupying 60% of the area of the strip, with 11.6% corresponding to forest and 48.4% to savannah.

The sampling of vegetation and flora on the Plant site carried out in March 2023 recorded 169 species, within 59 botanical families. The families with the highest number of representatives were Fabaceae, Asteraceae, Cyperaceae and Poaceae, with 18, 12, 10 and 9 species, respectively. Of the total number of species recorded, 90 were observed in the forest transects, 46 in the savanna transects, and 33 species were recorded in both vegetation types. In relation to habit type, 64% of the species recorded are herbs, and 23% are trees or shrubs. Of the recorded species, 36 have cultural value due to their use in folk medicine, 4 species are reported as a source of timber, 4 of fodder use, 3 as raw material for handicraft products and 2 as ornamentals. Considering the data from the first and second campaigns combined, the total species richness recorded in the forests resulted in a total of 121 species. For the Savannah, the total was 125 species.

Four species are listed as threatened according to MADES Resolution N° 470/2019 (**Table 4.3.1.a**). None of them are on the IUCN Red List[1] and no endemic species were recorded.

Table 4.3.1.a
Threatened species present on the site with their MADES categories

Species	Common name	State of conservation
Cohniella jonesiana (Rchb. F.) Christenson	Orchid	Endangered

[1] International Union for Conservation of Nature: IUCN Red List of Threatened Species

Table 4.3.1.a
Threatened species present on the site with their MADES categories

Species	Common name	State of conservation
Libidibia paraguariensis (D. Parodi) G.P. Lewis	Guayacán	Endangered
Monteverdia ilicifolia (Mart. Ex Reissek) Biral	Kangorosa	Endangered
Prosopis nigra (Griseb.) Hieron	Black locust	Threatened with extinction

Source: own elaboration.

4.3.2
Terrestrial Fauna

The first fauna survey campaign was carried out from 4 to 8 March 2023 and the second from 20 to 24 June 2023. The sampling methods were:

- Birds: direct observation, with the naked eye or with Swarovski 8x32 binoculars, auditory recordings by *playback* technique and by comparison with recordings of the voices of the species with a Samsung Galaxy A72 player.
- Amphibians and Reptiles: walking tours throughout the Plant site, randomly selecting the different strata/environments found in the sampling sites, and randomly searching within them, which involved actively searching for amphibians and reptiles, examining all types of potential refuges such as leaf litter, stones, logs, hollows, etc.
- Medium and large terrestrial mammals: direct and indirect observation with limited time, four hours in the morning and four hours between twilight and night periods, monitoring with camera traps and interviews with local residents.
- Aerial Insectivorous Bats: ultrasonic recording using Song Meter equipment.

Results

Birds

Considering the results obtained in the two field campaigns, a total of 2,140 records have been made belonging to 138 bird species, distributed in 22 orders and 43 families.

The combined list of birds considering primary and secondary data results in 195 species classified in 23 orders and 52 families.

Relevant records: Parakáu, Paragua or Talking Parrot (*Amazona aestiva*); Pato bragado, pato negro ype hû (*Cairina moschata*); and Chiripepe (*Pyrrhura frontalis*), considered endemic to the Atlantic Forest, but also inhabits the humid Chaco.

Threatened species: no species is considered threatened according to Resolution No 254/19. For IUCN (2022), only the Lesser Spotted Parrot (Amazona aestiva) is classified as "Near Threatened - NT" of extinction. According to CITES (2023), only the Jabiru mycteria (Jabiru mycteria) is in Appendix I. On the other hand, 22 recorded species are listed in Appendix II.

Migratory species: 12 species with some form of migratory behaviour were recorded in the two survey campaigns.

Endemic species: two species recorded in the survey campaigns are classified as endemic to the Chaco: the white-rumped woodpecker (*Campephilus leucopogon)* and the giant tree creeper (*Xiphocolaptes major*). In addition to these, the green-headed warbler (*Pyrrhura frontalis*) is classified as endemic to the Mata Atlántica biome domains. All these species are widely distributed.

No species recorded in the field are introduced. Only two species on the secondary list are classified as introduced, the domestic pigeon (*Columba livia*) and the cobartita (*Passer domesticus).*

Amphibians and Reptiles

The diversity obtained by consolidating the results of the two field surveys results in a total of 27 species, of which 21 represent the order Anura and six the order Squamata. Considering the total estimated richness, based on primary and secondary data, there are 63 species, distributed in six families of the order Anura and 12 of the order Squamata.

Threatened species: among the reptile and amphibian species recorded, none are in danger of extinction on the MADES and IUCN lists consulted. In terms of CITES, two species, the anaconda (*Eunectes notaeus*) and the Brazilian lizard (*Salvator merianae*) are included in Appendix II.

Endemic species: no endemic species of herpetofauna are recorded in the working area.

The only exotic reptile species resident in Paraguay is *Hemidactylus mabouia*.

Insectivorous Bats Air Bats

Considering the results obtained in the two bat survey campaigns, a total of 591 records have been made belonging to 14 taxa, distributed in three families. The list of expected species for the Project based on secondary data records 28 species of bats, belonging to the order Chiroptera and distributed in three families.

Threatened species: according to the national list (Resolution SEAM N° 632 of 2017), no species was categorised as endangered. Likewise, there are no species categorised according to the international classification of the IUCN (2022) and CITES (2023). Based on secondary data, one species is considered nationally threatened (*Peropteryx macrotis*) and one near threatened by the IUCN (*Myotis ruber*).

Endemic species: no species considered endemic to the biome were recorded.

Terrestrial Mammals

Considering the results obtained during the two field campaigns, a total of 85 records have been made belonging to 12 taxa, distributed in seven orders and nine families. Considering both primary and secondary studies, we have a total of 47 taxa, distributed in nine orders and 19 families.

Threatened species: Regarding the conservation status of the species recorded in the field campaigns, according to the national list of protected species of wild fauna of the Mammalia class (Resolution SEAM No. 632 of 2017), none has been categorised as endangered. Likewise, no species categorised according to the international classification of the IUCN (2022) were recorded in the field. On the other hand, considering the list of probable occurrence in the region (secondary data), there are 4 vulnerable species (VU) according to the IUCN (*Leopardus tigrinus*, *Tapirus terrestres*, *Blastocerus dichotomus* and *Tayassu pecari*). Two others are considered endangered (EN) (*Pteronura brasiliensis* and *Catagonus wagneri*). Finally, *Lontra longicaudis*, *Leopardus braccatus*, *Leopardus wiedii* and *Panthera onca* are classified as Near Threatened (NT). For the international CITES list (2023), 9 species are listed in Appendix I, of which only 1 (*Leopardus geoffroyi)* was recorded in the field. Appendix II lists 17 species, 4 of which were recorded in the field.

Endemic species: None of the species recorded are considered endemic to the biome.

Alien, introduced, invasive or invasive native species: no alien, introduced, invasive or invasive native species of medium and large mammals were recorded.

4.3.3
Areas of Biodiversity Interest

Protected Areas (PA)

The project's AII does not overlap with any protected wildlife areas. The nearest PAs are the Guyrati Nature Reserve and the Lago Ypoá National Park, which are about 3 kilometres from the AII boundary.

Other Areas of Biodiversity Concern

Near the AII of the Project there are other internationally recognised areas of biodiversity importance. An Important Bird Area (IBA) in Argentinean territory and Lake Ypoá, also considered an IBA and Ramsar Site.

4.4
Socio-economic environment

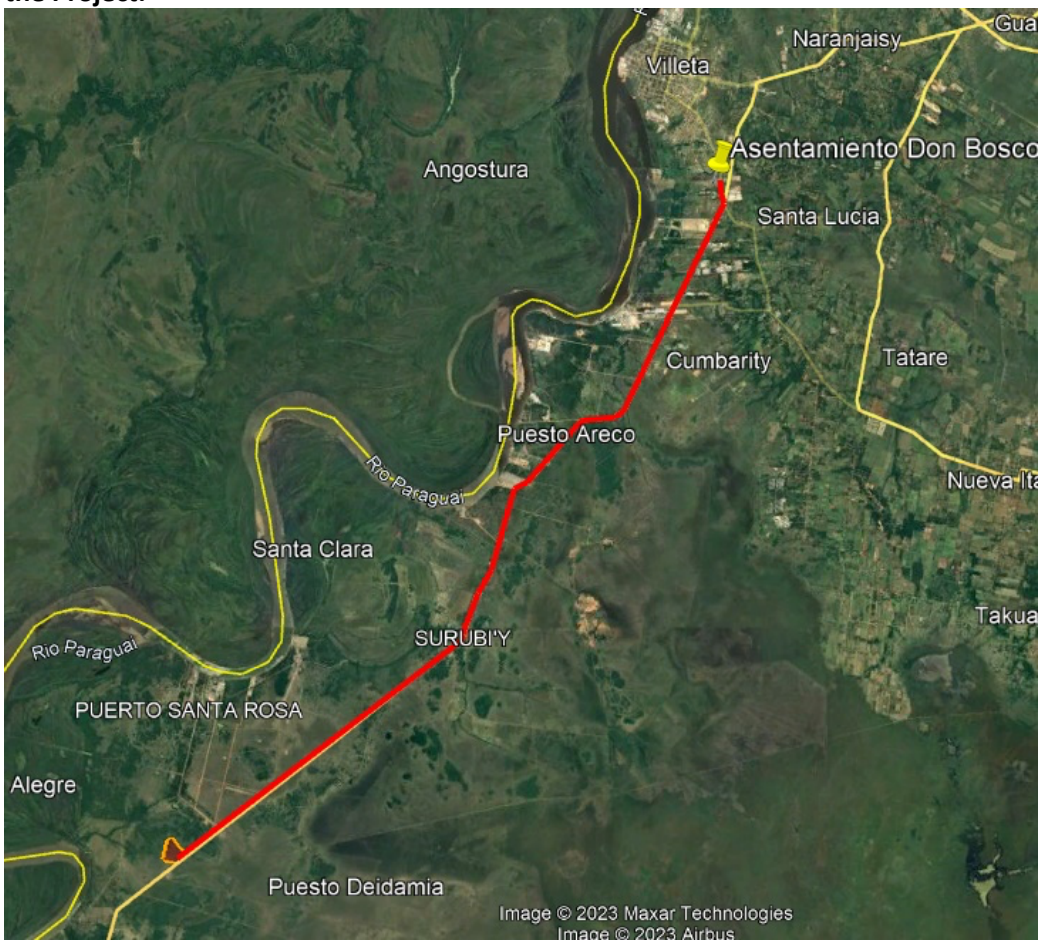
AII

For the AII, secondary data were collected for the Municipality of Villeta, including demographic data; socio-economic level of the population; housing characteristics and infrastructure of basic services (water supply, sewage, rubbish disposal, electricity, public safety); economic aspects

(activity, employment and unemployment rates of the active population; predominant economic activities in the study area; fishing activity); information on public services (health, education, transport); information on social organisations present and on the existence of indigenous population. In relation to this last point, it is worth mentioning that official data indicate that the closest community is Cerro Poty, in the Jukyty neighbourhood of Asunción, approximately 42 km from the field.

During a fieldwork interview, however, the presence of a small Ava Guaraní community in the Don Bosco settlement of Villeta was mentioned. The search for information on this community revealed that it is in fact the Takuapumirî community, of the Mbya Guaraní ethnic group, located in Guasu Corá, and distant about 26 km from the ATOME Project by road (see **Figure 4.4.a**). The coordinates of the Don Bosco Settlement or Don Bosco Social Territory, where the indigenous community is located (P1 - 445,048 m E and 7,175,415 m S; P2 - 445,027 m E and 7,175,613 m S - see Detail **Figure 4.4.a**), were obtained from the Ministry of Urbanism, Housing and Habitat (MUVH) of Paraguay[2] .

Figure 4.4.a
Location of the Ava Guaraní indigenous community of the Don Bosco Settlement in relation to the Project.



2 https://www.muvh.gov.py/sitio/wp-content/uploads/2021/09/IM-P02-08-FONAVIS.pdf

Detail



According to the information found[3], the community is made up of a total of 33 families, including children, young people and adults. The Takuapumirî community subsists on handicrafts, some family farming, and contributions from citizens, and does not receive support from INDI. Wood carving is one of the forms of subsistence of the community, making various shapes and figures of animals, with emphasis on species that are in danger of extinction.

The Don Bosco settlement where the indigenous people live is located in the urban expansion area of Villeta, neighbouring the Sol Naciente settlement. It is far from the Atome Project, but relatively close to the Villeta - Alberdi road, which, along this stretch, will be used by the Project during the construction and operation phases by the buses that will transport the workers. However, this community will not be directly impacted by the Project as it is located on the margins of the Ruta Villeta - Nueva Italia, parallel to the Ruta Villeta - Alberdi and its boundaries are about 220 metres from the latter, not affecting its lands or territoriality (see Detail in **Figure 4.4.a**).

AID

In relation to archaeological and cultural heritage, no cultural elements or vestiges were found in the field, due to the vegetation formations present, as well as changes in land use and removal. Therefore, archaeological monitoring should be considered during soil movement in the event of potential fortuitous discoveries, and if necessary, a Preventive Archaeology Action Protocol should be drawn up.

3 https://tucronista.com/news.php?slug=comunidad-ind-gena-takuapumir-de-villeta-solicita-atenci-n-al-indi

The use and occupation of the land around the Plant is basically composed of native savannah and forest vegetation and areas of cultivation and pasture.

The cultivated areas are located on the opposite side of National Route PY19 to where the Project site is located and consist of large areas of irrigated rice plantations. On the same side of the road is the ANDE's Buey Rodeo substation. Next to the substation, there are areas of pasture, in mosaic with areas of savannah.

On the same side of the road as the plant's land, the predominant use corresponds to savannah areas, with fragments of sub-humid forest. On the side of the road and adjacent to the plant's land, there is a property with silvopastoral uses. The area of the ATOME plant site is occupied by hydro morphic savannahs wooded with black palm or Karanda''y (*Copernicia alba*) and forest islands, with recent livestock use. There is a cut-off formed by the exploitation of borrow material for road works, almost entirely within the Plant's land and with a small part located in the neighbouring land.

Field surveys revealed that the neighbouring farm consists of a livestock production unit called "Ganadera San Rafael", of approximately 7 hectares owned and 100 adjacent hectares owned under lease. The unit exploits the production of morocco ducks, sheep (22 heads), goats (28), donkeys (6), horses (10), and cattle (55).

The farm has a dwelling made of material, a farmyard with barns and a stable very close to the boundary of the ATOME farm. The farm has a 20-metre deep artesian well from which water is extracted for drinking, cleaning, and some domestic tasks. Wastewater goes into a cesspit. The waste produced on site is disposed of by burning it. Electricity, gas, and firewood are used as energy sources.

The owner, who acquired the property 10 years ago, does not reside on the farm permanently. Approximately four people reside on the site, three of the four are employees of the owner who carry out maintenance activities and care for farm animals and a cook who lives with her daughter temporarily. However, it varies according to the activities needed on the farm, with approximately 4 to 5 people working and living in the house.

5.0
List of Identified Environmental and Social Impacts and Risks

Based on the technical characteristics of the project and the results obtained during the diagnostic stage (baseline), the environmental and social impacts and risks were identified and assessed.

As defined in the IFC Performance Standards on Environmental and Social Sustainability (IFC, 2012), environmental and social impacts refer to any potential or actual change to the physical, natural or cultural environment and the surrounding community or workers resulting from the project. Environmental and social risks, in turn, are a combination of the likelihood of a given hazard occurring and the severity of the impacts resulting from such an occurrence.

The identification of impacts was based on the cross-referencing of the environmental and social components likely to be altered by the Project with the actions of the different phases of the Project likely to interfere with these components. As a result, the potential impacts of the Project were identified and the resulting impacts were then ranked, considering the effects of the application of the measures proposed in the ESMP. The list of impacts identified for the Project is presented in **Table 5.0.a.** below.

Table 5.0.a
Impacts identified for the Project

Impacts on components of the Physical Environment	
Impacts on Soil/Relief	Occurrence and/or intensification of erosion processes during construction phase
	Increased soil impermeabilization and alteration of the current drainage regime.
Impacts on Surface and Groundwater Resources	
	Impacts on the water quality of the Paraguay River due to reduced flow and discharge of treated effluents during operation.
	Risk of impact on the water quality of the Paraguay River during the implementation of water catchment infrastructure (1)
Air Quality Impacts	Impacts on air quality during construction
	Impact on air quality during operation
	Reduction of Greenhouse Gas (GHG) emissions and carbon footprint in H2, NH3 and green fertiliser production
Impacts on components of the biotic environment	
Impacts on Flora and Vegetation	Loss of vegetation cover and affectation of flora and fauna.
Impacts on Fauna	Loss of terrestrial wildlife habitats
Impacts on components of the socio-economic environment	
Impacts on Employment and the Local Economy	Generation of direct and indirect jobs during the planning and construction phases.
	Generation of direct and indirect jobs in the operation phase.
	Boosting the local economy during the construction phase
	Physical and/or economic displacement due to land acquisition and establishment of easements

Table 5.0.a
Impacts identified for the Project

Impacts on Infrastructure, Social Equipment and Public Services	Appropriation of the capacity of the access roads to the project in the construction phase
	Appropriation of the capacity of access roads to the project in the operation phase
	Appropriation of the capacity of the Paraguay - Paraná Waterway
	Overloading of solid waste disposal sites in the construction phase
	Impact on traffic on National Route PY19 during the laying of the TL cables.
Impacts on the Quality of Life of the Population	Generating expectations
	Nuisance caused by construction activities
	Noise nuisance in the operation phase
	Odour nuisance in the operation phase

(1) for possible spills and dredging activities

Of the impacts mentioned in **Table 5.0.a** above, the most important positive impact of the Project is the reduction of greenhouse gas (GHG) emissions and carbon footprint in the production of green fertilisers.

Considering the totals of t CO_2eq/year for the production and distribution of CAN fertiliser estimated for the green plant of ATOME compared to those of a grey plant, it is observed that the total of the green plant corresponds to 28.6% of the total value in the grey plant. Taking these figures into account, it is observed that the ATOME project has a displacement capacity of around 600,000 t CO_2 -eq/year, with a total of 15,000,000 t CO_2 eq if the Project's useful life of 25 years is taken into account.

The list of risks identified for the Project is presented in **Table 5.0.b** below.

Table 5.0.b
Project impact risks

Risks of impacts associated with components of the physical environment.	
Risks of impacts on Surface and Groundwater Resources	Risk of impact on groundwater quality during construction phase
Soil/relief impact hazards	Risk of soil contamination during construction phase
	Risk of soil contamination in the operation phase
Risks of impacts associated with components of the biotic environment.	
Risks of impacts on Flora and Vegetation	Risk of spread of invasive species
Risks of impacts on wildlife	Risk of impacts on wildlife during construction
Risks of impacts associated with components of the socio-economic environment.	
Risks of impacts on Infrastructure, Social Facilities and Public Services	Risk of increased demand for health services
Risks of impacts on Community and Worker Health and Safety	Risks to the health and safety of workers during construction
	Risks to the health and safety of workers during operation
	Risk to the health and safety of workers of other stakeholders during the operation (inland waterway and land transport workers, Terport workers, others).
	Risk to the health and safety of the community during construction and operation
Risks of impacts on Archaeological and Cultural Heritage	Risk of damage to archaeological or cultural heritage during earthworks

6.0
Environmental and Social Management Plan (ESMP)

The prevention, mitigation, control and monitoring measures and compensation for the environmental and social impacts proposed for the "Free Trade Zone and green fertiliser production Plant" Project were brought together in the Environmental and Social Management Programme (ESMP), which is subdivided into various Programmes to facilitate its implementation and management throughout the planning (pre-construction), construction and operation stages of the Project. The Programmes that make up the ESMP are those whose need has been verified in order to satisfy the set of impacts assessed for the different phases of the Project.

The ESMP Programmes, and related measures, ensure that all direct and indirect impacts of project implementation are addressed, mitigated and/or compensated for. The set of ESMP Programmes and measures are presented in **Table 6.0.a.** below.

Table 6.0.a
Programmes and measures of the ESMP

Programmes	Measures	Timeline
P.01 - Environmental Construction Control Programme	• Management of earthmoving activities • Prevention and control of soil contamination • Water and effluent management • Control and monitoring of atmospheric emissions • Noise and vibration monitoring and control • Control of vegetation clearance activities • Temporary facilities/construction camp management • Solid waste management • Hazardous materials handling • Construction traffic control • Promotion and development of local suppliers • Recovery of areas degraded by the works	• During the entire construction and assembly phase (31 months); • Management and monitoring to be carried out by the Contractors; • Management and monitoring of effluents generated in the oil and water separator box: monthly; • Visual emission monitoring (Ringelmann scale): at least once a year; • Monitoring of the amount of fuel consumed by stationary sources (engines and power generators, to be used only in case of emergency): annual periodicity; • Monthly environmental noise monitoring and management.
P.02 - Environmental and Social Management Programme and social	• Organisation and equipment • Construction supervision • Conformity Assurance Procedure • Coordination of environmental and social programmes of PGAS • Greenhouse gas emissions management • Procedures for negotiating and acquiring land and establishing easements • • Environmental quality monitoring measures – Air quality monitoring: PM_{10}, $PM_{2.5}$, SO_2 , NO_2 , CO and O_3 . – River and groundwater water quality monitoring	• During the construction, assembly and decommissioning phases of the works; • Periodic supervision of works (routine inspections) to assess contractors' activities; • Procedures for establishing easement strips: start at the planning stage, with contacts with landowners and establishment of the easement constitution document. Air quality monitoring: annually, preferably in the dry season; • River and groundwater water quality monitoring: biannual periodicity.
P.03 - Stakeholder Involvement Programme	• Stakeholder identification and analysis • Public consultation • Communication sub-programme Mechanism for complaints, queries and suggestions management	• It starts before construction, with stakeholder mapping and ESIA interviews, and continues throughout the operation; • Public consultation in the framework of compliance with international standards: before the start of construction; • Distribution of newsletters, visits and/or one-off meetings at least quarterly during construction; • Grievance handling mechanism: throughout the construction phase and in operation.
P.04 - Occupational Health and Safety	• Preparation of an Integrated Health and Safety Plan (IHSP) • Health and safety management staff	• During the construction and operation phases; • Preparation of the PISS: before the start of the works;

Table 6.0.a
Programmes and measures of the ESMP

Programmes	Measures	Timeline
Programme in the Construction and Operation Phases	• Requirements legal requirements and international best practices for Safe Work Procedures • Occupational safety training • Supervision of the conditions of health and safety • Worker health management • Committee for the prevention of accidents	• OSH training: during the admission process and weekly for 15 minutes; • Periodic self-monitoring; • Periodic occupational noise monitoring during construction and operation according to international standards and good practice.
P.05 - Management of Labour and Working Conditions Programme	• Preparing a Human Resources Policy • Recruitment and job training • Working and employment conditions • Complaints handling mechanism • Code of Conduct for Employees • Environmental and social education of workers	• Preparation of the Human Resources Policy and Code of Conduct: prior to the start of works; • Environmental and social education of workers: before the start of construction and every six months during construction, or when necessary according to the activities carried out; • Recruitment of workers: prior to the start of construction, extending to much of the construction phase; • Application of the Human Resources Policy and standards for recruitment, training, working conditions and conduct: throughout the construction and assembly of the Plant, extending to the operation phase.
P.06 - Emergency Response Programme for the Construction Phase	• Emergency Action Plan in the event of a spill of hazardous products • Emergency Action Plan for fires / explosions • Emergency Action Plan for extreme events, such as severe storms and droughts • For each of the Plans, details will be provided: – Resources needed to address the accidental scenario envisaged – Organs to be activated – Emergency response procedures	• Preparation of Emergency Action Plans by Contractors and approval by ATOME: prior to commencement of works; • Application during the construction and decommissioning phases of the works; • Emergency response team training: semi-annually.
P.07 - Biodiversity Action Plan (BAP)	• Structure the project's mitigation strategy according to the stages of the mitigation hierarchy set out in GL25 of IADB's ESD6 and IFC's PS 6; • Detail the measures needed to achieve zero net loss of natural habitats. The BAP should be developed in accordance with international best practice, with the support of experts and in consultation with stakeholders, following the recommendations of IADB's GL93, GL103 and GL104. The BAP should include time-bound implementable actions with adequate budget allocations, which	• The BAP will be prepared after the wildlife monitoring has been completed, as the results will contribute to its elaboration; • Fauna and flora monitoring: for at least one year in the operation, covering the whole seasonal period (dry and rainy); • Compensation measures: to be completed before the operation phase.

Table 6.0.a
Programmes and measures of the ESMP

Programmes	Measures	Timeline
	should be detailed in the Biodiversity Conservation Programme (the Biodiversity Monitoring and Assessment Programme). The BAP should contain the following structure: – Presentation and justification; – Objectives; – General description of the project; – Description of applicable laws and regulations related to biodiversity, including applicable international laws; – Overview of the baseline biodiversity and critical habitat assessment, which is presented in more detail in the ESIA; – General description of the project alternatives analysis, which is presented in more detail in the ESIA; – General description of the impacts of the project on biodiversity, which is presented in more detail in the ESIA; – Proposed actions to achieve zero net loss for natural habitats. This section should include an assessment of ecological/technical, social and political feasibility, as well as address assumptions, uncertainties and risks. In addition, the calculation of zero loss should be clearly demonstrated; – Monitoring and Evaluation Programme (detailed below P.07-1); – Relationship with the other programmes of the ESMP; – Timeline, budgets and organisational requirements. • Biodiversity Conservation Programme – Fauna and Flora Monitoring – Environmental compensation through forest conservation – Environmental compensation through the purchase of Environmental Services Certificates (ESCs) – Environmental compensation for felled trees	

Table 6.0.a
Programmes and measures of the ESMP

Programmes	Measures	Timeline
P.08 - Programme for the Prevention of Impacts on Flora and Fauna	• Germplasm rescue • Pre-scaring and wildlife rescue during construction phase	• Germplasm rescue and wildlife scaring and rescue: concomitant with clearing activities, during the construction phase.
P.09 - Environmental and Social Management Programme of the Operation Phase	• Supervision of compliance with environmental and social measures of the operation phase • Environmental and social training of the operation and maintenance (O&M) team • Solid waste management • Hazardous waste management • Hazardous materials handling • Monitoring of treated effluent • Water quality monitoring • Noise monitoring • Monitoring of atmospheric emissions • Air quality monitoring • Odour control • Supervision of contracted companies • Maintenance of the easement strip	• During the lifetime of the project; • Operation and maintenance (O&M) team training: annually or as needed; • Monitoring of the effluent treated at the WWTP: – Flow rate, pH, temperature, conductivity and free chlorine residual - continuous measurement; – BOD5, COD and ammonia analysis - daily; – Analysis of suspended solids, settleable solids, fats and oils, floating materials, sulphates, total nitrogen, total phosphorus, faecal coliforms and ammonium nitrate - weekly; – Analysis of remaining parameters - six-monthly. • Monitoring of the water quality of the Paraguay river: biannual periodicity; • Environmental noise monitoring at the time of testing and commissioning and periodically thereafter; • Monitoring of atmospheric emissions at the time of testing and commissioning and periodically afterwards; • Air quality monitoring: annual periodicity, in the dry season; • Continuous monitoring of contracted companies.

Table 6.0.a
Programmes and measures of the ESMP

Programmes	Measures	Timeline
P.10 - Operational Phase Emergency Response Programme	• Emergency Action Plan in case of physical explosion in structures of the NH_3 Synthesis Unit, Electrolysis Plant, H_2 and NH_3 tanks and synthesis gas compressors. • Emergency Action Plan in case of structural fires in the NH_3 Synthesis Unit , in the Electrolysis Building, in the H_2 and NH_3 tanks , in the synthesis gas compressors, in the Nitric Acid (NA) Plant and in the Ammonium Nitrate Solution (AN) Plant. • Emergency Action Plan in case of NH_3 leakage , HNO_3 or NH_4 NO_3 • Emergency Action Plan for extreme events, such as severe storms and droughts • For each of the Plans, details will be provided: – Resources needed to address the accidental scenario envisaged – Organs to be activated – Emergency response procedures	• Preparation of Emergency Action Plans by operation and maintenance (O&M) company teams: prior to the start of operation; • Application during the operation phase; • Training of emergency response teams: annual periodicity.
P.11 - ADA Archaeological and Cultural Heritage Conservation Programme	• Preparation of an Action Protocol on Preventive Archaeology • Archaeological accompaniment and procedure in case of chance finds	• During vegetation removal and land clearing and earth moving/excavation activities.
P.12 - Transport Management Programme in the Operation Phase	• Driver training • Routine maintenance • Inspection of roads and implementation of improvements	• During the operation phase of the Project; • Regular driver training; • Periodic maintenance of trucks; • Periodic monitoring of black smoke.

1.0 Introduction

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Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

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1.0
Introduction

1.1
Presentation

1.1.1
Name of the Project

"Free trade zone and green fertiliser production Plant".

The present Environmental and Social Impact Assessment (ESIA) provides the necessary elements for the analysis of the environmental and social viability of the Project corresponding to the "Free Trade Zone and Green Fertiliser Production Plant" of ATOME Paraguay S.A.

Currently, the "Green Ammonia and Hydrogen Plant" project has an environmental licence issued by the Ministry of Environment and Sustainable Development (MADES) according to DGCCARN Declaration No. 105/2023. In view of the inclusion of a chain of technologies and processes for the production of the fertiliser Calcium Ammonium Nitrate (CAN), an adjusted ESIA will be submitted to MADES to obtain an extension of the licence, in accordance with the indications of the environmental agency.

1.1.2
Identification of the Project Proponent

Table 1.1.2.a
Identification of the Project Proponent

Name of the company:	ATOME Paraguay S.A.
RUC:	80115975-0
Administrative management:	Avda. Aviadores del Chaco 2050, Edificio WTC, Torre 3, Piso 15**.**
Legal Representative:	Econ. James Spalding.

1.1.3
Identification of the Study Manager

Table 1.1.3.a
Identification of the person responsible for the study

Name of the company:	JGP Consultoria e Participações Ltda.
RUC:	69.282.879/0001-08
Address:	Rua Américo Brasiliense, 615, Chácara Santo Antonio, São Paulo - SP. CEP: 04715-003. Brazil
Legal Representative:	John Piazza

1.2
Project Justification

The objective of the ATOME Project is to develop an industrial plant for the production of the green fertiliser Calcium Ammonium Nitrate (CAN), whose production capacity will be up to 270,000 tonnes of CAN per year.

Fertilisers play a key role in sustaining global population growth. Without them, it is estimated that 50% of the world's population would suffer from hunger. However, fertilisers face a major global challenge due to the high environmental cost of their production. Currently, 80% of the world's fertilisers are produced using ammonia synthesised from hydrogen produced from fossil fuels, resulting in carbon emissions of 2.6 billion tonnes per year (5% of global greenhouse gas (GHG) emissions, exceeding even the combined emissions of the global aviation and shipping industries. As the world's population grows by 1 billion people every 10 years, the challenge is how to continue to feed the world more sustainably.

Green fertilisers are key to this, and international food and agriculture brands are starting to set aggressive targets to decarbonise their products by using sustainable fertilisers.

In this context, ATOME has identified the opportunity to produce the first green fertiliser without carbon emissions* in Latin America, at a competitive cost, in the largest fertiliser importing markets in the world.

The Project proposes to integrate available renewable energies (hydroelectric) throughout its production chain, including the generation of hydrogen from water electrolysis and the synthesis of ammonia through the Haber-Bosch process, thus replacing traditional methods of its production that require the burning of fossil fuels. In addition, for the production of the CAN fertiliser, facilities such as the Nitric Acid Plant, the Ammonium Nitrate Solution Plant and the Granulation Plant will incorporate the best technologies available on the market, which will ensure greater efficiency in the use of water and energy, as well as the reduction of atmospheric emissions, effluents and noise to comply with national regulations and even stricter international standards.

To secure the provision of hydropower, ATOME has signed a Power Purchase Agreement (PPA) associated with a contracted capacity of 120 MW with the National Electricity Administration (ANDE). The power will be supplied and transmitted from ANDE's Buey Rodeo Substation (ES), which is located approximately 550 m from the intended construction site of the Plant and its ES.

In this way, the Project will have the potential to significantly reduce GHG emissions in the fertiliser and food industry sector. It is estimated that the Project will displace up to 600,000 tCO_2 eq/year of carbon emissions in the fertiliser sector. Considering the lifetime of the Project (25 years), this impact would translate into 15,000,000 tCO_2 eq avoided.

The selection of CAN as a final product is mainly based on its agronomic advantages, environmental sustainability and safety in its management. CAN is in line with sustainable agricultural practices because NO_3^- fertilisers have a lower environmental impact than urea-based products. CAN's balanced nutrient release, better control of nitrate leaching, low physiological acidity and neutral pH contribute to improved soil health and sustainability. In

addition, the versatility of the product allows its use in various types of arable, fruit and vegetable crops, and provides high yield and quality.

By producing CAN with renewable energy it is possible to reduce up to 50% of the CAN life cycle emissions, as is the case of the proposed Project, standing out for this and for the agronomic advantages mentioned, as a more sustainable alternative.

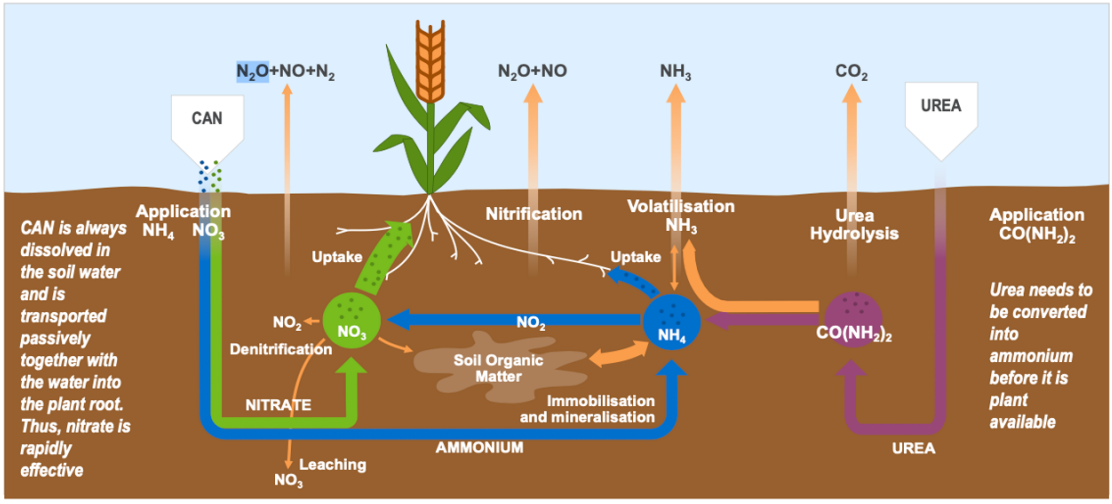
In terms of handling, transport and storage, CAN is more stable than other nitrogen fertilisers, which allows for safer and wider use.

NO_3^- fertilisers , such as CAN, are the most effective and reliable source of nitrogen available, essential for plant growth and development. Because plants can absorb it immediately and easily, it has a direct impact on agricultural productivity and profitability.

CAN can supply both fast and slow release nitrogenous nutrients to the plant. NO_3^- is readily absorbed by plants at high rates. Unlike urea or ammonium, NO_3^- is immediately and completely available as a nutrient. NO_3^- is highly mobile in the soil and reaches the plant roots quickly.

With a nitrogen content of 27%, CAN dissolves in the water contained in the soil and is passively transported along with the water to the plant root. In comparison, urea must be converted to NH_4 before it is available to plants. The nitrogen efficiency of urea depends on soil moisture and soil conditions, where current applications lead to a high volatilisation of NH_3.

Figure 1.2.a
Comparison between CAN fertiliser and urea application



The increasing world population requires higher crop yields, which drives the demand for efficient fertilisers such as CAN. Globally, CAN is a well-established nitrogen fertiliser, which is growing in demand thanks to the previously mentioned benefits; its easy handling and agronomic properties. By 2045, global demand for CAN is estimated to reach 23 million tonnes.

In particular, the Mercosur region is an important agricultural hub representing a vast and growing market for fertilisers such as CAN. Mercosur is the third largest producer of five major world crops combined (maize, wheat, rice, sugar, soybeans), and Brazil alone accounts for 8% of global fertiliser consumption, making it the fourth largest fertiliser importer. In 2021, fertiliser imports in the region amounted to 30 million tonnes. The CAN market is relatively nascent in the region, but is slowly displacing urea and traditional ammonium nitrate, all of which are imported.

With a production capacity of up to 270,000 tonnes per year, the Project's production is expected to represent a very small fraction of Mercosur's demand for ammonium nitrate (34 million tonnes in 2021, of which 30 million tonnes are imported), and will benefit from being the lowest cost CAN producer for the region. The Project intends to sell its production mainly in the region but will also consider exporting to global markets.

In countries such as Paraguay, in the Mercosur region, dependent on imports (1.5 Mton of ammonia fertilisers in 2021), the cost of ammonia and the need to import has a direct impact on the costs of agriculture and agricultural products as farmers depend on ammonia-based fertilisers to increase crop yields. The Project will have the possibility to produce CAN locally and therefore offer it at competitive prices and contribute to food security in the region.

Finally, it should be noted that the Project is aligned with national climate change policies[4] , the national energy policy[5] , the National Development Plan 2030[6] and the Nationally Determined Contributions (NDC)[7] by the Ministry of Environment before the United Nations Framework Convention on Climate Change, as well as technical studies[8] that highlight and encourage the incorporation of new technologies that allow the diversification of products based on fossil fuels and the energy matrix, in which the electrification of the production process of green hydrogen and ammonia are framed as potential viable alternatives.

Furthermore, the operational processes of the future Industrial Plant are integrated with multiple Sustainable Development Goals (SDGs), serving as a model to promote awareness of the shift towards more sustainable economies. In that sense, the Project aims to address key global challenges ranging from food security to climate action, highlighting mainly its relationship with SDG 2 Zero Hunger, through the provision of sustainable fertilisers in import-dependent regions such as Mercosur, SDG 7 Affordable and Clean Energy, operating entirely with clean energy without overloading the national electricity grid, SDG 9 Industry, Innovation and Infrastructure, by introducing advanced technological processes to reduce the carbon footprint of fertiliser production, and SDG 13 Climate Action, by significantly reducing carbon emissions, aligning with Paraguay's climate commitments and promoting the decarbonisation of the fertiliser and food industries.

[4] Public Policy on Climate Change - DNCC (mades.gov.py).
[5] https://www.itaipu.gov.py/sites/default/files/u51/Decreto_Nro_6092_0.pdf.
[6] https://www.stp.gov.py/pnd/wp-content/uploads/2014/12/pnd2030.pdf.
[7] Nationally Determined Contributions (NDC) - DNCC (mades.gov.py).
[8] Renewables Readiness Assessment: Paraguay (irena.org), H2 Marco_Conceptual_DIGITAL.pdf (ssme.gov.py).

1.3
Objective of the Study

1.3.1
General Objective

This technical study has been prepared in order to comply with national and international environmental, social and cultural legal regulations, to be submitted to multilateral financing banks.

Specifically, the document has been prepared in accordance with Law N° 294/93 on Environmental Impact Assessment and its Regulatory Decrees N° 453/13 and N° 954/13. The first, in its Art. 1, declares mandatory the Environmental Impact Assessment to identify, foresee and estimate environmental impacts, in any work or activity planned or under execution (Art. 2) and establishes that it must contain an Environmental Management Plan (Art. 11) with measures to be fulfilled to support the issuance of the Environmental Impact Statement for the undertaking. It is also elaborated within the framework of compliance with the following international standards:

- IDB-Invest Environmental and Social Sustainability Policy;
- International Finance Corporation (IFC) Performance Standards and related guidance and guidance notes;
- IFC General EHS Guidelines;
- IFC Environmental, Health and Safety Guidelines for Nitrogen Fertiliser Production;
- IFC Environmental, Health and Safety Guidelines for Electricity Transmission and Distribution;
- BAT or Best Available Techniques and management criteria (BPEM - Best Environmental Management Practices);
- Equator Principles 4;
- UN Guiding Principles on Business and Human Rights;
- ILO Conventions on core labour standards, basic terms and conditions of employment.

1.3.2
Specific Objectives

This Environmental and Social Impact Assessment was carried out for the following purposes:

- Develop a baseline of the physical, biological and socio-economic conditions of the intervention area.
- Define the area of environmental, socio-economic and cultural influence that could be affected.
- Identify and assess the potential social and environmental impacts and risks of Project implementation.
- Establish preventive, mitigating and compensatory measures based on previously assessed potential impacts.
- Form an Environmental and Social Management Plan (ESMP) to manage the main environmental aspects likely to cause socio-environmental impacts and/or risks.

1.4
Geographical Location

The H_2, NH_3 and green fertiliser plant will be located in the locality called Puerto Sara in Surubi'y, south of the city of Villeta, Paraguay, near the eastern bank of the Paraguay River, 50 km south of the city of Asunción, next to the Villeta-Alberdi road and the SE Buey Rodeo (see **Map 1.4.a - Project Location Map**).

The land owned by ATOME Paraguay S.A. is approximately 30 ha and is identified with number 16.490, according to the title deed. Of the total area, it is estimated that approximately 20 ha will be occupied by the plant facilities, as shown in the general *layout* (**Figure 2.6.a**, in **Section 2.6**). The UTM coordinates of the land vertices are presented in **Table 1.4.a**, below:

Table 1.4.a
UTM coordinates of the terrain vertices

Vertices	UTM Coordinates - Zone 21J	
	E	S
V1	429,677 m	7,156,179 m
V2	429,966 m	7,156,406 m
V3	429,549 m	7,156,940.5 m
V4	429,416 m	7,156,838.5 m
V5	429,280 m	7,156,270 m

The project also includes the construction and operation of a 220 kV power transmission line (TL) of about 550 m in length between the existing Buey Rodeo substation and the plant substation. The UTM coordinates of the vertices of the TL are presented in **Table 1.4.b** below:

Table 1.4.b
UTM coordinates of the vertices of the LT

UTM Coordinates - Fuso 21J		
Vertices	**E**	**S**
V1	429,563.97 m	7,155,799.05 m
V2	429,680.46 m	7,155,853.33 m
V3	429,724.06 m	7,156,090.42 m
V4	429,753.87 m	7,156,252.14 m

In addition to the TL, the Project includes the construction and operation of a water intake and pumping structure from the Paraguay River to the ATOME Plant and raw water and effluent discharge pipelines to the river. The coordinates of the raw water and effluent pipelines and the intake and discharge point are shown in **Table 1.4.c** below.

Table 1.4.c
UTM coordinates of raw water and effluent pipes

UTM Coordinates - Fuso 21J		
	E	**S**
Starting point	429,285.56 m	7,156,279.42 m
V1	428,485.96 m	7,156,165.75 m
V2	428,096.90 m	7,156,430.75 m

End-point (point of uptake and discharge)	427,051.32 m	7,156,476.72 m

Map 1.4.a - Project Location Map

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	1.4.a - MAPA DE LOCALIZACIÓN DEL PROYECTO





Carátula Juridica Legal

Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	25/10/2023

Fuente Cartográfica

Proponente, DGEEC 2012
http://www.OpenStreetMap.org.

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:500.000

1.5
Associated Project - Adequacy of ANDE's Buey Rodeo ES.

The Buey Rodeo substation will provide green (hydroelectric) power to the Plant. It is located near the ATOME site, on the opposite side of National Route PY19.

To this end, a 120 MW power purchase agreement (PPA) has been signed with ANDE. At the plant, the incoming alternating current will need to be converted into direct current, for which the existing substation will be adapted.

The adaptation works of the ANDE's Buey Rodeo substation will be carried out by ATOME Paraguay S.A. as established in the agreement between the parties. For this, ATOME will hire the services of a company duly qualified and approved by ANDE to carry out the works comprising: the construction of the 220 kV busbars for "double main busbar" configuration, completing the existing 220 kV LT and transformer positions, construction of the new 220 kV ATOME LT position and the busbar coupling position, with the complete provision of electrical power equipment, protection, measurement, control, communication equipment and associated systems, as well as all the equipment, materials and accessories necessary for the installations and their correct operation.

The work also includes the design of the detailed engineering, the execution of the required civil, electromechanical and electrical works, the commissioning and start-up of the respective installations and training in their operation.

The supply includes the design, calculations, preparation of plans, diagrams and documents of the equipment and materials, manufacture, assembly, factory tests, transport, customs formalities, disassembly, assembly, checking, installation, adjustment, painting, tests and trials at the final site and supervision of the complete installations within the trial period until the end of the guarantee period established in the constructor's contract.

The purpose of all these components will be the necessary adaptation for the provision of the connection and supply of electricity from ANDE to ATOME, which will allow the 220 kV TL to be built to connect the existing Buey Rodeo substation to the future ATOME substation.

ANDE's Buey Rodeo substation has an Environmental Licence granted under the Statement DGCCARN No. 216/2019. ANDE is responsible for the corresponding updates and presentation to MADES.

2.0 Project Description

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Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

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2.0
Project Description

This chapter describes in detail the facilities and processes involved in the Project "Plant for the production green fertilisers (calcium ammonium nitrate - CAN)". The Project description is based on the front-end engineering design (FEED) developed by the consortium of URBAS Energy-Ingeser, TSK and Casale.

2.1
Project Overview

The ATOME Project, which is the subject of this ESIA, consists of the construction and operation of a plant for the production of hydrogen (H_2), ammonia (NH_3) and green fertiliser (calcium ammonium nitrate - CAN) with an electrical power demand of 120 MW. This Plant will be installed in the district of Villeta, Paraguay, and will be the first in Latin America with the capacity to produce green fertilisers on an industrial scale and at a constant rate (**270,000 tonnes/year of CAN**) from hydroelectricity (**120 MW**), 100% renewable energy; water (**165.4 m^3/h**); ambient air and dolomite (**173 tonnes/day**).

With its production, ATOME could respond to local demand for ammonium fertilisers and regional demand for neighbouring countries such as Brazil, the world's largest importer of ammonium fertilisers (13.7% of the world's ammonium nitrate).

The main raw materials of the Project are hydropower and water. Therefore, the following components are also part of the Project:

- A 220 kV power transmission line (TL) of about 550 m in length, which will transmit hydropower from ANDE's Buey Rodeo substation to the ATOME substation.
- An intake, pumping and piping system for the supply of water from the Paraguay river to the ATOME plant and effluent discharge pipes to the river.

The CAN production project will have six main process blocks, which will be developed in the following facilities:

- Electrolysis plant, where hydrogen (H_2) is generated from water and energy.
- Air separation unit (USA), where nitrogen (N_2) is produced from ambient air.
- Ammonia synthesis unit (NH_3), which is produced from H_2 and N_2.
- Nitric acid plant - AN (HNO_3), where HNO_3 is produced from NH_3.
- Ammonium nitrate solution plant - SNA ($NH_4\ NO_3$), which will produce $NH_4\ NO_3$ in solution from NH_3 and HNO_3.
- Solid feedstock (dolomite/limestone) granulation plant (GRAN), where CAN will be generated from $NH_4\ NO_3$ and solid feedstock.
- Packaging and storage.

Table 2.1.a summarises the main characteristics of the Project.

Table 2.1.a
Main characteristics of the Plant

NO.	Item/Component	Details
1	Location	Villeta (Locality Puerto Sara - Surubi'y)
2	Energy source	Hydroelectricity from ANDE's Buey Rodeo substation through a 220 kV TL
3	Surface area of the property (ha)	30 ha
4	Construction footprint	Approximately 20 ha
5	Plant life	25 years
6	Work Schedule	31 months, starting in the first four months of 2024. The pre-commissioning phase is expected to start in month 19 and commissioning in month 21.
7	Human Resources (direct jobs)	**Construction:** between 200 - 500 people, with peaks of 1020 to 1073 people in months 21 to 24. **Operation:** 90-100 people.
8	Electrical energy (hydropower)	▪ **Total electricity consumption:** 112.9 MW. It should be noted that the Project includes turbosets capable of generating energy from the steam generated as a result of heat recovery at the AN Plant. This energy will be able to feed the processes of the AN-SNA-GRAN plants. It can also be used as extra power at 6 kV at the NH Plant$_3$ to reduce the energy demand of the syngas compressors. The surplus generated by the turbosets is 2.7 MW.
9	Net water consumption	165.4 m^3 /h.
10	Dolomite/limestone consumption	173 tonnes/day.
11	Operational characteristics	The normal operation of the industry considers an operation regime of 24 hours for 350 days/year, except for the granulating Plant with a regime of 22 hours for 330 days/year. All plants are expected to operate simultaneously.
12	Key plant facilities	**Main facilities** ▪ Electrolysis plant; ▪ Air separation unit (USA); ▪ NH synthesis unit$_3$; ▪ Nitric acid (NA) plant; ▪ Ammonium nitrate solution (ANS) plant; ▪ Granulation Plant (GRAN); ▪ Packaging and storage. ▪ *Flare* system; **Auxiliary installations** ▪ Water catchment system and water supply and effluent discharge pipes; ▪ 220 kV transmission line; ▪ Raw water pre-treatment system; ▪ Raw water treatment system; ▪ Service water storage and distribution system; ▪ Demineralised water storage system; ▪ Air system for Instruments and Plant;

Table 2.1.a
Main characteristics of the Plant

NO.	Item/Component	Details
		▪ Utility and liquid nitrogen system; ▪ Cooling system; ▪ Fire extinguishing system; ▪ Wastewater treatment plant (WWTP).
13	Emergency power	▪ An emergency power generator. ▪ One diesel unit of the fire-fighting system.
14	Amount of effluent	77.30 m^3 /h, with peaks of 84.20 m^3 /h. The effluent will be treated at the Plant's Wastewater Treatment Plant (WWTP).
15	Effluent discharge	▪ In the Paraguay River through pipes of approximately 2.3 km in length that connect the ATOME effluent treatment plant and the river and a sub-fluvial outfall that includes dispersers.

2.2
Geographical Location

As mentioned in **Section 1.4**, the CAN Plant will be located in the locality called Puerto Sara in Surubi'y, south of the city of Villeta, Paraguay, near the eastern bank of the Paraguay River, 50 km south of the city of Asunción, next to the Villeta-Alberdi road and the SE Buey Rodeo (see **Map 1.4.a - Project Location Map**, in **Section 1.4**).

The land owned by ATOME Paraguay S.A. is approximately 30 ha and is identified with number 16.490, according to the title deed. Of the total area, it is estimated that approximately 20 ha will be occupied by the plant facilities, as shown in the general *layout* (see **Figure 2.6** in **Section 2.6**).

2.2.1
Land Ownership and Tenure

As will be seen in **Section 3.1.1** of the study of alternatives, the land chosen for the construction of the Plant corresponds to an area of 30 ha formed by fractions 1 and 2 identified with number 8369, purchased from the company Monteclaro S.A., as indicated in the title deed in the name of ATOME. This land was acquired through a simple and friendly negotiation and acquisition process (*willing buyer - willing seller*), applying market values.

In the case of the areas necessary for the installation of the water catchment system on the banks of the Paraguay River, the TL and the water and effluent pipelines, easements of way and aqueduct will be established, respectively, based on Art. 2188 of the Paraguayan Civil Code (Law 1183/85). In the easement areas a long-term right of use is established, and compensation is fixed by mutual agreement with the owner of the property.

The current uses in the area where the LT easement strip will be established include savannah-type vegetation and rice cultivation. Also, in the study of alternatives, in **Section 3.1.2**, it will be seen that the alternative chosen for the establishment of the LT easement strip is located in fraction 1B of the property identified with number 9722 owned by El Arreglo S.A., which has an area of 22.52 ha. Although Law No. 6681/2020 establishes a width of 50 metres for 220 kV TL

easements, the actual area affected by the suppression of rice cultivation and savannah is limited to 0.33 ha or 3,300 m^2. For this area, a compensation cost has been previously agreed with the landowner and a contract will be signed between the landowner and ATOME to constitute the easement.

In the case of the water and effluent pipelines, the easement strip to be established by contract will be approximately 5 metres wide and 2.3 km long, totalling an area of 1.15 ha or 11,500 m^2. It should be noted that the dimensions could be adjusted during the executive project phase of the pipelines and raw water collection system. The route chosen for these pipelines, described in **Section 3.1.3**, is located within two properties, the larger part within Fraction A, owned by the company Omega Green, and a smaller part on land identified with number 8262, which is owned by [redacted]

2.2.2
Zoning of Villeta

The CAN plant will be located in the locality called Puerto Sara in Surubi'y, south of the city of Villeta, Paraguay. This city is in the process of developing a Land Use Plan as consulted with the Municipality of Villeta, therefore, the area does not yet have an official designation or classification.

However, according to Note I.M.V. No. 283/2023 of the Municipality, the area does not present restrictions for the location of the ATOME project, considering the characteristics of the surroundings and the existence of industries of various branches currently installed.

On the other hand, it should be noted that the ATOME property has been declared an industrial and services free zone, according to Presidential Decree Nº 651 issued on 09 November 2023. In accordance with Law 523/95, free trade zones are areas of national territory within which their operation is authorised to carry out commercial, industrial, or service activities.

2.3
Technical Aspects of Project Design

2.3.1
Codes and Standards in the Design, Manufacture and Testing of Facilities

This section lists the reference codes and standards considered for the design, manufacture and testing of the plant facilities. These shall be in accordance with the current edition of the standards and their most recent amendments. In case of discrepancy between any code and standards, the most stringent shall prevail and be applied.

The hierarchy of the different standards to be considered in design and manufacture are imposed in the following order:

- International codes and standards:
  - International Finance Corporation (IFC)/World Bank General Guidelines on Environment, Health, and Safety (MASS).

- World Bank/IFC Environmental, Health and Safety Guidelines for Nitrogen Fertiliser Production.
- IFC Environmental, Health and Safety Guidelines for Electricity Transmission and Distribution;
- BAT or Best Available Techniques and Management Criteria (BPEM - Best Environmental Management Practices).
- Recommended international best practice for industry.

- Relevant national legislation and standards:
  - Law N° 1100/97 on the Prevention of Noise Pollution.
  - Resolution MADES N° 259/15 By which the permissible parameters of air quality are established.
  - Resolution MADES Nº 222/02 Establishing the water quality standard in the national territory.
- ATOME standards.

Table 2.3.1.a
Reference Codes for the Design, Manufacture and Testing of Plant Facilities

CODES	DESCRIPTION
AGMA	American Gear Manufacturers Association
AISI	American Iron and Steel Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Materials Testing
AWS D1.1	American Welding Society
AWWA	American Water Works Association
ASME	American Society of Mechanical Engineers
PTC	ASME Power Test Code
PTC 36	Industrial Sound Measurement
AFBMA	Antifriction Bearing Manufacturers Association
ASHRAE	American Society for Heating, Refrigeration and Air Conditioning
DIN	German Standards Institute
CTI	Cooling Tower Institute
FEM	European Association of Manufacturers of Material Handling, Lifting and Storage Equipment
EJMA	Expansion Joints Manufacturers Association
HI	Institute of Hydraulics
HEI	Heat Exchange Institute
ISO	International Organisation for Standardisation
MSS	Manufacturers' Standards Society
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Association
THEME	Tubular Exchanger Manufacturers Association
TIMA	Thermal Insulation Manufacturers' Association
SIS	Swedish Standards Commission
SSPC	South American directives

2.3.2
Reduction of Atmospheric Emissions

The different process blocks that make up the Plant consider in their design the Best Available Techniques (BAT) and internationally recommended for the industry. In this way, the Plant incorporates adaptations necessary to fully comply with local and IFC regulations such as those mentioned in item 2.3.1.

Table 2.3.2.a presents the main sources of air emissions expected during operation, distinguishing them according to their operating regime; continuous or eventual. The location of the sources of atmospheric emissions is shown in **Figure 2.3.4.a** in **Section 2.3.4**, identified by the acronyms E1 to E12.

The following sections present the technologies chosen for each Plant whose emissions are considered to be polluting and steady-state and the mitigation measures envisaged.

Table 2.3.2.a
Sources of Atmospheric Emissions during Operation

Acronym Figure 2.3.4.a	Description	Type of issue	Operation	Flow rate (kg/h)	Composition (%Vol)
E1	USA	O-enriched air outlet$_2$	CONTINUOUS	13,200	Ambient air enriched in O $_2$ (90% O_2, 10% N_2, <0.5% Ar and traces of CO)$_2$
E2	Electrolysis Plant	Venting of O_2 at two points	CONTINUOUS	17,820	98.5% O_2; 1.5% H_2; 4 g/ Nm^3 of H_2 O and 1 mg/Nm^3 of KOH
E3		H vent$_2$ at two points	EVENTUAL <500h/year	1,980	98.5% H_2; 1.5% O_2, 4g/ Nm^3 of H_2 O and 1 mg/ Nm^3 of KOH
E4	Main Torch	Combustion (burning)	EVENTUAL <500h/year	29,626	**Burner + pilot:** 22.38 kg/h CO_2, 6,664.22 kg/h H_2 O, 22,920.34 kg/h N_2 , 2.28 kg/h NOx, 12.42 kg/h CO, unburned 4.70 kg/h Pilot: 22.38 kg/h CO_2 , 12.22 kg/h H_2 O, 89.34 kg/h N_2 , 0.010 kg/NOx, 0.055 kg/h CO, unburned 0.021 kg/h
		Pilot Flame	CONTINUOUS	124	
E5	Unloading of the AN Plant after abatement	-	CONTINUOUS	73,929	Air with NOx 10 ppmv, NH_3 5 ppmv, N_2 O 20 ppmv
E6	NH Synthesis Unit$_3$	Process gas venting	CONTINUOUS	5	53% H_2 , 43% N_2 , 2% Ar and 0.3% H O_2

Table 2.3.2.a
Sources of Atmospheric Emissions during Operation

Acronym Figure 2.3.4.a	Description	Type of issue	Operation	Flow rate (kg/h)	Composition (%Vol)
E7	Secondary Flare	Combustion (burning)	EVENTUAL <500h/year	29,626	**Burner + pilot:** 22.38 kg/h CO_2, 6,664.22 kg/h H_2O, 22,920.34 kg/h N_2 , 2.28 kg/h NOx, 12.42 kg/h CO, unburned 4.70 kg/h Pilot: 22.38 kg/h CO_2 , 12.22 kg/h H_2O, 89.34 kg/h N_2 , 0.010 kg/NOx, 0.055 kg/h CO, unburned 0.021 kg/h
		Pilot Flame	CONTINUOUS (pilot)	124	
E8	Granulation Plant	Grinding discharge	CONTINUOUS	<0.629 PM_{10} 0.221 $PM_{2.5}$	Air with <37 mg/Nm^3 PM and $_{10}$ 13 mg/Nm^3 $PM_{2.5}$
E9		Discharge of the grinding scrubber	CONTINUOUS	269,500	Air with < 50 mg/ Nm^3 dust, and < 50 mg/ Nm^3 NH_3
E10	Diesel generator of the anti-pollution system fires	Diesel combustion	EVENTUAL 0h/year	1,078	71% N_2 , 9.5% H2O, 9% CO_2 , 8.5% CO, 2% Ar <2,500 mg/ Nm^3 NOx, <25 mg/ Nm^3 PM, <450 mg/ Nm^3 CO, <125 mg/ Nm^3 HC, SO_2 will depend on S content in diesel
E11	Emergency generator	Diesel combustion	EVENTUAL <500h/year	1,594	71% N_2 , 9.5% H_2O, 9% CO_2 , 8.5% CO, 2% Ar <2,500 mg/ Nm^3 NOx, <25 mg/ Nm^3 PM, <450 mg/ Nm^3 CO, <125 mg/ Nm^3 HC, SO_2 will depend on S content in diesel
E12	AN Plant Auxiliary Boiler Exhaust Stack	Diesel combustion	EVENTUAL <500h/year	1,078	71% N_2 , 9.5% H_2O, 9% CO_2 , 8.5% CO, 2% Ar <2,500 mg/ Nm^3 NOx, <25 mg/ Nm^3 PM, <450 mg/ Nm^3 CO, <125 mg/ Nm^3 HC, SO_2 will depend on S content in diesel

2.3.2.1
NH_3 Synthesis Unit

2.3.2.2.1.1
Technology Choice

The process chosen for ammonia synthesis is the Haber-Bosch method, a process with more than 100 years of use, in which hydrogen and nitrogen react in a catalytic bed at 450-550 ºC and 200 bar. Current ammonia production is based on hydrogen produced from non-renewable sources, with green hydrogen being an alternative for the decarbonisation of the ammonia industry. Greenhouse gas (GHG) emissions from the ammonia production stage involve CO_2, CH_4 and NOx from steam reforming to produce hydrogen and from burning natural gas to generate electricity.

The use of green hydrogen and electricity from renewable energies drastically reduces the carbon footprint of ammonia production. The resulting process is cleaner and less energy intensive, resulting in lower consumption of natural resources, greater energy efficiency by avoiding losses associated with the conversion of hydrocarbons to hydrogen, reduced operating costs and reduced carbon footprint.

2.3.2.2.1.2
Measures Incorporated in the Design

Table 2.3.2.2.1.2.a describes the measures adopted in the design of the NH Synthesis Unit$_3$ applying Best Available Techniques (BAT).

Table 2.3.2.2.1.2.a
Actions taken in the design of the NH_3 Synthesis Unit applying BAT

BAT	Design
Use of small catalyst particles for catalyst netting	Choice of AMOMAX-Casale catalyst, with beneficial characteristics compared to standard catalysts, having more stable catalytic activities, higher conversion, reduced circulation rate and synthesis pressure, higher resistance and mechanical strength, being stable at high pressure drops.
Indirect cooling of the ammonia synthesis reactor	The ammonia synthesis reactor is designed in sections/parts with indirect heat exchangers. The heat removed is used to produce high-pressure steam and/or for preheating of the feed gas streams.
Implementation of an advanced process control system	An advanced model-based or model-based predictive control system will be incorporated in order to provide weighted and hierarchical optimisation.
Ammonia removal from process condensates	Condensates from scrubbers, blowdowns and flash tanks will be in a closed condensate circuit containing high ammonia values. These will be reused in processes within the ammonia plant and/or AN plant depending on the ammonia content, as a way of recovering the nitrogenous component. Otherwise, it will be stored in tanks for subsequent disposal and treatment by specialised third party companies.
Production of ammonia from electrolytic hydrogen	Hydrogen will be produced in the hydrogen plant using alkaline electrolysers. Direct and indirect emissions are minimal compared to hydrogen produced from steam reforming and/or partial oxidation.

As a result of these measures, significant benefits in conversion efficiency, reduced catalyst volume, increased ammonia production capacity and reduced energy consumption are expected.

2.3.2.2
Nitric Acid - AN Plant

2.3.2.2.2.1
Choice of Technology

The technology chosen for the production of nitric acid (AN) is the dual pressure (M/H) technology[1], which allows controlling the temperature in the ammonia oxidation stages at medium pressures and increasing the absorption efficiency at high pressures. This will allow for reduced formation of nitrogen oxide gases, thus lower NOx emissions in the tail gas.

Dual pressure plants have the advantage of higher ammonia conversion efficiency, i.e. less ammonia feedstock is needed to produce nitric acid. In addition, dual-pressure plants have a longer catalyst lifetime and require less frequent catalyst replacements.

Without a flue gas abatement system, flue gas NOx compositions in the range of 100-200 ppmv are found compared to 1,000-2,000 ppmv in medium and low-pressure technologies.

2.3.2.2.2.2
Measures Incorporated in the Design

Table 2.3.2.2.2.2.a describes the measures adopted in the design of the AN Plant using BAT.

Table 2.3.2.2.2.a
Actions taken in the design of the AN Plant applying BAT

BAT	Actions taken in the design
Optimise removal of impurities from raw material	Air stream and liquid ammonia/vapour ammonia filters to increase catalyst efficiency (reduction in NO yield).
Optimise raw material mix	Static air-ammonia mixer to avoid excess ammonia in the burner and overheating of the catalyst.
Optimise gas distribution over the catalytic converter	Air-ammonia mixture is evenly distributed, hydrogen is used to activate the catalyst prior to ammonia oxidation. The distribution of the mixture, speed, contact time and oxidation temperature are controlled.
Catalyst efficiency monitoring	Catalyst composition will be adjusted to minimise component loss and associated costs. Monitoring of N_2 O levels in the tail gas will be carried out.
NH optimisation /air_3	Efficient conversion of NH_3 is ensured and risks of explosion are avoided in the reactor with a composition NH_3 /(NH_3 +air) = 9.85% (v/v).
Optimisation of pressure and temperature conditions in the oxidation process	Pressure and temperature conditions in line with new nitric acid plants. Oxidation takes place at medium pressure 5 bar(a) and absorption at high pressure 11.5 bar(a), reaction temperature at 890ºC.

[1] Oxidation takes place at medium pressure 5 bar(a) and absorption at high pressure 11.5 bar(a).

Table 2.3.2.2.2.a
Actions taken in the design of the AN Plant applying BAT

BAT	Actions taken in the design
Combined NOx and N abatement system O_2	Abatement system consisting of Fe catalysts and zeolite at the tail gas outlet.

2.3.2.2.2.3
Abatement System

Abatement systems are understood as operations to reduce NOx concentrations in the tail gas, and additional processes such as water absorption, non-selective catalytic reactions[2] and selective reactions[3] can be used. For new plants, the latter technology is chosen as it does not generate additional GHGs, such as CO_2, CO, unburned hydrocarbons; and allows further NOx reduction from values < 100 ppmv.

The abatement system designed for the ATOME Project consists of a tertiary control system[4] of catalytic reaction at the tail gas outlet composed of Fe and zeolite catalyst meshes for the simultaneous removal of NOx and N_2 O. Emissions achieved with this system are in compliance with national and international parameters.

2.3.2.2.2.4
Greenhouse Gas - GHG - Emissions

Table 2.3.2.2.2.4.a presents a comparison of the limits/standards for GHG emission parameters and the emissions of the ATOME Project.

Table 2.3.2.2.2.4.a
Parameter comparison of GHG emission parameters limits/standards and emissions of the 120 MW Villeta project.

Greenhouse gas	Units	Emissions to be achieved with BAT		IFC limits	120 MW Villeta - ATOME project
		New Plants	Existing plants		
NOx	ppmv	20-100	20-300	200	< 10
N O_2	ppmv	-		800	< 20

2.3.2.3
Ammonium Nitrate Solution - ANS Plant

The design of the Ammonium Nitrate Solution - ANS plant considers BAT measures with emphasis on the optimisation of the neutralisation/evaporation process by taking the following actions:

- Use of the heat of the exothermic reaction between ammonia and nitric acid to preheat the nitric acid feed and/or vaporise ammonia;

[2] NSCR stands for Non-selective catalytic reduction.
[3] SCR stands for Selective catalytic reduction.
[4] There are three types of controls for N_2 O in nitric acid plants, depending on the location of the control within the nitric acid production process.

- Control of pH, flow rates and temperature in the neutralisation/evaporation stage, water content and impurities will allow for more efficient production of ANS and avoid its decomposition during the process;
- The use of the steam generated from the AN plant for the evaporation of ANS, and for the treatment of process condensate;
- All vapours produced in the process will be condensed and the condensate will be reused in the AN plant as make-up to the absorber fluid and in the scrubbing section of the ANS and GRAN plant.

As a result of the optimisation of the neutralisation/evaporation stage, environmental and process efficiency benefits are obtained, achieving greater safety, lower concentration of ammonia and AN in the steam and condensate (< 50 mg/L of AN in the condensate), recirculation of nitrogenous components to the production process, less energy to evaporate water from the ANS and generation of steam at high temperature with ANS with a higher concentration of 95% without the need for additional energy.

2.3.2.4
Granulation Plant

The granulation plant - GRAN will be sealed/insulated and designed to operate autothermally by recirculating hot gas stream from the outlet of the product cooling beds to the drying drum, resulting in significant energy savings by reducing the volumetric flow of outlet gas by 50%. In addition, it will be equipped with an efficient particulate matter removal/collection system to mitigate its emission into the atmosphere. The Plant's exhaust gases will be treated by cyclones and/or bag filters[5] reaching values <50 mg/Nm^3 . Additionally, BAT will be taken into account for the appropriate selection of equipment in the fines classification sector and recirculation of process water to the site.

2.3.3
Gas Detectors

2.3.3.1
Ammonia

The gas detection system shall be capable of monitoring all areas where there may be a risk of accidental release and accumulation of ammonia gases due to localised leaks in plant equipment or specific process lines.
The ammonia gas detectors shall be of the electrochemical cell or solid (semi-conductor) type and shall have low and high level alarms set to plant standards normally corresponding to the long-term exposure limit (*LTEL*, equal to 20 ppmv) and short-term exposure limit (*STEL,* equal to 50 ppmv) values, respectively, with different colours for each alarm level, as well as a wind speed and direction indicator, alarm reset and test buttons.

Although the specific points of installation of these detectors have not yet been defined, the companies in charge of the *FEED* suggest the following facilities, areas and equipment as potential points:

[5] According to the vendor of the milling unit

- Ammonia synthesis unit.
- Ammonia synthesis unit refrigeration section.
- Ammonia buffer tank.
- Plant buildings that may be exposed to toxic clouds (at the air intake of the heating and air-conditioning (HVAC) system).
- Nitric acid plant.
- Ammonium nitrate solution plant.
- Separators and exchangers.
- Gas compressors and compressor house.
- Pumps and pump house.
- Areas with a high density of flanges and connections.

Since ammonia is a lighter gas than air (density relative to air ≤1), ammonia gas detectors shall normally be installed 1000~2000 mm above the location of the potential source of release depending on the prevailing wind direction.

The gas detection system shall be a stand-alone system. The alarms shall be displayed on a dedicated gas alarm display located in the control room. The display shall be easily visible from the operator's station and shall show the actual position where each detector is installed.

Visual and audible gas alarms will be installed to warn operating personnel. Generally, flashing lamps/beacons and horns/beeps/sirens are installed in the area monitored by gas detectors. The sound intensity of audible alarm devices inside buildings shall be 85~90 dB at 1 m, while it shall be 110~115 dB at 1 m for audible alarm devices located on the outside walls of buildings and in installation areas. The elevation of audible and visual alarms in the installation areas shall be at least 2.4 m.

2.3.3.2
Nitrogen dioxide

NO_2 gas detectors will be installed at the Nitric Acid Plant to control the accidental release of nitrous gases.

The ammonia gas detectors shall be of the electrochemical cell type and shall have low and high level alarms set to plant standards (normally corresponding to LTEL 0.5 ppmv and STEL 1 ppmv, respectively), with different colours for each alarm level, as well as a wind speed and direction indicator, alarm reset and test buttons.

Some areas/equipment in the Nitric Acid Plant that require monitoring with NO_2 gas detectors are as follows:

- Turboset building.
- Boiling auxiliary boiler building.
- Air intake from buildings/analysers that can be reached by toxic clouds of nitrous gases.

Since nitrous gas is a heavier gas than air (density to air ≥1.5), NO_2 gas detectors shall be installed as follows:

- Location 500 mm above ground level or above platform level in case of raised installation.
- *Transmitter/display* location at 1,000 ~ 1,500 m above ground level or platform level in case of elevation installation.

For visual and audible NO alarms$_2$, the same recommendations as for the detection of ammonia gas apply.

2.3.3.3
Nitrogen

Nitrogen released in confined or poorly ventilated spaces has the risk of oxygen depletion. At the Plant, nitrogen is mainly found in the Air Separation Unit (USA), in the ammonia synthesis loop (synthesis gas), in the nitric acid plant and in the electrolysis plant.

It is planned to install an oxygen depletion detector which will be of electrochemical type and will be installed at 1,500 ~ 1,700 mm above the finished floor. The detectors will be activated when the oxygen concentration in the air equals 19% by volume.

As in the previous cases, the sites for the installation of these detectors have not yet been defined, but the *FEED* contractors recommend the following areas:
- USA nitrogen compressor building.
- Other completely enclosed spaces where asphyxiating gases are likely to be present.

For visual and audible oxygen depletion alarms, the same recommendations as for ammonia gas detection apply.

2.3.3.4
Oxygen

Oxygen is mainly produced in the electrolysis plant and in the USA. For these cases, oxygen gas enrichment detectors are used in installations where accumulation may occur due to lack of adequate ventilation conditions after a release.

- Where oxygen lines are present.
- In enclosed areas such as analysers and process buildings (process area of electrolyser plants and USA).

Oxygen enrichment detectors shall be of the electrochemical type and shall be installed at 1,500 ~ 1,700 mm above ground level.

For oxygen enrichment, the alarm threshold is normally set at a concentration of 23% by volume and shall therefore be taken as a reference. For visual and audible alarms for oxygen enrichment, the same recommendations as for ammonia gas detection apply.

2.3.3.5
Hydrogen

Hydrogen gas detectors will be installed in the electrolysis plant, in the area of the hydrogen buffer tank and associated compressors, and in the ammonia synthesis unit.

Since hydrogen gas is much lighter than air (density relative to air ≤1), detectors shall only be installed at points where gas can accumulate due to lack of adequate ventilation conditions (e.g. roofed structures, buildings, battery rooms, etc.).

Hydrogen gas detectors shall be of the catalytic type and shall be provided with the following alarm thresholds: (i) in plants (lower explosive limit; *LEL*: 20% high alarm, LEL: 50% very high alarm), (ii) buildings, HVAC air inlet (LEL: 10% high alarm, LEL: 25% very high alarm).

2.3.4
Noise

Noise during the operation phase of the Plant will come from the operation of heavy vehicles and some equipment, on a continuous basis. Heavy vehicles may contribute occasionally. Noise from major equipment will be continuous and of long duration, and therefore equipment that respects noise limits will be used, and the noisiest equipment will be placed as far away from the property boundary as possible. The noise levels to be respected are the limit for industrial areas within the Plant and the standard for residential areas on the neighbour's property. Noise monitoring will be carried out to check compliance with these specifications.

In terms of equipment, the equipment that emits the most noise is listed below, accompanied by the acronyms R1 to R5, which represent them in **Figure 2.3.4.a**:

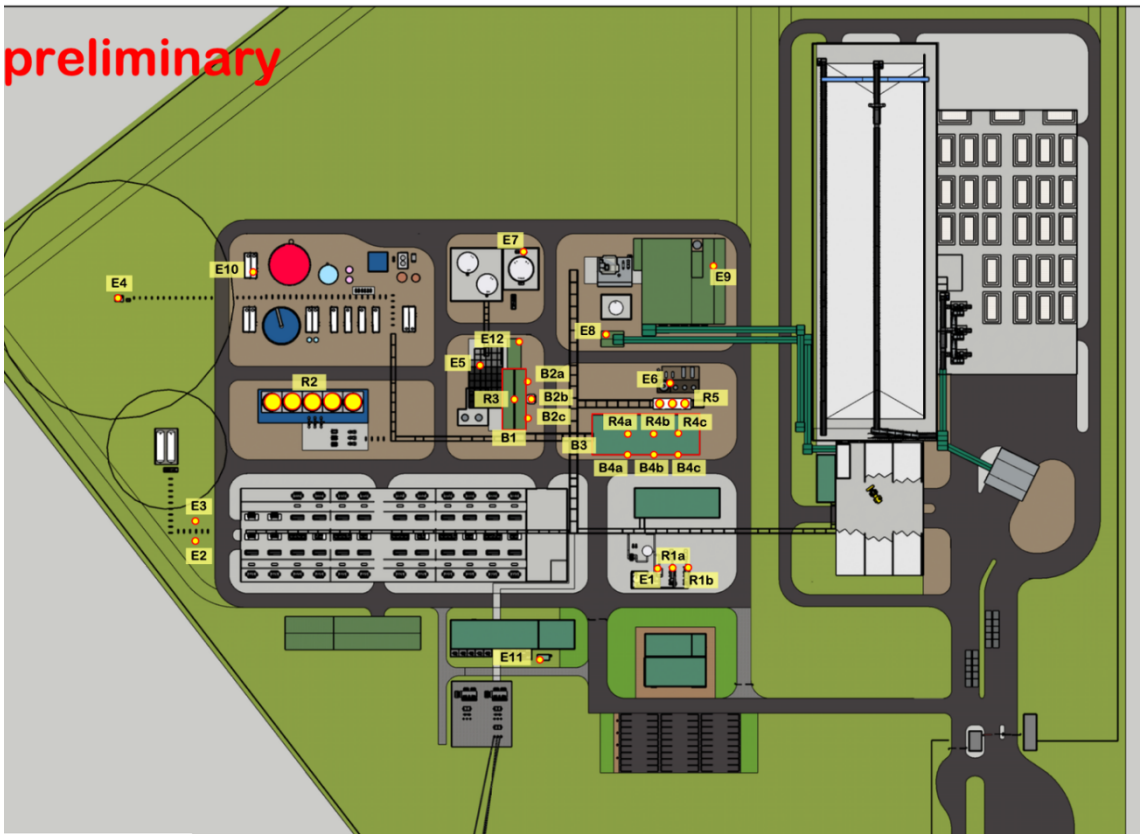
- Main compressors - R1a and reserve - USA R1b
- Cooling tower - R2
- Turboset - R3
- *Syngas* compressor - R4a and standby compressor - R4b
- NH Synthesis Unit Compressor$_3$ - R4c
- NH Chiller$_3$ - R5

It is foreseen that the compressors and turbosets will be provided with abatement measures such as encapsulation. The enclosure material will be of sandwich panel type on the roof and facade. Additionally, silencers for axial ventilation systems in the compressor rooms (SDM silencers) and intake filter silencers in the turboset are considered.

This equipment shall be designed to emit a maximum noise level of 85 dBA at 1 m from the equipment (distance at ground level). Mitigation measures shall be provided to achieve 70 dBA at the property boundary.

In order to estimate the effectiveness of the incorporated measures, a noise emission modelling was carried out (see impact 8.03 in **Chapter 6.0**) considering the maximum daytime and night-time noise values allowed by Paraguayan legislation and international standards, both for industrial and residential areas.

Figure 2.3.4.a
Location of facilities emitting gases in operation (E1 to E12 in the Figure) and those emitting noise (R1 to R5)



According to the results of the sound pressure level modelling of the Plant's operating condition, the abatement measures are adequate to prevent impacts on future sound quality at the nearest receptor considered, the neighbouring dwelling.

2.3.5
Safety and Security Aspects

As part of the Basic Engineering Design or FEED, safety studies will be carried out such as:

- Quantitative Risk Assessment (QRA).
- RAM study (Reliability, Availability, Maintainability).
- HAZID/ENVID reports.
- Fire protection design considerations.
- Environmental risk assessment.
- Preliminary noise data.
- Flaring and relief systems (radiation, headers, etc.).
- HAZOP Report.
- HAZID/ENVID/HAZOP/SIL share tracker and share closure reports.
- Safety Integrity Level (SIL) Report.

- Fire Hazard Analysis (FHA) reports.
- ATEX study including hazardous area classification Report and drawings.
- Plant&Building Siting Studio.
- Fire zones (drawings) / Hazardous areas programme.
- Mechanical handling report.
- Detection of O_2 and H_2 in buildings.

Based on the results of these studies, controls and mitigation measures for the identified risks will be defined and implemented.

2.4
Properties and General Risks associated with Raw Materials and Products

2.4.1
Hydrogen (H_2)

H_2 is a colourless, odourless gas (at 20°C) with low molecular weight and high flammability. It is stable under normal conditions but may react violently with oxidising substances and form explosive mixtures with air. Keep away from sources of heat, sparks, open flame, or hot surfaces. The characteristics and safety data for H_2 are given in **Table 2.4.1.** below.

Table 2.4.1.a
Characteristics and safety data of H_2

Item		Detail
Product Identifier	**CAS NO.**	1333-74-0
Hazard identification(s)	**Indications of danger**	Extremely flammable gas Under pressure may explode if heated May form explosive mixtures with air Burning with invisible flame
Physical and chemical properties	**Molecular mass**	2 g/mol
	Melting point	-259.2 ºC
	Boiling point	-252.9 ºC
	Critical temperature	-239.9 ºC
	Auto-ignition temperature	566 ºC
	Density	0.089 g/l
	Solubility in water	Water: 1.6 mg/l
	Explosive limits	4 - 77 vol% vol
Toxicological information	**Acute toxicity**	Not classified.
	LC50 (ppm)	>15,000 ppm/1h (rat)
Ecological information	**Ecology - general**	No ecological damage

Source: Praxair (2015).

2.4.2
Nitrogen (N_2)

N_2 is a colourless and odourless gas. It is stable under normal conditions, but under certain conditions it can react violently with lithium, neodymium, titanium and magnesium to form nitrides. At high temperature it can also combine with oxygen and hydrogen.

Table 2.4.2.2 below presents the characteristics and safety data of N_2.

Table 2.4.2.a
Characteristics and safety data of N_2

Item		Detail
Product Identifier	**CAS NO.**	7727-37-9
Hazard identification(s)	**Indications of danger**	Under pressure may explode if heated
Physical and chemical properties	**Molecular mass**	28 g/mol
	Melting point	210 ºC
	Boiling point	-195.8 ºC
	Critical temperature	-149.9 ºC
	Auto-ignition temperature	Not applicable
	Solubility in water	Water: 20 mg/l
	Explosive limits	No data available
Toxicological information	**Acute toxicity**	Not classified.
	LC50 (ppm)	No data available.
Ecological information	**Ecology - general**	No ecological damage

Source: Praxair (2015).

2.4.3
Ammonia (NH_3)

NH_3 is a colourless liquid gas at normal temperature and pressure, with a pungent and irritating odour. It is a corrosive or toxic substance whose inhalation or contact should be avoided. It is stable under normal conditions, may form potentially explosive atmospheres in air and react violently with materials. Normal products of combustion are N2 and water, H2 may also be formed at temperatures above 840°C.

Table 2.4.3. below presents the characteristics and safety data of NH_3 .

Table 2.4.3.a
NH_3 characteristics and safety data

Item		Detail
Product Identifier	**CAS NO.**	7664-41-7
Hazard identification(s)	**Indications of danger**	Flammable gas. Under pressure it can explode if heated. Toxic if inhaled. Causes severe skin burns and eye damage. Very toxic to aquatic organisms, with long lasting harmful effects.

Table 2.4.3.a
NH_3 characteristics and safety data

Item		Detail
Physical and chemical properties	**Molecular mass**	17.03 g/mol
	Melting point	-77.7 °C
	Boiling point	-33 °C
	Critical temperature	132.0 °C
	Auto-ignition temperature	651 °C
	Solubility in water	531 g/l (20 °C) (affects pH)
	Flammability limits	33.6 % - higher 15.4 %(v) - lower
	Vapour density (air=1)	0.59 AIR = 1
Toxicological information	**Acute toxicity**	Not classified.
	LD50	350 mg/kg (ingestion) (rat)
	LC50	2,000 ppm (inhalation) (rat)
Ecological information	**Ecology - general**	Avoid release to the environment. Discharge of the product into ground water or the aquatic environment is not permitted.
	Acute toxicity	Fish LC50: 0.44 mg/l (semi-continuous flow) Aquatic invertebrates: LC 50 (48 h): 101 mg/l Micro-organisms: Depending on the local conditions and existing concentrations, these are possible alterations in the biodegradation process.
	Chronic toxicity	Fish LOEC (Fish, 73 Days): 0.022 mg/l Aquatic invertebrates LC 50 (Daphnia magna, 96 h): 4.07 mg/l (continuous flow) Aquatic plants LC 50 (Algae, algal mat (Algae), 18 Days): 2,700 mg/l

Source: Linde (2020).

2.4.4
Nitric acid (HNO_3)

HNO_3 is a reddish-brown liquid with a characteristic irritating and suffocating odour. It is stable and non-combustible but facilitates the combustion of other substances, so it should not come into contact with acetic acid and combustible materials. Nitric acid can form a photochemical smog from the reaction of nitric oxide and hydrocarbons. After decomposition, products such as nitrogen monoxide and nitrogen dioxide may be formed.

Table 2.4.4.4 below presents the characteristics and safety data of HNO_3.

Table 2.4.4.a
Characteristics and safety data of HNO_3

Item		Detail
Product Identifier	**CAS NO.**	7697-37-2
Hazard identification(s)	**Indications of danger**	May aggravate a fire, oxidiser. May be corrosive to metals. Causes severe skin burns and eye damage. It should be kept away from heat sources. Do not mix with combustible materials.
Physical and chemical properties	**Molecular mass**	63.02 g/mol
	Melting point	-42 °C
	Boiling point	86 °C
	Solubility in water	100%
	Vapour density (air=1)	2.2
Toxicological information	**LD50**	110 mg/kg (human)
	LC50	N.D.
Ecological information	**Ecology - general**	Hazardous to aquatic fauna and flora in very low concentrations. Hazardous to drinking water by contaminating it. High mobility on the ground.

Source: UNAM (2016).

2.4.5
Ammonium nitrate solution (NH_4NO_3)

$NH_4\ NO_3$ is a salt consisting of nitrate and ammonium ions. It is a colourless to slightly opaque compound and highly soluble in water. It has a slight ammoniacal (pungent) odour. It is stable under normal conditions, but at temperatures above 210°C it starts to decompose and emit nitrogen oxides (NOx) and water vapour and may explode if the environment is closed.

As an oxidising substance it may increase the flammability and explosiveness of other substances. Ammonium nitrate fertiliser does not have the property of spontaneous combustion.

The characteristics and safety data of $NH_4\ NO_3$ are presented in **Table 2.4.5.** below.

Table 2.4.5.a
Characteristics and safety data of $NH_4\ NO_3$

Item		Detail
Product Identifier	**CAS NO.**	6484-52-2
Hazard identification(s)	**Indications of danger**	May aggravate a fire, oxidant. Causes severe eye irritation. Keep away from extremely high temperatures, ignition sources and incompatible materials.
Physical and chemical properties	**Molecular mass**	80.05 g/mol
	Melting point	75.5 °C
	Boiling point	130 °C

Table 2.4.5.a
Characteristics and safety data of $NH_4 NO_3$

Item		Detail
	Decomposition temperature	Starts at ≥ 170 °C
	Solubility in water	100%
	Flammability limits	Non-flammable
Toxicological information	**Acute toxicity**	Unclassified
	LD50 and LC50 data (rate)	> 5,000 mg/kg bw/day by ingestion.
Ecological information	**Ecology - general**	May be toxic to aquatic life forms; spills may cause algal blooms in standing water.

Source: CF Industries (2016).

2.4.6
Calcium Ammonium Nitrate (CAN)

CAN is a granular inorganic fertiliser for agricultural use. It is a stable, off-white to grey, odourless product. Its thermal decomposition can produce vapours of nitrogen oxides (NOx).

Calcium ammonium nitrate does not have explosive properties. Its molecular structure does not contain groups that could lead to ignition in contact with water and/or to the evolution of a flammable gas.

Table 2.4.6.a presents the characteristics and safety data of CAN.

Table 2.4.6.a
Characteristics and safety data of CAN

Item		Detail
Product Identifier	**CAS NO.**	6484-52-2
Hazard identification(s)	**Indications of danger**	Not applicable.
Physical and chemical properties	**Density (25 ºC)**	Bulk density: 1.0 - 1.3 g/cm^3 depending on granulometry and packaging
	Melting point	1,600-1,709 °C, depending on moisture content
	Boiling point	Not applicable
	Decomposition temperature	Decomposes at over 210 °C
	Solubility in water (20 ºC)	Highly soluble (1,920 g/l); calcium and magnesium carbonates are hardly soluble. The fertiliser is hygroscopic.
	Flash point	No explosive properties.
Toxicological information	**LD50**	Oral (rat, OECD 425): > 2,000 mg/kg Dermal (rats, OECD 402): > 5,000 mg/kg
	LC50	Inhalation (4hs, rat, OECD 403): 88 mg/l.
Ecological information	**Ecology - general**	The product is highly soluble in water and of low toxicity to some aquatic organisms. Fish (48 h, Poecilia reticulata): 490 mg/l; (48 h, Daphnia magna) EC50: 490 mg/l Algae (10 days, Various species) EC50: > 1,700 mg/L.

Item		Detail
		Microbial activity: 3 hs EC50: >1,000 mg/l, NOEC: 180 mg/l (OECD 209, w/ sodium nitrate).

Source: Cámara de la Industria Argentina de Fertilizantes y Agroquímicos (n.d).

According to the United Nations (UN) Hazardous Products Classification System, CAN is significantly safer than AN and is not considered a hazardous substance because it mainly does not have the explosive characteristics of AN.

2.5
General Description of the Production Process

The two main raw materials for the production of hydrogen, ammonia and green CAN are hydropower and water. The former will come from the Buey Rodeo Sub-Station, belonging to the National Electricity Administration (ANDE), which would enter through a 220 kV transmission line (TL) and transformed to medium and low voltage in a substation at the Plant to feed the systems. For the supply of electricity ATOME has a power supply contract with ANDE.

Water will be obtained from the Paraguay River and treated to produce drinking water and demineralised water to provide drinking water for human consumption, to feed the electrolysers for hydrogen production (H_2) and other processes, to generate steam, and to store water for firefighting. **Figure 2.5.a shows** the conceptual flow chart of the production process.

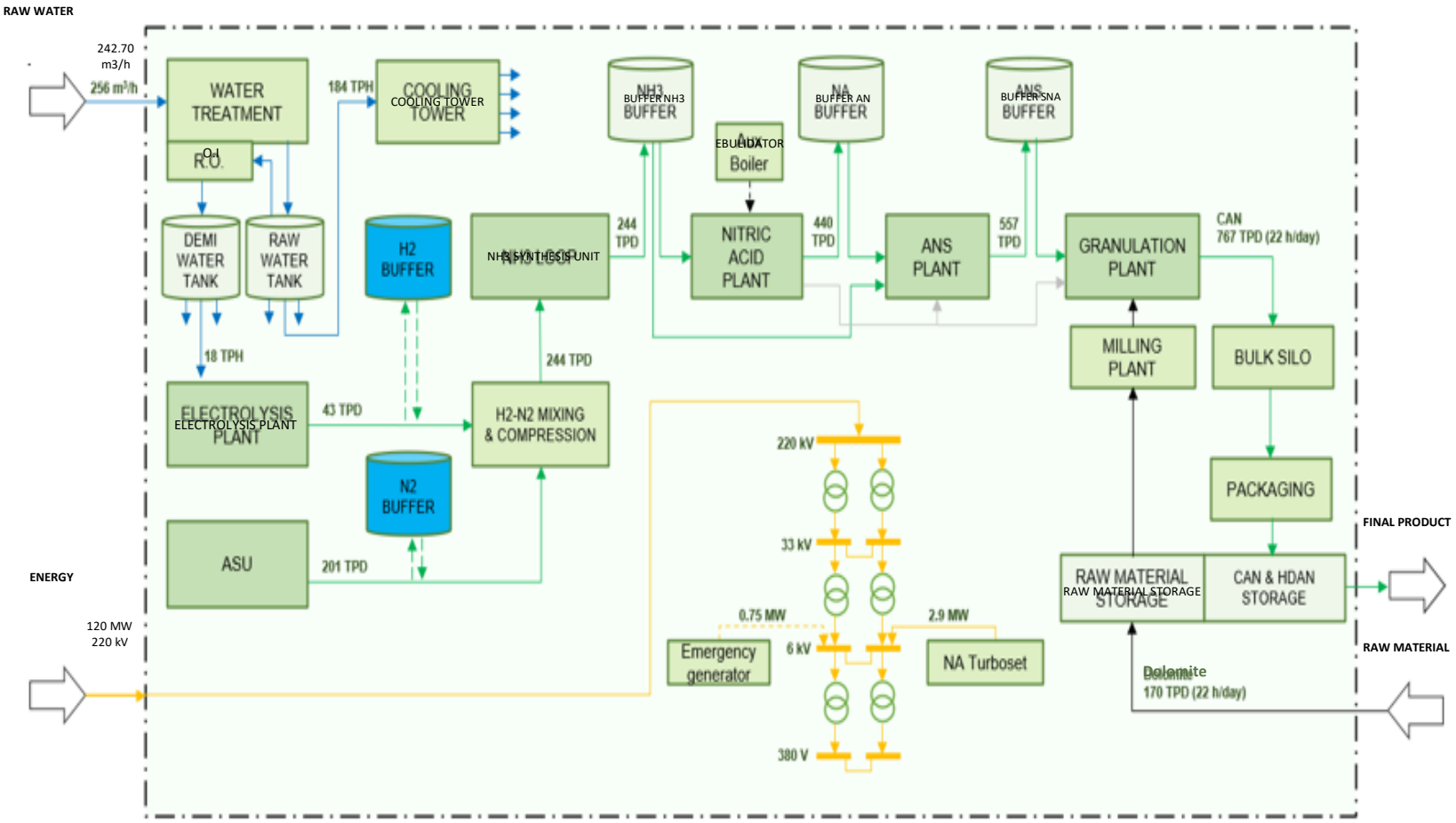
The main process to generate green H_2 is the electrolysis of water whereby the molecules are separated into their constituents; oxygen and hydrogen. The H_2 produced is cooled, dried and separated before being compressed for storage in the buffer tank that will feed the next process. The oxygen generated in the electrolyser will be vented to the atmosphere.

In the air separation unit (USA), the air is filtered, dried, compressed and cooled on its way to the cryogenic distillation columns to separate the constituents from the air. The nitrogen produced in the USA is stored for the next process. As a result of this process, Argon and Oxygen are generated, which will also be vented.

The process continues with the mixture of the produced H_2 and N_2 obtained from the air, compressed to 200 bar and circulated to the NH synthesis unit$_3$. Once NH_3 is produced through the Haber-Bosch (HB) process in a reactor, it enters the fertiliser production chain, including the nitric acid plant (AN), ammonium nitrate solution plant (ANS), and granulation plant (GRAN). For the production of CAN, SNA enters the GRAN plant for combination with ground dolomite. The final step is the packaging and storage of the CAN, with capacity to store 2 months of plant production at full load.

The normal operation of the Plant considers all units running simultaneously. Buffer storage tanks interconnecting the NH synthesis unit$_3$, AN, SNA and GRAN are foreseen in order to provide sufficient flexibility to the process blocks.

Figure 2.5.a
Conceptual process diagram



2.6
Description of Main and Ancillary Installations

The following sections describe the *main and auxiliary facilities* of the production process shown and listed in **Figure 2.6.a - General Layout**. In addition to these facilities, the Plant will have additional support facilities such as:

Storage, loading and transport facilities

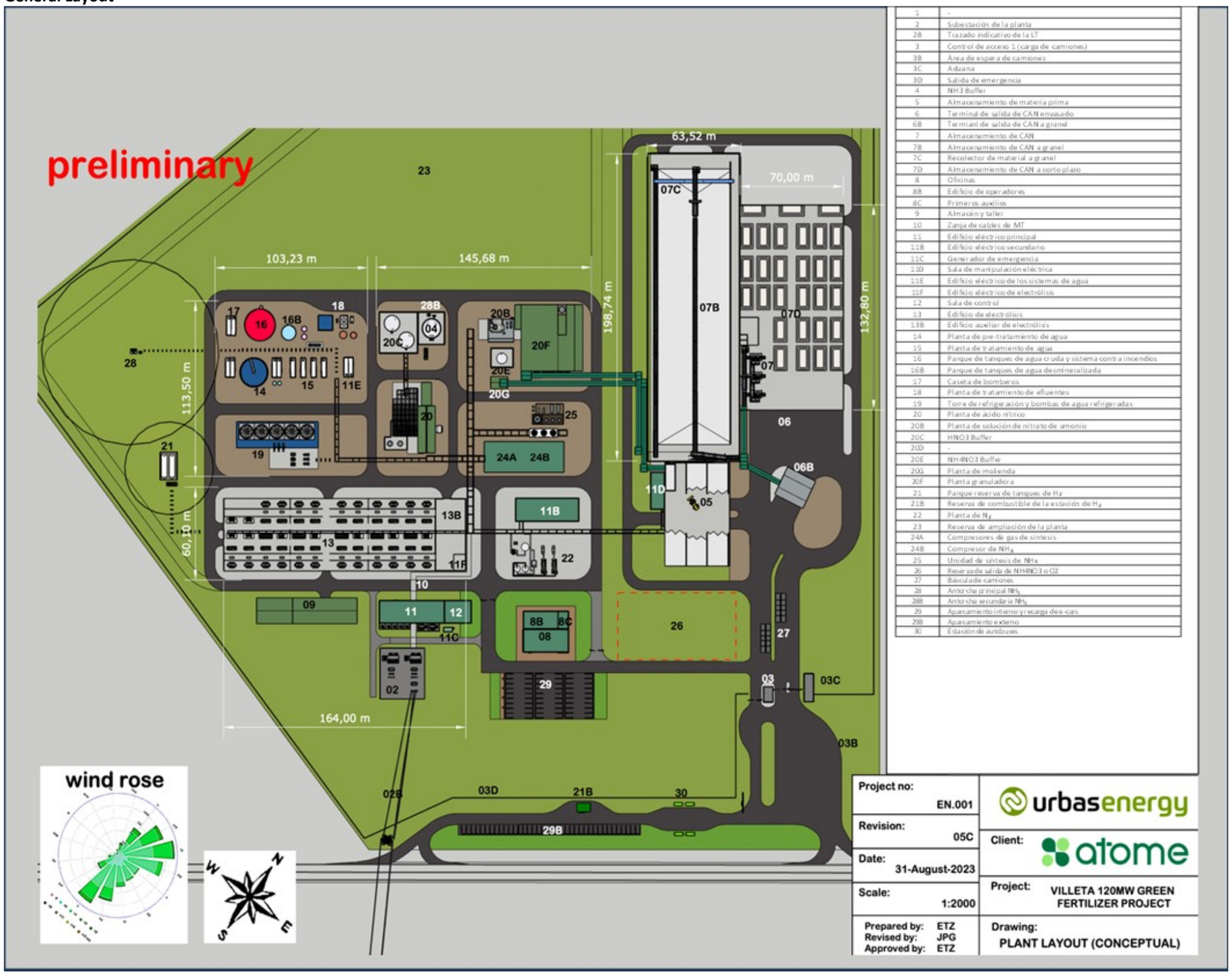
- Product access and dispatch area, comprising:
  - Access control 1, for access to the truck loading area and the Plant respectively;
  - Truck waiting area;
  - Customs office;
  - Truck scales;
  - Indoor parking and charging of e-cars;
  - External parking;
  - Bus station;
  - H_2 reserve station;
  - CAN packaged loading terminal;
  - Bulk CAN export terminal;
  - Emergency exit.
- Storage and packaging:
  - H_2 buffer storage tank farm;
  - NH_3 buffer storage tank;
  - AN buffer storage tank;
  - SNA buffer storage tank;
  - Storage of raw material from the granulating Plant;
  - CAN packaging;
  - Storage of bulk CAN;
  - Short-term storage of CAN.

Other facilities

- Administrative and maintenance area, consisting of:
  - Offices;
  - Operators' building;
  - First aid;
  - Warehouse;
  - Workshop.

- Power supply facilities to the Plant, such as:
  - Plant electrical substation;
  - 220 kV transmission line;
  - MV cable trench;
  - Main and secondary electrical building;
  - Control room;
  - Emergency generator.

Figure 2.6.a
General Layout

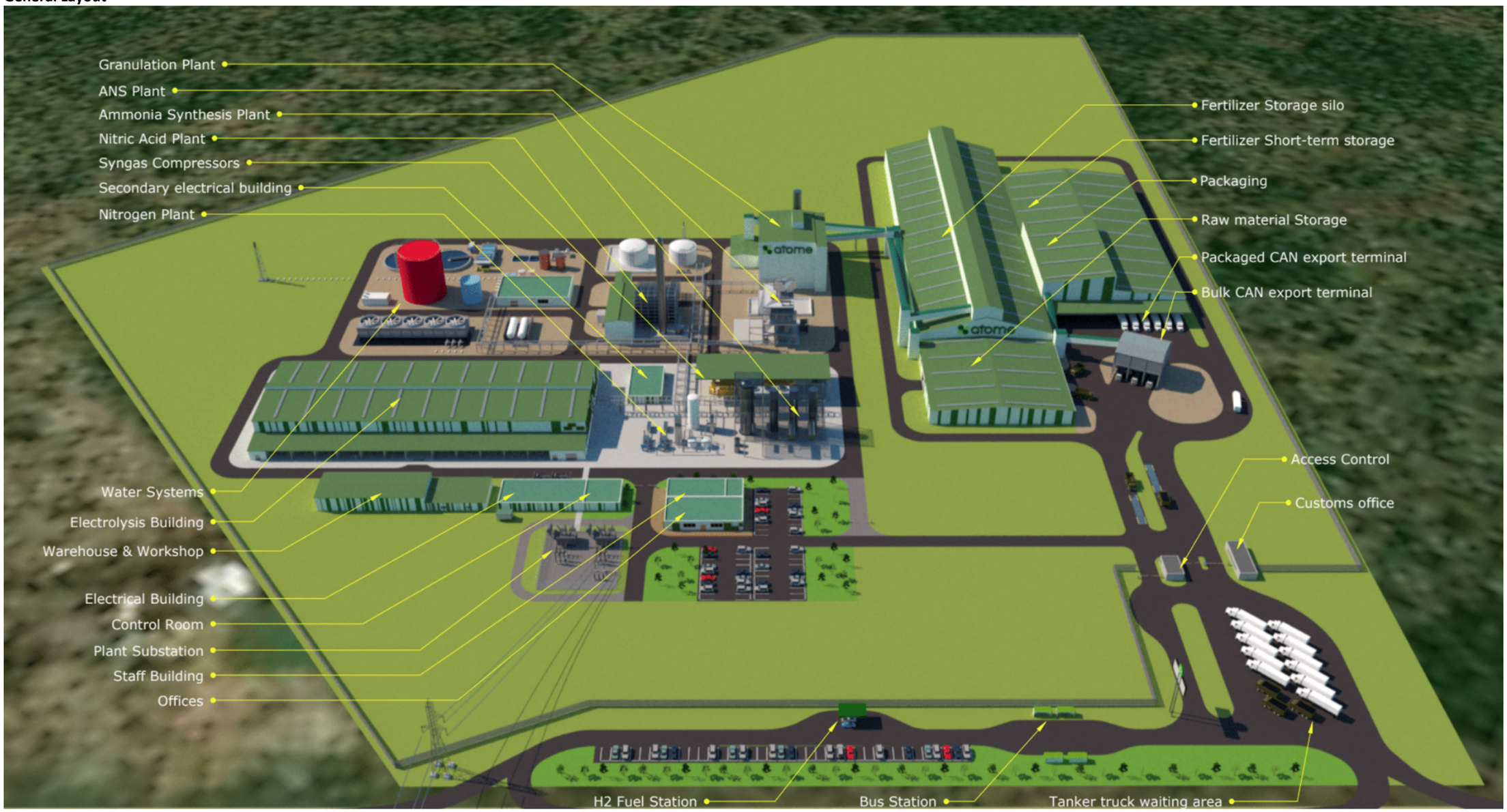


1	-
2	Subestación de la planta
2B	Trazado indicativo de la LT
3	Control de acceso 1 (carga de camiones)
3B	Área de espera de camiones
3C	Aduana
3D	Salida de emergencia
4	NH3 Buffer
5	Almacenamiento de materia prima
6	Terminal de salida de CAN envasado
6B	Terminal de salida de CAN a granel
7	Almacenamiento de CAN
7B	Almacenamiento de CAN a granel
7C	Recolector de material a granel
7D	Almacenamiento de CAN a corto plazo
8	Oficinas
8B	Edificio de operadores
8C	Primeros auxilios
9	Almacen y taller
10	Zanja de cables de MT
11	Edificio eléctrico principal
11B	Edificio eléctrico secundario
11C	Generador de emergencia
11D	Sala de manipulación eléctrica
11E	Edificio eléctrico de los sistemas de agua
11F	Edificio eléctrico de electrólisis
12	Sala de control
13	Edificio de electrólisis
13B	Edificio auxiliar de electrólisis
14	Planta de pre-tratamiento de agua
15	Planta de tratamiento de agua
16	Parque de tanques de agua cruda y sistema contra incendios
16B	Parque de tanques de agua desmineralizada
17	Caseta de bomberos
18	Planta de tratamiento de efluentes
19	Torre de refrigeración y bombas de agua refrigeradas
20	Planta de ácido nítrico
20B	Planta de solución de nitrato de amonio
20C	HNO3 Buffer
20D	-
20E	NH4NO3 Buffer
20G	Planta de molienda
20F	Planta granuladora
25	Parque reserva de tanques de Hz
25B	Reserva de combustible de la estación de H_2
22	Planta de N_2
23	Reserva de ampliación de la planta
24A	Compresores de gas de síntesis
24B	Compresor de NH_3
25	Unidad de síntesis de NH_3
26	Reserva de salida de NH4NO3 o O2
27	Báscula de camiones
28	Antorcha principal NH_3
28B	Antorcha secundaria NH_3
29	Aparcamiento interno y recarga diee-cars
29B	Aparcamiento externo
30	Estación de autobuses

Project no:	EN.001
Revision:	05C
Date:	31-August-2023
Scale:	1:2000
Prepared by:	ETZ
Revised by:	JPG
Approved by:	ETZ

urbasenergy
Client: atome
Project: VILLETA 120MW GREEN FERTILIZER PROJECT
Drawing: PLANT LAYOUT (CONCEPTUAL)

Figure 2.6.a
General Layout



2.6.1
Main Facilities

2.6.1.1 Green
Hydrogen Plant (H_2)

In the Hydrogen Plant, the electrolysis process is carried out in the electrolyser units. The electrolysers are composed of different components that are necessary to produce green H_2 and by-products such as oxygen from electrical energy (alternating current and medium voltage) and demineralised water.

The main characteristics of the Plant are:

- Maximum production capacity: 1,982 kg/h, at 15 bar.
- Installed capacity: 110 MW, including up to 10% additional capacity of the total rated capacity of the Plant at the beginning of its lifetime and additional overload capacity of 10% for emergency or transient situations.
- Storage capacity (Buffer Tank): 700 kg, intended to accommodate the equivalent of an emergency load reduction.
- Type of storage: pressurised.
- Instrumentation and control: safety valves that open or close according to control signals for flow, pressure, temperature and quality at which the hydrogen exits.

2.6.1.1.1
Technology and Processes in the Hydrogen Plant

The selected technology for electrolysis is the pressurised alkaline technology. Alkaline water electrolysis is a process of decomposition/dissociation of water into its elementary molecules (H_2 and O_2) by the action of an electric current. To make this possible, the demineralised water comes into contact with the electrolyte potassium hydroxide (KOH), which promotes the circulation of electrons through the fluid. The electrolyte is not consumed directly but is recovered during the process and re-injected into a closed circuit.

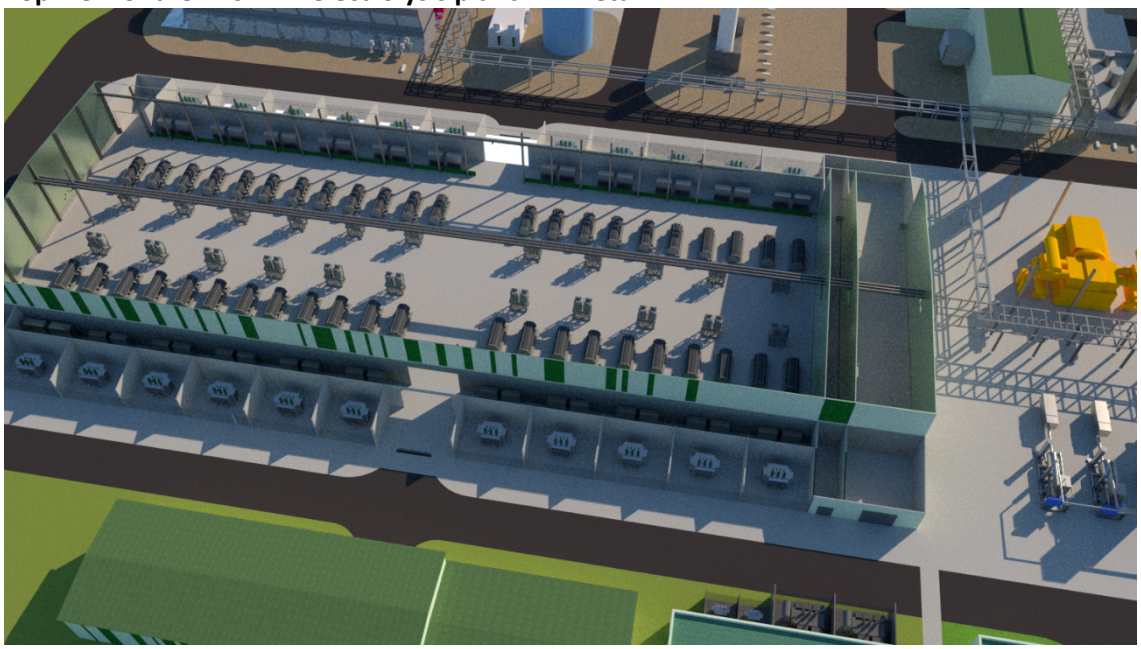
The reactions that take place in the electrolysis plant are as follows:

$$Oxidación\ Anódica:\ \ 2H_2O_{(l)} \rightarrow O_{2\,(g)} + 4H^+_{(aq)} + 4e^-$$
$$Reducción\ Catódica: 2H^+_{(aq)} + 2e^- \rightarrow H_{2\,(g)}$$

The reaction takes place in a pressurised electrolysis stack at 15 bar, reducing the overall dimensions of the equipment and avoiding further compression requirements by matching the inlet pressure of the syngas compressor.

The final streams of H_2 and O_2 are separately circulated through a different separation and purification unit to reduce the content of electrolytic impurities and condense any traces of water, resulting in H_2 with a purity of 99.9995% (as H content$_2$), the remainder being trace amounts of O_2 and H O.$_2$

Figure 2.6.1.1.1.1.a
Top view of the 110 MW electrolysis plant in Villeta



2.6.1.1.2
Electrolysers

Electrolysers consist of main and auxiliary systems, which are briefly described below:

- **Electrolytic cells**: hydrogen production is carried out using cells based on alkaline technology. Water entering the equipment is dissociated into hydrogen and oxygen molecules;
- **Electrolyte storage and dosing system (alkaline electrolyser)**: demineralised water is fed into the electrolytic circuit before being sent to the electrolytic cells. The KOH solution is stored in a tank and the electrolyte solution is pumped to the cells;
- **Feed water pumps**: these pump the deionised water to the electrolytic cells;
- **Hydrogen and oxygen separators:** these separate hydrogen and oxygen from the output streams of the electrolyser. In addition, the oxygen separator is used as a storage tank for demineralised water to ensure continuous supply to the electrolyser;
- **Gas cooling system:** cools the oxygen and hydrogen streams once they leave the electrolytic cells with subsequent separation and reuse of the condensed water;
- **Hydrogen purification system**: hydrogen is purified in a catalytic combustion reactor, commonly called a deoxidiser, where it reacts with residual oxygen molecules present in the stream producing water. A system of drying towers removes the water residues formed in the stream. These dryers will regenerate when the absorbent becomes saturated, normally every 4 hours. Therefore, the scrubbing system consists of two adsorption drying towers to ensure operation when one of the dryers is regenerating;
- **Oxygen purification system**: conditions the oxygen flow to meet the quality requirements of the supplier;
- **Interconnecting pipes, valves, brackets and fittings**;
- **Process instrumentation, detection and associated safety**;

- **Vent pipes, discharge pipes and safety valves**: consist of discharge pipes and safety valves that lead all vents generated inside the electrolyser room to a safe place outside.

While the specific characteristics of the electrolysers will be defined after selection of the supplier, there are fixed parameters that the electrolysers will meet and these are shown in **Table 2.6.1.1.2.a** below.

Table 2.6.1.1.1.2.a
Technical specifications of the electrolyser

Parameter	Value
Network frequency	50 Hz, three-phase
Mains voltage	220 kV
Electrolyser capacity	100 MW (1)
H supply pressure$_2$	≥20 bar (2)
Purity level of H_2	≥ 99.99% by weight
Purity level of the O_2	≥ 99.5% by weight
Design life	25 years (3)
H2O purity level	Max 3 ppm vol

(1) excluding ancillaries.
(2) to be confirmed by the supplier.
(3) excluding the replacement of electrolytic batteries.

2.6.1.1.3
Technical Specifications of the H_2 Produced

The H_2 resulting from the process and which will be fed to the Ammonia Synthesis Unit shall comply with the following characteristics (**Table 2.6.1.1.3.a**).

Table 2.6.1.1.3.a
Specification of the H_2 for ammonia plant feed

Parameter	Value
Purity of H_2 , % H	≥ 99.9%
Water, % Water, % Water, % Water, % Water	3 ppm vol (max)
Oxygen, % Oxygen, % Oxygen, % Oxygen, % Oxygen, % Oxygen, %	3 ppm vol (max)

2.6.1.2
Air Separation Unit (USA)

The second step in the Plant is carried out in the air separation unit (USA) to produce the nitrogen needed for ammonia synthesis and the nitrogen required for the Plant's processes.

Although by-products such as Argon and Oxygen are generated in the USA, their capture and storage for sale or use is not currently considered.

The main characteristics of the Plant are:

- Maximum production capacity: 8,363 kg/h, at 15 bar. This Plant also produces an extra 300 kg/h of utility nitrogen for purging equipment in the Plant.
- Storage capacity (Buffer Tank): 9,300 kg at 15 bar, intended to accommodate the equivalent of an emergency load reduction.
- Type of storage: pressurised.
- Instrumentation and controls: The plant and instrumentation air streams are equipped with a pressure gauge, temperature indicator, flow meter and check valve. The USA can be started and stopped from the central control room.

2.6.1.1.2.1
Technology and processes in the USA

The selected technology is of the **cryogenic type**, and the operating process follows the following steps:

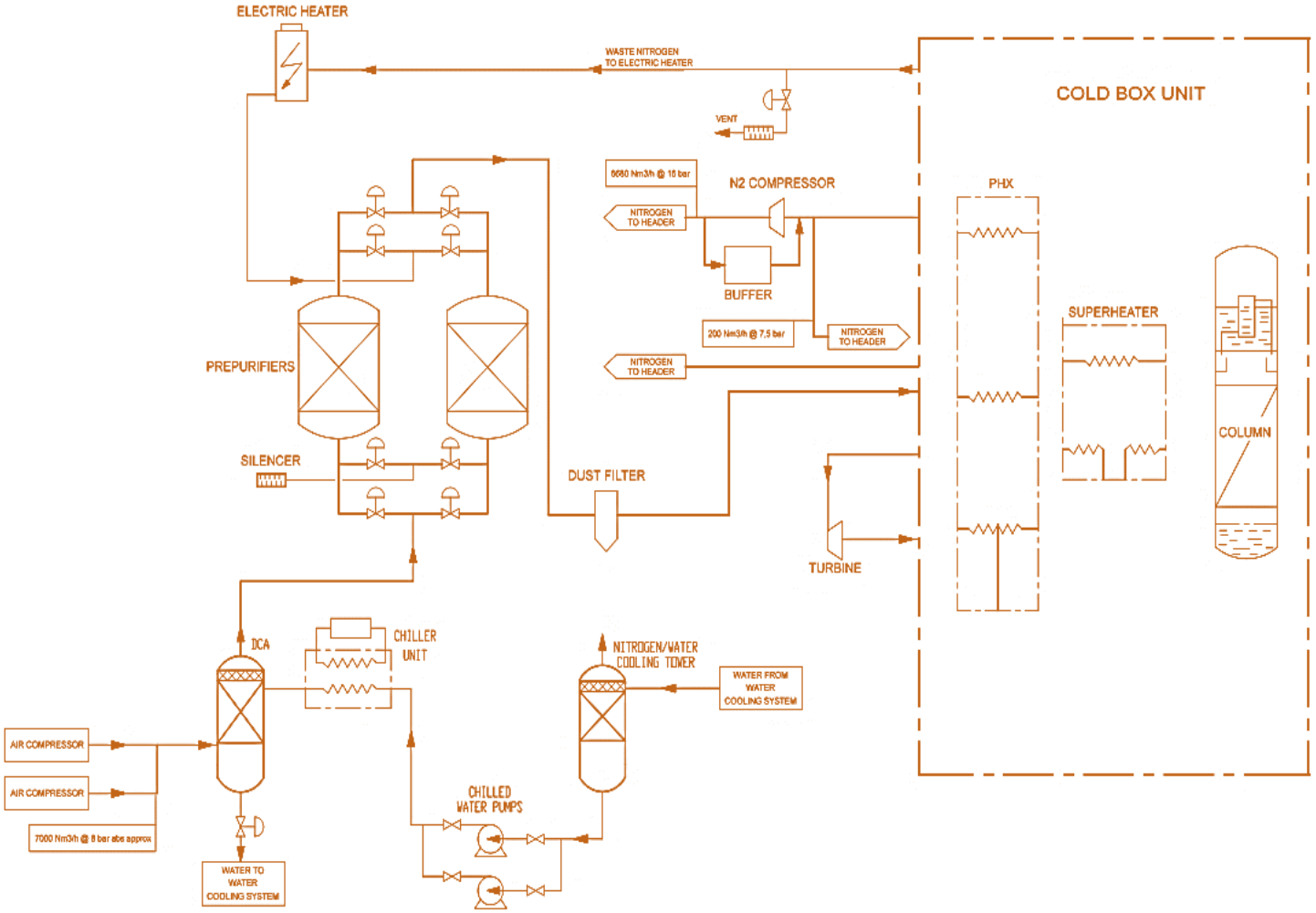
1. **Compression**: Air from the atmosphere is fed into the USA and compressed using a series of compressors. Compression increases the pressure and temperature of the air, making it easier to separate into its components.
2. **Pre-cooling**: The compressed air passes through a series of heat exchangers to remove the heat generated during compression. This pre-cooling stage helps to reduce the energy required for the subsequent cooling and liquefaction processes.
3. **Purification**: The pre-cooled air then enters a purification system where impurities such as moisture, carbon dioxide and trace contaminants are removed. This step is crucial to ensure the quality and purity of the final product gases.
4. **Cooling and liquefaction**: The purified air is further cooled in a heat exchanger system known as the main heat exchanger. Here, the air is cooled using a counter-current heat exchange process with previously cooled and liquefied gases from the distillation process. As the air continues to cool, it reaches cryogenic temperatures, typically around -190 to -200 degrees Celsius (-310 to -330 degrees Fahrenheit). At these temperatures, the components of the air begin to liquefy.
5. **Distillation column**: The cooled and liquefied air is fed into a distillation column, also known as a rectification column or fractionation column. The distillation column is a tall vertical tower that facilitates the separation of the liquefied air into its main components according to their boiling points. The column contains a series of trays or packing materials that allow efficient contact between rising vapours and falling liquids.
6. **Fractionation**: Inside the distillation column, the lower boiling point component, mainly nitrogen, vaporises at the bottom of the column, while the higher boiling point

component, mainly oxygen and argon, remains in liquid form and accumulates at the bottom. The vapours rise through the column, while the liquids flow downwards.

7. **Product collection**: At various heights in the distillation column, the separated gases are removed as products. Nitrogen, which has the lowest boiling point, is usually collected from the top of the column. Oxygen is usually collected from the middle section, while argon, which has the highest boiling point, is collected from the bottom.
8. **Expansion and reheating**: The collected gases undergo expansion through a butterfly valve or expansion turbine, which further reduces their temperature. The expanded gases are partially reheated by passing them through the main heat exchanger, where they exchange heat with the incoming supply air and pre-cool it.

The process diagram in the ASU is shown in **Figure 2.6.1.1.2.1.a** below.

Figure 2.6.1.1.2.1.a
ASU process diagram based on SIAD technology



2.6.1.2.2
Main USA Components

The USA will have the following components:

- **Air inlet blowers** shall operate for an uninterrupted period of time, without requiring shutdowns for maintenance or inspection;
- **Air inlet filters**, shall be of adequate mesh size to remove particulates depending on site conditions, air quality, etc., and to facilitate routine maintenance, cleaning and replacement;
- **Direct contact cooler**;
- **Molecular sieve dryers**;
- **Pumps**;
- **Heat exchangers**;
- **Distillation columns**, which may be packed or tray type or a mixture of both types that meet the performance requirements of the process;
- **Compressors / expanders** (in case of failure of the primary compressor, 2x100% redundancy will be available);
- **Nitrogen receptors**.

2.6.1.2.3
Product Gas Storage

If there is a need for product gas storage, the gaseous and liquid oxygen produced from the distillation column is sent for storage together with the O_2 produced in the H_2 production unit.

Coolers shall be installed upstream of the product storage tanks for oxygen, argon and liquid N_2 process streams. Cooling shall be provided from a refrigerant package, which may be liquid N_2 from the USA, through a Plate Heat Exchanger specified in accordance with ISO 15547-2:2005.

2.6.1.2.4
Technical Specifications of the N_2 for the NH Synthesis Unit$_3$

The N_2 shall be supplied to the ammonia synthesis unit at the pressure and temperature indicated in **Table 2.6.1.2.4.a. The** characteristics of the N_2 for supply to the Ammonia Synthesis Unit shall be in accordance with those indicated in **Table 2.6.1.2.4.b**.

Table 2.6.1.2.4.a
N conditions$_2$ for feeding the Plant to NH$_3$

	Unit	Min.	Normal	Max.
Pressure	barg	15.0	15.0	17.0
Temperature	°C	35	40	45

Table 2.6.1.2.4.b
Composition of the N_2 for feeding the NH Plant$_3$

Parameter	Value
N_2	99.99%
O_2	5 ppm mol (max)

Parameter	Value
Ar	30 ppm mol (max)

2.6.1.2.5
Technical Specifications of the Utility
N_2

Utility nitrogen shall be produced in the USA for purging of the equipment. It shall comply with the technical specifications of **Table 2.6.1.2.5.a**.

Table 2.6.1.2.5.a
Conditions of N_2 Useful for the Plant

	Unit	Min.	Max.
Pressure	barg	6	25
Temperature	°C	Environment	Environment

2.6.1.2.6
Instrument Air Technical Specification

The USA will produce air for the entire Plant complex. Instrument air is required to meet certain quality criteria for supply to the NH synthesis unit$_3$ and also to other units in the industry. The technical specifications are:

Table 2.6.1.2.6.a
Air Conditions for Instruments

	Unit	Min.	Normal	Max.
Pressure	barg	5.0	6.5	9.0
Temperature	°C	-	Environment	75

The instrument air composition meets the same characteristics as those given in **Table 2.6.1.1.2.4.b** of **Section 2.6.1.2.4**.

2.6.1.2.7
Plant Air Technical Specification

The USA will continuously produce clean and filtered air for the entire Plant, in addition to the NH synthesis unit$_3$, for the correct functioning and safe operation of all instruments. The technical specifications foreseen for the air for the Plant are:

Table 2.6.1.2.7.a
Air Conditions for Instruments

	Unit	Min.	Normal	Max.
Pressure	barg	5.0	6.5	9.0
Temperature	°C	*	*	*

*To be confirmed by the technology provider.

2.6.1.2.8
Specifications for Other USA Products (Oxygen)

As mentioned above, other gases resulting from the separation of nitrogen from the captured atmospheric air will be taken as products of the USA. Some of them, as in the case of oxygen and argon, have a market value and must meet certain characteristics in order to be sold.

Initially, it is envisaged that both will be returned to the atmosphere like all other gases that are not used at the Plant. However, the possibility of storing the oxygen for commercial purposes or at the Plant itself is being considered in the future. The specifications for this product shall comply with the following.

Table 2.6.1.2.2.8.a
Oxygen Technical Specifications

Parameter	Value
Oxygen, % by weight	≥ 99.5%
Water (H_2 O), % by weight	≤ 0,05%
Total hydrocarbons, bpwp%*	≤ 100

* Parts per million by weight.

2.6.1.3
Ammonia Synthesis Unit

The third step of the ProjectProject is the ammonia synthesis unit. The main features of the Plant are:

- Maximum production capacity: 10,165 kg/h.
- Storage capacity (Buffer Tank): 976 tonnes, buffer output for 4 days of production. The buffer is cryogenic. The capacity is defined to allow the downstream process to continue to operate during the interruption of the NH synthesis unit$_3$ for maintenance work.
- Type of storage: atmospheric-cryogenic.
- Instrumentation and controls: The design includes a control valve connected to the flare system with a signal from the pressure transmitter. In addition, there will be at least two vent lines led to the flare system. The instrumentation of the NH tank$_3$ will consist of 2 level transmitters used to monitor the ammonia level and control the fill line valve and pumps, 1 local level indicator, 1 pressure transmitter and 1 temperature transmitter with alarm for high and low measurements in the tank. To implement this control, the level of the NH3 storage tank will be transmitted from the central control room to the control system of the NH3 synthesis unit. This level will be continuously calculated in the central room taking into account level transmitters with relative pressure sensors.

The technical specifications of the NH Synthesis Unit$_3$ are given in **Table 2.6.1.3.a** below.

Table 2.6.1.3.a
Technical parameters of the NH Plant$_3$

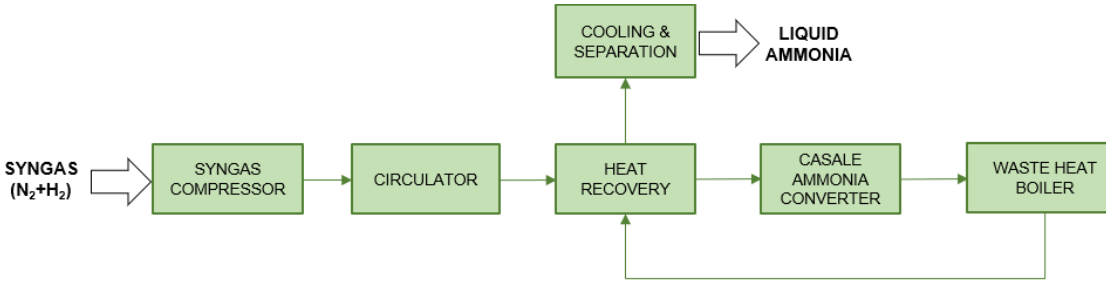
Parameter	Value
Network frequency	50 Hz, three-phase
Mains voltage	220 kV
Nominal capacity of the NH Plant $_3$	243.96 MTD
Reduction ratio	50%
Design availability	96%
NH supply temperature$_3$	-32ºC
NH supply pressure$_3$	10 bar
NH supply status$_3$	liquid
Purity level	≥ 99.5% by weight
Design life	25 years

2.6.1.3.1
Technology and processes at the NH Synthesis Unit$_3$

The technology to be used is that of a Haber-Bosch reactor licensed from **Casale**. The Haber-Bosch process is a well-established nitrogen-fixing process that has been used to produce ammonia on an industrial scale since the early 20th century. The process is traditionally steam-driven, but this Plant will adopt an electrical alteration of the process to allow cold start-up of grid electricity.

Hydrogen and nitrogen enter the ammonia synthesis unit from the electrolysis unit and the air separation unit, respectively. The two gas streams are compressed through multi-stage compression at **200 bar**. The compressed stream is mixed with a reactor recycle stream containing N_2 and unreacted H_2 . This stream is preheated in the feed heat exchanger using the output stream of the Haber-Bosch reactor. During start-up, an electric heater can be used to heat this stream. This mixed stream then enters the Haber-Bosch reactor for ammonia synthesis using excess nitrogen in a ratio N_2 :H_2 of 1:2. The reaction is carried out **at 200 bar and 400 °C using the** AmoMax© **catalyst**, a new wustite-based catalyst for ammonia synthesis, developed by Casale.

Figure 2.6.1.1.3.1.a
NH synthesis block diagram$_3$ based on Casale technology



A stream of produced NH_3 and unreacted H_2 and N_2 leaves the Haber-Bosch reactor and is cooled in the reactor feed heat exchanger and in the secondary cooler. The cooled stream then enters a condenser where the ammonia product (NH_3) is condensed, separated, and directed to atmospheric storage at **-33°C**. Unreacted gaseous H_2 and N_2 leave the condenser and are recycled back to mix with the incoming feed stream of H_2 and N_2 .

A purge stream is provided for flaring to prevent unreacted trace build-up within the system. A vapour recovery package is provided in this purge stream to extract unreacted hydrogen and recycled ammonia as a valuable reactant and product.

2.6.1.3.2
Main Components of the NH Synthesis Unit$_3$

The overall system is composed of main equipment consisting of:

- **Mixing station H -N$_{22}$** , where the flow is controlled by a regulator to ensure a 3:1 hydrogen:nitrogen mixture;
- **Synthesis gas compressors H_2 - N_2 ;**
- **NH synthesis system$_3$** , with:
  - Reactor package, the reactor shall be of the radial flow type with catalyst
  - Synthesis circuit package, will have a condenser to condense and separate the NH_3 from the HB reactor output stream for storage. The cooler supply will come from the refrigeration unit (via an indirect cooling circuit); however, alternatives (e.g. liquid N_2 from the USA) will be considered.
  - Emergency scrubber
  - Interconnecting piping
  - Pipe supports
  - Recycling compressor
- **Dedicated auxiliaries of the NH synthesis circuit$_3$ and interfaces with the common balance of Plant**;
- **Connection to the NH flare$_3$ of the Plant**.

In addition to the main flare, the Plant will have a secondary NH flare$_3$.

2.6.1.3.3
Storage of NH_3

The ammonia shall be stored under atmospheric conditions at cryogenic temperature (typically -33 °C). The exhaust gases shall be cooled by a local refrigeration circuit, condensed and returned to the storage tank.

Ammonia storage will be sufficient for one month of production. Higher pressure storage options will be explored.

Where airborne concentrations of ammonia greater than 16% by volume are likely to be encountered, electrical equipment and wiring shall be specified for use in hazardous areas.

Storage options are assessed in **Section 3.2.4.** For the design, refrigerated storage at atmospheric pressure is considered as the basis. The storage shall be sufficient for at least 30 days. The ammonia storage vessel shall be of the double-walled integrity type.

The product (storage) ammonia specification shall have the following characteristics (**Table 2.6.1.3.3.a**).

Table 2.6.1.3.3.a
Ammonia product according to storage specifications

	Storage option		
Parameter	**Atmospheric**	**Intermediate**	**Pressurised**
Ammonia storage capacity	1 month		
Pressure, barg	0 (Atmospheric)	4-5	< 16 (< 45)
Temperature, ºC	-33 ºC	0	<34 (< 75)
Specific gravity at 16 ºC	0.62	0.62	0.62
Ammonia, % by weight	99.5-99.8	99.5-99.8	99.5-99.8
Water (H_2 O), % by weight	0.2-0.5	0.2-0.5	0.2-0.5
Oil, ppm	<5	<5	<5

2.6.1.3.4
Technical Specifications of the NH_3 Produced

The technical specifications of the NH product$_3$ are given in **Table 2.6.1.3.4.a**.

Table 2.6.1.3.4.a
NH Product Specifications$_3$

Parameter	**Value**
Temperature	Around -33 ºC
Pressure	Atm
State	Liquid
NH_3	>99.5% wt (min)
H O_2	< 0.5% wt (max)
Oil	<5 ppm

2.6.1.4
Nitric Acid Plant (NA)

The fourth step is the nitric acid (NA) production plant. Approximately 51% of the ammonia produced in the previous process is converted into NA, while the rest is fed directly to the ANS plant.

This Plant includes an auxiliary biodiesel boiler for start-up, which will generate the steam necessary to ensure that the Plant reaches the required working pressure and temperature.

The main characteristics of the Plant are:

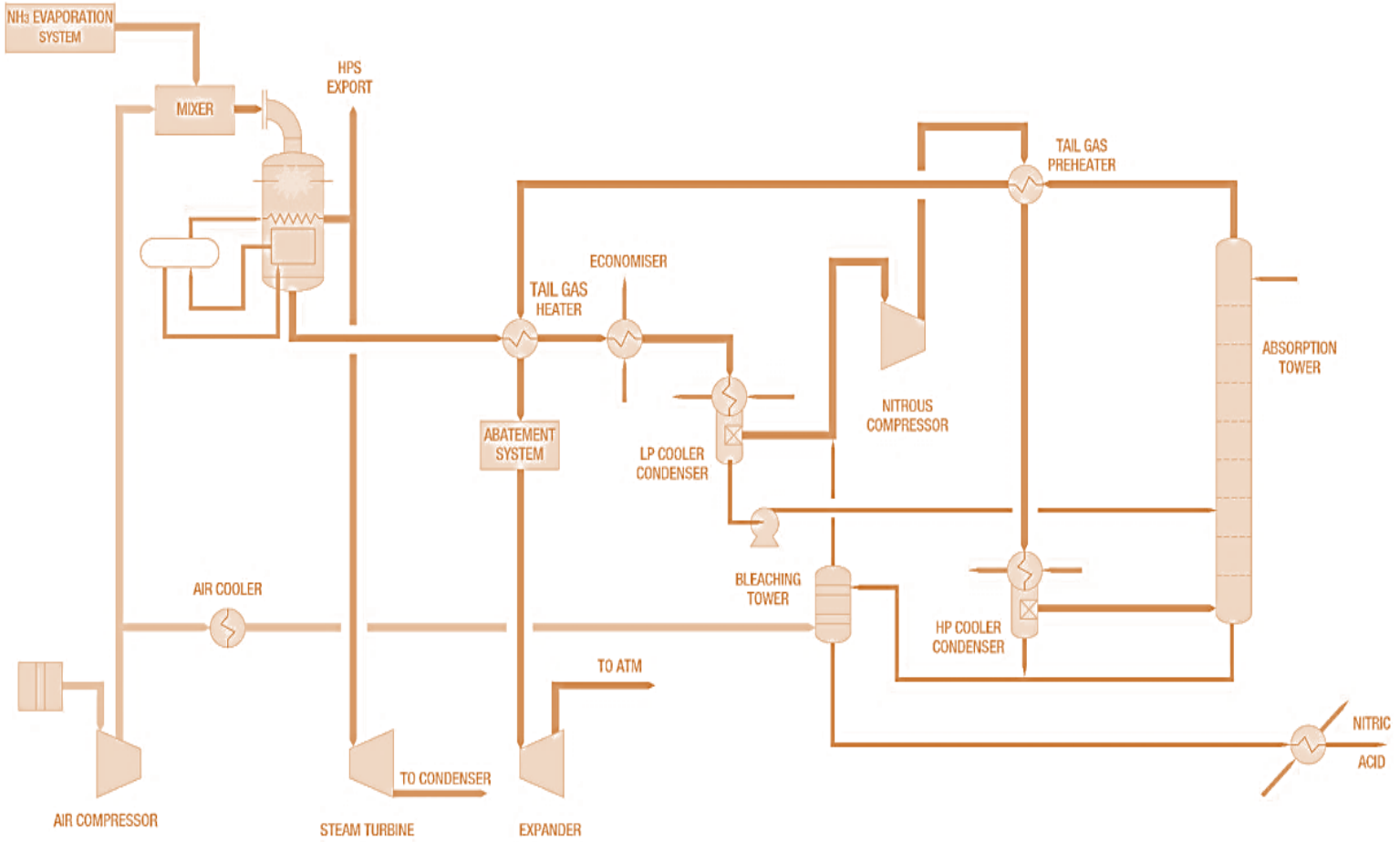
- Maximum production capacity: 18,333 kg/h.
- Storage capacity (Buffer Tank): 2,900 tonnes, output buffer for 4 days of production. The buffer contains liquid AN at a concentration of 62%.
- Type of storage: atmospheric.
- Instrumentation and controls. The following will be available:
    - 2 vent lines operated with a safety valve and led to the flare system, another vent line connected to the flare system and a vent line from the upper chimney with flame arrester.
    - 1 drain line fitted with double insulated gate valves.
    - 1 vent stack on top of the storage tank.

It is envisaged that the storage tank instrumentation will consist of level transmitters, used to monitor the nitric acid level and control the filling line valve and pumps, local level indicators, a pressure transmitter and a temperature transmitter with alarm for high and low tank measurements. To implement this control, the storage tank level will be transmitted from the central control room to the AN synthesis plant control system. This level will be continuously calculated in the central room taking into account the level transmitters.

2.6.1.4.1
Technology and Processes in the AN Plant

The nominated technology is the **Casale** double pressure nitric acid process (see process diagram in **Figure 2.6.1.4.1.a**).

Figure 2.6.1.1.4.1.a
Diagram of nitric acid process based on Casale technology



This Plant produces nitric acid (HNO_3) from ammonia (NH_3), in the following steps:

1. **Ammonia oxidation**: In this step, purified ammonia gas is mixed with air and passed through a catalytic burner. The burner operates at high temperatures, around 850-950 °C. The ammonia reacts with oxygen (O_2) from the air in the presence of a platinum-rhodium alloy-based catalyst to produce nitrogen monoxide gas (NO) and water vapour (H_2 O).

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H\ O_2$$

2. **Conversion to nitrogen dioxide**: The nitrogen monoxide gas produced in the previous step is further oxidised by air in a separate reactor to form nitrogen dioxide gas (NO_2). This reaction is exothermic and usually occurs in the presence of a catalyst, such as vanadium pentoxide (V O).$_{25}$

$$2NO + O_2 \rightarrow 2NO_2$$

3. **Absorption and nitric acid formation**: Nitrogen dioxide gas is dissolved in water to form nitric acid. The absorption process takes place in an absorption tower, where the gas bubbles through a tower filled with water or a weak solution of nitric acid. The nitrogen dioxide reacts with water to form nitric acid and nitrogen monoxide, which is recycled back to the oxidation stage.

$$3NO_2 + H_2\ O \rightarrow 2HNO_3 + NO$$

4. **Concentration**: The dilute nitric acid produced in the absorption tower is with an output concentration of 60%. These processes involve heating the nitric acid solution to remove water and increase the nitric acid concentration.
5. **Purification**: The concentrated nitric acid undergoes additional purification steps to remove impurities such as nitrogen oxides, metals and organic compounds. The main purification step occurs in the reduction tower.
6. **Storage**: Once the nitric acid has been produced and purified, it is stored in a suitable atmospheric tank in a liquid state at a concentration of 60%.

2.6.1.4.2
Main Components of the AN Plant

The AN Plant will have the following components:

- **Ammonia evaporator I and II:** are heat exchangers used in the Nitric Acid Production Plant with the main function of vaporising liquid ammonia using cooling water.
- **Tail gas final heater:** its main function is to heat the tail gas using nitrous gas obtained from the catalytic combustion reactor. The purpose of the heating process is to increase the temperature of the tail gas in order to expand it inside the turbosets and generate electricity.
- **Economiser:** the function of the economiser is to cool the low pressure nitrous gas and heat the boiler feed water.
- **Low pressure reaction water condenser (BP):** has the function of cooling and condensing the reaction water generated in the process. By condensing the vapour, the reaction water is recovered and converted into liquid, which can be reused in the process or treated appropriately according to the needs of the Plant. This helps to conserve water and ensure the efficiency of the AN production process.
- **High pressure reaction water condenser (AP):** is a heat exchanger used in the AN plant. Its function is to cool and condense the high-pressure nitrous gas using cooling water.

- **Absorption tower:** performs the absorption of nitrous gas in a stream of liquid nitric acid.
- **Bleaching tower:** the raw nitric acid, which contains impurities such as NOx and other undesirable compounds, is subjected to a purification process in the tower to obtain a more concentrated and purified AN product.
- **Product acid cooler:** cools the AN produced in the chemical process prior to storage or further use. It uses a plate heat exchanger design where hot nitric acid and cooling water flow in separate channels, but in contact across the plates, transferring temperature allowing the product temperature to be cooled.
- **Steam condenser:** has the function of condensing the water vapour generated in the processes, transforming it back into liquid. This allows the latent heat of the vapour to be recovered and reused, saving energy and reducing vapour emissions to the atmosphere. It also helps to maintain the right pressure and temperature conditions, ensuring the efficient and safe operation of the nitric acid production system.
- **Start-up acid tank:** allows smooth start-up of plant operations, providing a temporary storage solution for the initial production of nitric acid.
- **Secondary air cooler:** cools the compressed air consumed by the bleaching tower to assist in the purification process of the raw nitric acid.
- **N_2 O and NOx reduction reactor:** reduces emissions of these harmful gases by minimising their release.

2.6.1.5
Ammonium Nitrate Solution Plant (ANS)

The fifth step in the production process is the production of ammonium nitrate (NH_4 NO). $_3$

In the SNA plant, nitric acid reacts with ammonia in a reactor, leading to the formation of ammonium nitrate. The heat generated in this reaction is used to concentrate the ammonium nitrate, resulting in the production of steam. This vapour contains some ammonium nitrate and goes through a purification process via a *scrubber* and then through the scrubber exchanger.

After the steam cleaning process, two types of condensate are obtained: clean condensate and condensate with impurities, the latter is used in the absorption tower of the AN Plant.

The main features of the ANS Plant are:

- Maximum production capacity: 23,125 kg/h.
- Storage capacity (Buffer Tank): 1,160 tonnes, buffer output for 2 days of production. The buffer contains liquid SNA at a concentration of 95%.
- Type of storage: atmospheric.
- Instrumentation and controls. It will include:
    - 2 vent lines operated with a safety valve and connected to the flare system, another vent line connected to the flare system and a vent line from the upper chimney with flame arrester.
    - 1 drain line with double insulated gate valves.
    - 1 vent stack on top of the storage tank.

In addition to the controls already mentioned for the AN Plant that also work for the ANS Plant, a steam heating system is included to maintain the temperature of the liquid ANS at 150°C, which is the temperature required in the GRAN Plant.

2.6.1.5.1
Technology and Processes in the ANS Plant

The nominated technology is a **Casale-licensed** pipeline reactor (see process diagram in **Figure 2.6.1.5.1.a**).

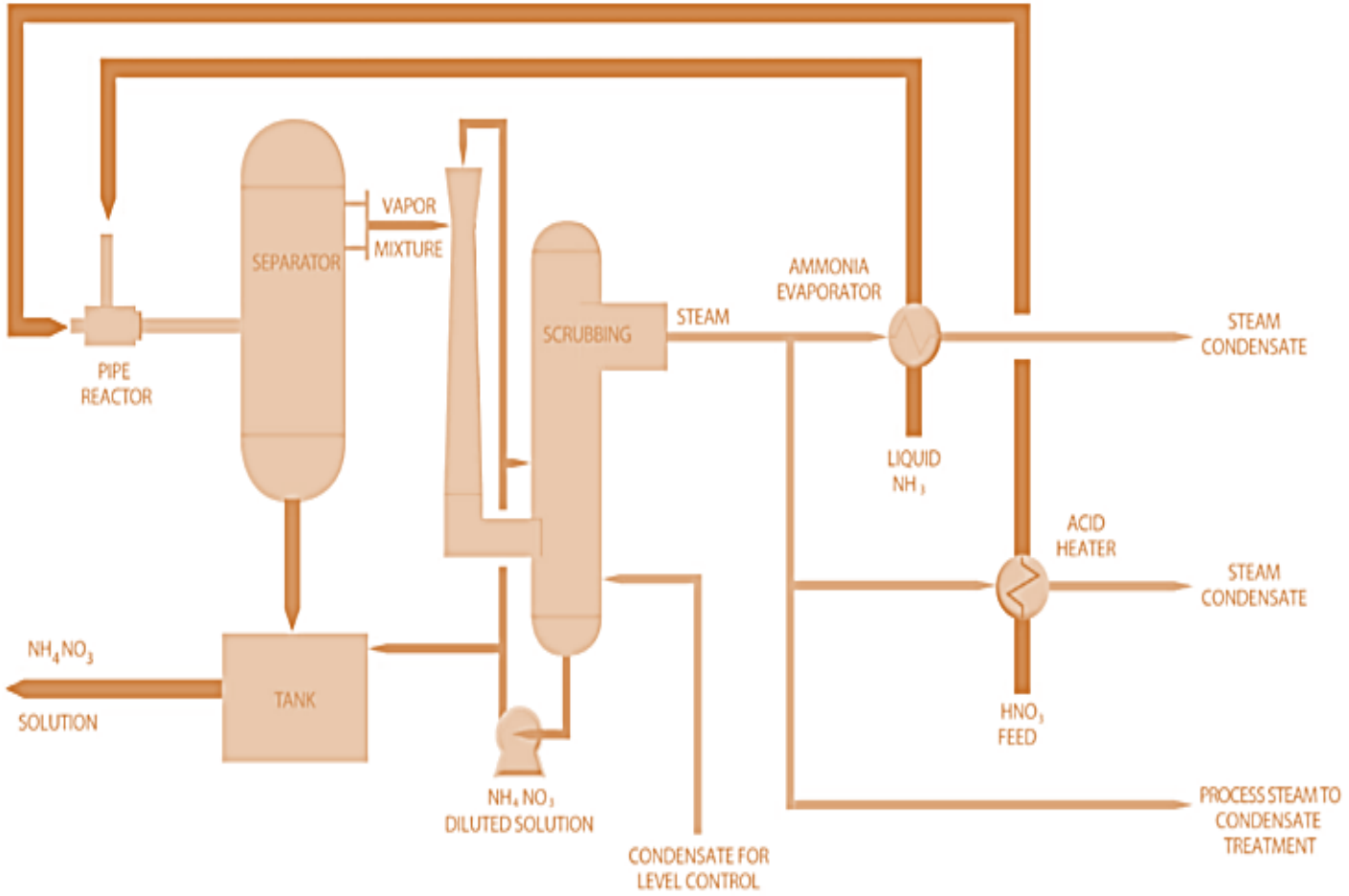
This Plant produces an ammonium nitrate solution ($NH_4\ NO_3$) from nitric acid (HNO_3) and ammonia (NH_3), in the following steps:

1. **Ammonia evaporation**: using the low pressure steam produced in the nitric acid plant.
2. **AN synthesis**: In this step, nitric acid and ammonia are combined to initiate a neutralisation reaction. Nitric acid is added to an ammonia solution in controlled amounts to achieve the desired pH level. The reaction results in the formation of ammonium nitrate and water.

$$HNO_3 + NH_3 \rightarrow NH_4\ NO_3$$

3. **Gas separation and *scrubbing*:** The gases are separated and circulated to a scrubber section, the total liquid obtained is sent to the atmospheric SNA storage tanks, in a liquid state at a concentration of 95%.

Figure 2.6.1.5.1.a
Ammonium nitrate solution process diagram based on Casale technology



2.6.1.5.2
Main Components of the SNA Plant

- **Separator:** contains the tubular reactor where the synthesis takes place. The heat generated by the reaction is used to concentrate the SNA and generate steam for the process. The excess pressure is released to the separator, which operates with a slight overpressure of 0.10-0.2 barg. The liquid ammonia obtained is vaporised and superheated in the ammonia evaporator and then fed into the tubular reactor. The flow rate of nitric acid entering the tubular reactor is regulated by a ratio control system based on the flow rate of ammonia supplied to the reactor.
- ***Scrubbing*:** scrubs the vapour generated by the reaction in the Venturi scrubber which is supplied with an acidic scrubbing solution through a spray nozzle. It then passes to the cyclone column where an additional amount of scrubbing solution is sprayed.
- **Steam condenser:** condenses the steam inside the SNA tank.
- **Heat exchanger:** cools a circulating flow of ANS to reach the desired temperature of the substance.
- **ANS tank:** stores the ammonium nitrate solution produced.

2.6.1.6
Granulation Plant (GRAN)

The Granulation Plant (GRAN) is the last stage of the plant. The aim of this plant is to convert the ANS into a granulated nitrate-based fertiliser: CAN 27%wtN.

The GRAN Plant can operate at a turndown ratio of between 70% and 100% of normal capacity under design conditions. The GRAN Plant is designed to operate for no less than 7,260 hours per year (equivalent to 330 days), 22 hours per day.

The GRAN Plant will have the following main characteristics:

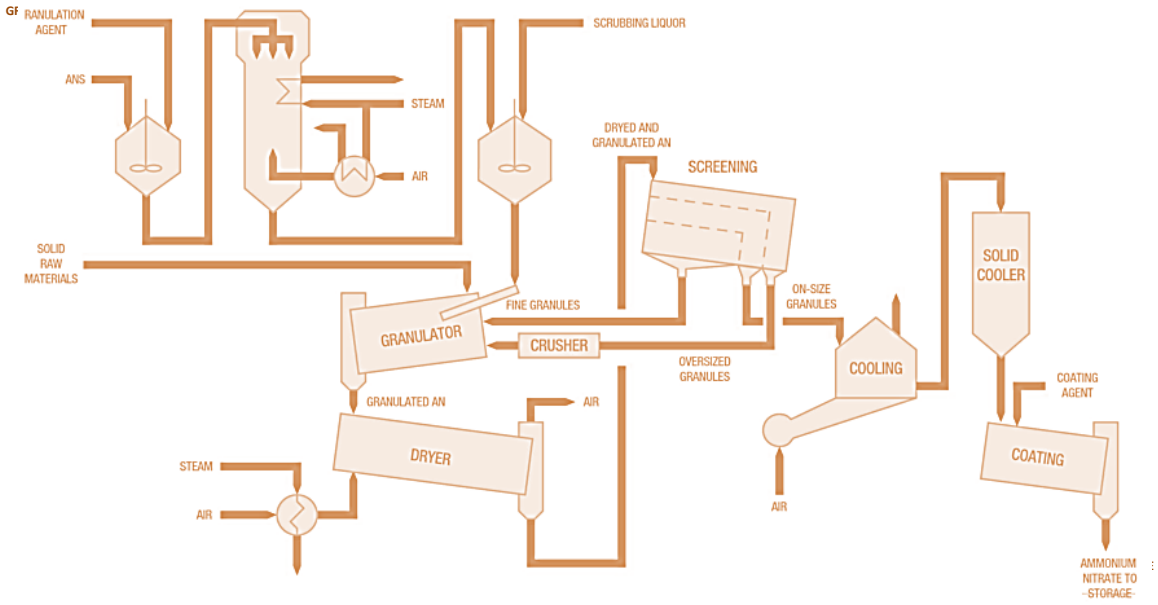
- Maximum production capacity: 31,958.33 kg/h.
- Storage capacity: 205 tonnes, equivalent to 6 hours of production.
- Type of storage: storage behind the BIG plant for CAN will consist of packages ranging from standard 50 kg bags to intermediate "Big Bags" with capacities typically up to 1 tonne. Groups of bags may be palletised for stacking by forklift or other suitable means.

The pelletisation building shall be sealed and equipped with a dust collection system to ensure that no particulate pollutants are released into the atmosphere or cause unhealthy working conditions.

2.6.1.6.1
Technology and Processes in the Granulation Plant

The nominated technology is licensed from **Casale** (see process diagram in **Figure 2.6.1.6.1.a**).

Figure 2.6.1.1.6.1.a
Diagram of the granulation process based on Casale technology.



CAN is produced by transforming a mixture of upstream liquid ANS, vapour condensate, coating agent and solid feedstock (crushed dolomite) into solid granules. Once the ammonium nitrate solution reaches the desired concentration of components, it is dried and granulated to produce solid ammonium nitrate granules. The drying process involves removing the remaining moisture from the concentrated solution. The granulation process involves shaping the dried product into small, uniformly sized particles to improve handling, storage and application characteristics.
Steps in the process:

1. **Ammonium nitrate solution preparation**: SNA preparation (in weight %) is controlled in a falling film evaporator (Casale patented technology), in three stages with:
    a. Dissolution of the granulation agent.
    b. No solid content in the AN film evaporator.
    c. Optimal control of final pH (minimised NH_3 loss).
2. **Addition of raw material**: The ammonium nitrate solution is mixed with raw materials (mainly dolomite, which is previously crushed), adding also solids and liquid recyclates from the granulation process, controlling the liquid/solid ratio. The plant is versatile and is able to operate with alternative calcium-rich raw materials.
3. **Granulation: it is** carried out in a rotating empty drum with:
    a. Air flow for water removal and temperature control.
    b. Easy control of the energy balance.
    c. Solid mixture ensured by internal movements.
4. **Drying**: Once the pellets are formed, they are dried in a second rotating drum using low pressure steam generated in the Nitric Acid plant. The dryer includes an automatic cleaning system, an internal lump crusher and Casale's patented design for internal risers for optimised heat and water exchange.
5. **Size control**: The size of the ammonium nitrate granules is controlled by a sieving stage, in which the ammonium nitrate granules are sieved:
    a. The fine granulates are returned to the granulator.

   b. Oversize pellets are crushed and returned to the pelletiser.
   c. The sized pellets are delivered to the next stage.
6. **Cooling**: The fertiliser granules are cooled in two stages to ensure a temperature below 45ºC.
   a. Fluidised bed cooler.
   b. Solid cooling column.
7. **Coating**: A coating agent is added to improve the mechanical characteristics of the granules, such as durability, moisture absorption or slow release properties.

2.6.1.6.2
Major Components of the BIG Plant

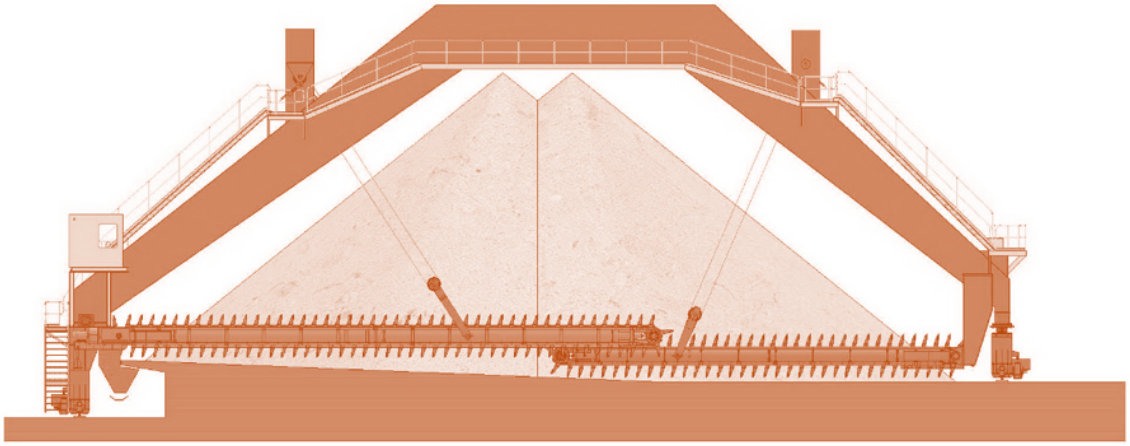
- Granulator: designed for the production unit to operate at optimum granulation quality.
- Dryer: designed to achieve the required moisture content of the product.
- Fluidised bed cooler: designed to achieve the required temperature for the
- Product.
- Cyclones: designed to achieve the lowest possible dust content in the exhaust air. It considers parameters such as air flow rate, dust particle size, amount of recovered dust (dust outlet diameter).
- Flushing system: designed in order to reach the dust and ammonia content at the chimney outlet.

2.6.1.6.3
CAN storage

CAN is a fully stabilised and non-explosive product. The storage system will ensure the superior quality of the product by controlling the humidity and stable temperature of the product.

1. **Long-term storage**: The final product is stored in piles (see **Figure 2.6.1.6.3.a**) in a longitudinal bulk silo for **a production capacity of 50 days**, equipped with a material gantry reclaimer and a conveyor belt system with bypass possibility. The maximum pile dimensions are 180 m long, 10.5 m high and 50.8 m wide, with a fall angle of 22°.

Figure 2.6.1.6.3.a
Typical cross-section of the proposed reclaimer and bulk material pile



2. **Export of bulk granulates**: The stored bulk fertiliser will be exported in bulk or in big bags. For bulk export, the plant includes an export terminal with 3 zones.
3. **Packaging**: If granulate is exported, then CAN moves from the bulk silo to a packaging stage, with a **6h capacity** feed buffer and redundancy (3x50% lines), capable of preparing 500, 1,000 and 1,500 kg big bags on pallets, before storing the final packaged product.
4. **Short-term storage, packaging**: A warehouse is provided with a **10-day production** capacity, in stacked big bags and equipped with forklift placement area, space for **24 sets of 300-tonne bags on 3 levels**, space for export preparation and logistics and a warehouse office.
5. **Export of packaged fertilisers**: Short-term storage is provided in a logistics area with the capacity to export to 8 trucks simultaneously at 8 terminals.

Figure 2.6.1.6.3.b shows the project area where the produced CAN will be stored.

Figure 2.6.1.6.3.b
Villeta project storage area



2.6.1.7
Flare System

There are two destination vents in the plant, to atmosphere or to the flare system. All continuous and discontinuous discharges from process stacks and/or safety valves containing hazardous or flammable gases are directed to the flare head and discharged to the atmosphere through the flare tip.

The vents from the hydrogen, oxygen, argon, nitrogen, air and water services shall be sent to the atmosphere at a safe height. On the other hand, vents from ammonia synthesis, ammonia storage and ANS, NA or GRAN plants, if necessary, shall be sent to the flare system.

Safety vents shall occur only under abnormal operating conditions and are uncontrolled vents. Controlled vents shall occur during start-up or maintenance operations, taking into account the following safety conditions:

- Venting, inerting, purging of pipe sections and equipment involving limited and locally controlled reliefs.
- Purge isolation arrangements, e.g., double block and bleed arrangements that are performed in situ to check the tightness of the isolation system.

The flare system shall be continuously available to provide a safe path for system depressurisation in the event of an emergency (e.g. a site-wide power failure) or transient process conditions.

The flare and flare pilot shall be suitable for ammonia and hydrogen gas combustion. The design considers API STD 537, ASME STS-1 (stack) and ASME BPVC VIII (pressure design).

The system shall function within its design limits under all Plant emergency operating conditions. The equipment shall consist of:

- A discharge drum for handling and storage of condensed liquids from the discharge gases;
- A torch drum;
- A vaporiser;
- A torch chimney and;
- A pilot gas supply.

The pilot gas will normally be supplied from the hydrogen buffer tank; however, it will include a propane reserve for the start-up of the Plant and in case of interruption of the flow from the hydrogen buffer tank.

A purge stream is supplied to the flare to prevent the accumulation of trace unreacted reactants in the system. A vapour recovery system will be installed in this purge stream to extract unreacted hydrogen and recycled ammonia as valuable reagent and product. The system will comply with the limits set by Paraguayan environmental legislation and international standards related to fume burnability, opacity, ground level pollutant concentration and noise.

2.6.2
Ancillary installations

2.6.2.1
Raw Water Collection System

2.6.2.1.1
Water Requirements

All the water consumed by the plant will be obtained from the Paraguay River. The only alternative being considered is the use of a deep tubular well to supply a secondary tank for fire fighting, in order to comply with related legislation, although this is still under evaluation.

The estimated water intake from the river is 242.70 m^3 /h, returning approximately 77.30 m^3 /h to the river, with peak values of 84.20 m^3 /h, with an extraction balance of 165.4 m^3 /h (0.05 m^3 /s) or 158.5 m^3 /h (0.04 m^3 /s), respectively (**Figure 2.6.2.1.1.a**).

If the flow of 600 m^3 /s associated with the most severe drought level of the river is considered, the flow to be extracted for production represents only 0.008% (flow of 0.05 m^3 /s) and 0.007% (flow of 0.04 m^3 /s), respectively. In terms of average flow, the Paraguay river has a flow of approximately 2,700 m^3 /s, so the net extraction of ATOME is 0.002% (flow of 0.05 m^3 /s) and 0.001% (flow of 0.04 m^3 /s) of the river flow.
The main functions of the Raw Water Treatment Plant will be to produce pre-treated water for the production of:

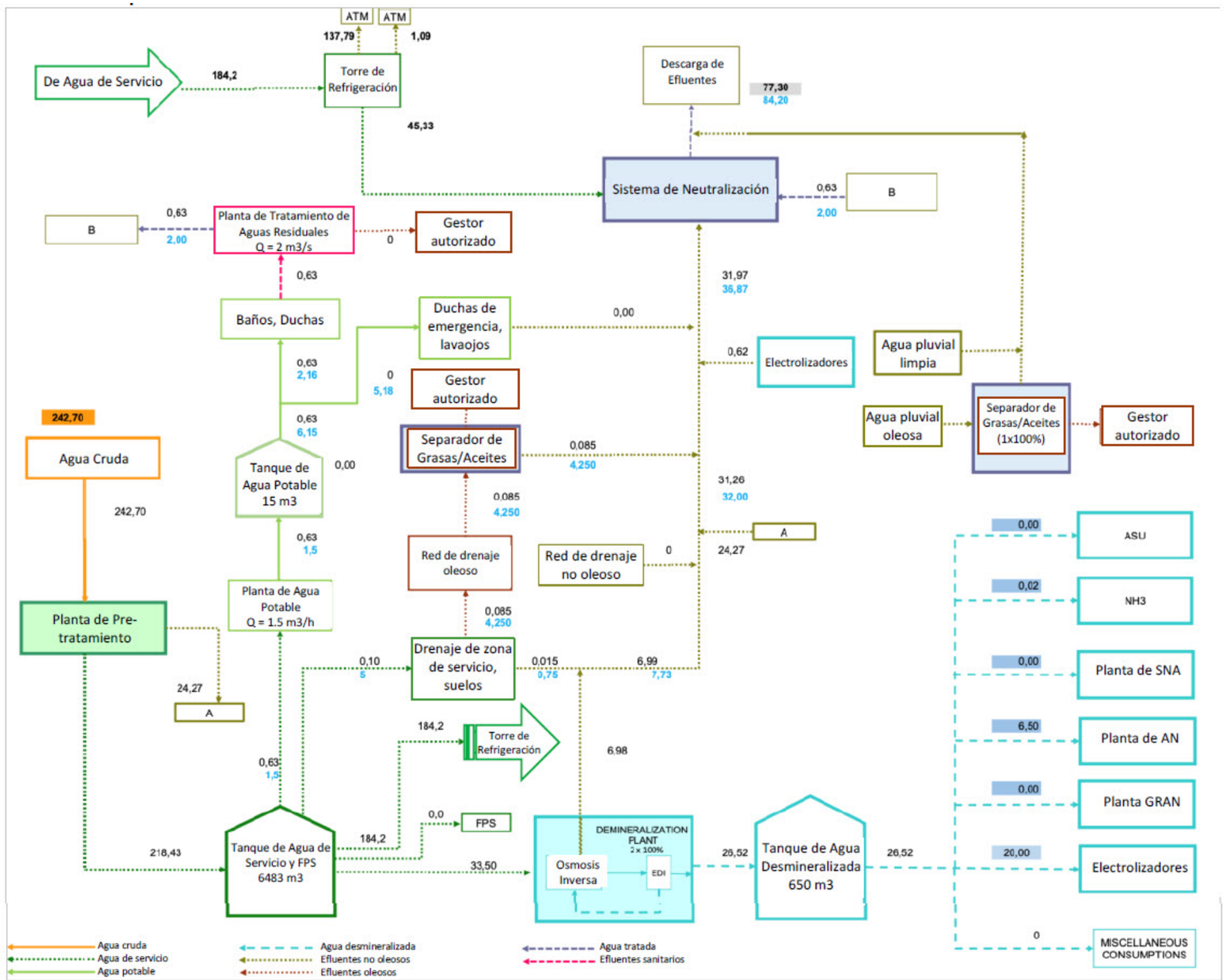
- **Drinking water, in order** to provide drinking quality water for services that require drinking water, such as toilets, cooking, etc. For human consumption, drinking water will be purchased in jerry cans.

- **Demineralised water, in order** to supply water to the electrolysers and other consumers such as the NH3 Synthesis Unit, AN Plant, SNA Plant, GRAN Plant, replenishment for other services such as chemical dilution, etc.
- **Service water.**
- **Water for fire fighting.**
- **Water for cooling tower replenishment.**

Estimated treated water flow will be:

- Pre-treatment = 218.43 m /h.^{3}
- Potabilisation = 0.63 m /h.^{3}
- Demineralisation = 26.52 m.

Figure 2.6.2.1.1.a
Plant Water Footprint



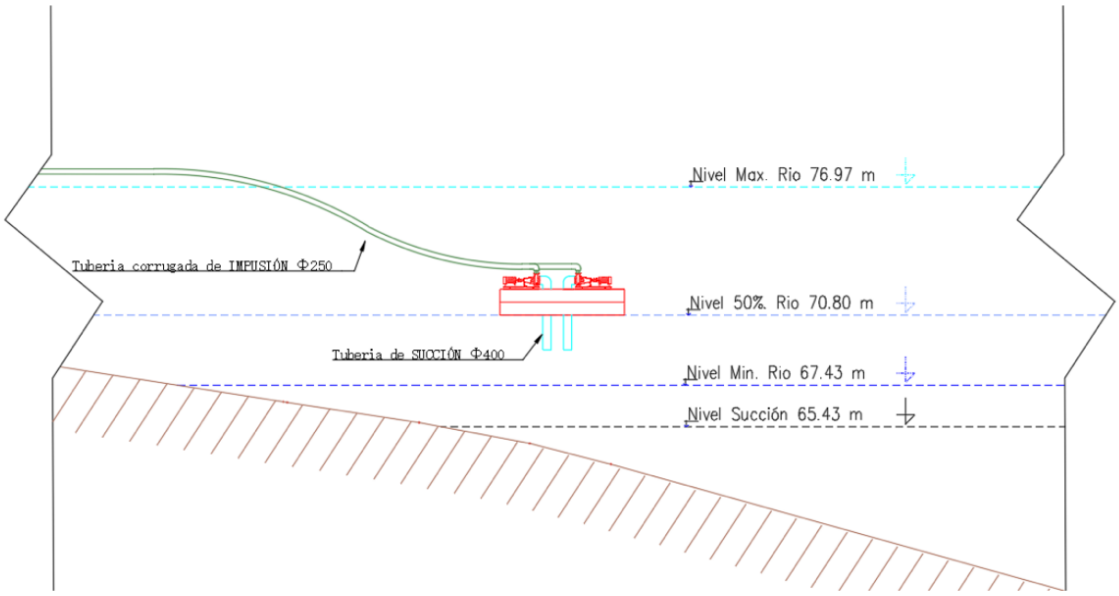
Note: Peak values in blue. Expected values in normal operation in black.

2.6.2.1.2
Raw Water Intake and Supply

As mentioned, raw water will be supplied from the Paraguay River. In addition, the use of the existing deep tubular well on the site for secondary supply of the fire fighting system is under evaluation. This well is supplied from the Quaternary aquifer. The availability according to the studies of the well and the availability of the Paraguay River for water supply to the Project are shown in **Section 3.2.7**.

Water will be collected from the river by means of a floating pumping station. A 30 HP pump (plus a reserve), with a suction pipe of 400 mm is estimated. **Figure 2.6.2.2.1.2.a** shows an example of the infrastructure.

Figure 2.6.2.2.1.2.a
Floating pumping station with horizontal centrifugal pumps



In order to comply with international good practice, the velocity on the approach to the inlet section of the pumping station (where the fish, sediment, gravel or debris screens are located) shall be no greater than 0.15 m/s. For this case, although the suction pipe has a section of 400 mm and the velocity immediately at that point will be 1.47 m/s for the extracted flow, the velocity in the vicinity of the grilles will be much lower, considering that the section of the water intake pipe from the river will be higher.

For its part, the buried rising main that will transport the water to the industry will be approximately 2.3 km long and 250 mm in diameter. The water collection point located at UTM coordinates 426.750 m E and 7,156.596 m S 21J, is shown in **Figure 2.6.2.2.1.2.b**.

Figure 2.6.2.2.1.2.b
Water catchment point



Some design considerations are based on international best practice for this type of structure, these are:

- Reduction of the maximum intake velocity to 0.15 m/s.
- Reduction of the intake flow to a flow sufficient to maintain other water uses (irrigation, fishing, etc.) as well as biodiversity considering the lower mean annual flow values of the river.
- Design technologies such as net barriers to prevent suction of aquatic species or operational measures such as flow reduction or seasonal shutdowns, among others.

Basic dimensioning of water intake, pump and delivery lines:

Pump shaft	
Pump shaft height	Variable
Suction	
Minimum river water level	67.43 m
Minimum permissible speed	0.5 m/s
Diameter at suction adopted	400 mm
Impulse	
Total rising main length	2,300 m
Arrival level of the impulsion to the plant	77 m
Pumping hours	24 hs
Pumping rate	0.07222 m /s^3
Adopted diameter in mm	250 mm
Speed	1.47 m/s
Pump sizing	

Static height	9.7 m
Manometric height	25.87 m
Pumping rate	260,000 l/h (0.072 m^3 /s)
Power adopted	30 HP

Aqueduct Easement Strip

The water and effluent pipelines will be installed in the same 5 metre wide and 2.3 km long easement strip, resulting in an affected area of 1.15 ha, it should be noted that the dimensions could be adjusted during the executive project phase. They will be buried and will run parallel from the plant to the point where water is collected and effluent is discharged into the Paraguay River. As the effluent will be treated in such a way as to fully comply with Paraguayan legislation and the requirements of the IFC's general environmental, health and safety guidelines, adopting the most restrictive values, the layout of the two pipelines was planned to reach the same point of the Paraguay river, with the intake closest to the shore and the effluent discharged further away.

Technical Data of the Deep Tubular Well at the Plant

- Type of well: Type A
- Borehole diameter and depth: 12.1/4": 0.00m - 96 m
- Diameter and depth of casing: 150 mm: 0.00m - 96 m
- Sanitary seal (cement, sand, crushed): 0.00 m - 25 m
- Pre-filter of selected gravel: 25 m - 96 m
- Piped with geo-mechanical PVC pipes DN 1500 mm, length 4 m.

Lithological description in the area of the borehole:

Depth (m)	Lithology
0-3	Organic, clayey, dark-coloured, organic soil
3-30	Yellowish-brown clay (without water supply)
30-42	Quartz sandstone, medium-grained and sub-rounded, with abundant hyaline quartz, no clay, whitish to yellowish colour (water-bearing)
42-48	Sandy clay, whitish to yellowish in colour
48-58	Quartz sandstone, medium-grained and sub-rounded, with abundant hyaline quartz, no clay, whitish to yellowish colour (water-bearing)
58-90	Fine-grained sandstone, with well-rounded castes, whitish to yellowish in colour, with clayey layers
90-96	Granite

2.6.2.2
Raw Water Treatment Plant

It is envisaged that the upstream pumping station will only include coarse filtration and no additional water treatment. The raw water will then be subjected to the treatment processes described below.

- **Pre-treatment:** consists of a physico-chemical treatment followed by an ultrafiltration process to treat the raw water and obtain an optimal water quality to be used as service water, to feed the demineralisation plant and to feed the drinking water treatment plant.
- **Drinking water treatment plant:** consists of activated carbon filtration to obtain optimum water quality for use as drinking water.
- **Demineralisation plant: consists** of a pre-treatment by cartridge filtration, two (2) demineralisation trains by back-up osmosis (RO) and a subsequent final polishing by electrodeionisation (EDI) together with cleaning systems (CIP) for washing the membranes and EDI.

2.6.2.2.2.1
Pretreatment System

The water from the Paraguay River will be pre-treated by means of an Ultrafiltration (UF) system in order to obtain a standard water quality to be used as service water and to feed the drinking water treatment plant and the demineralisation plant.

The ultrafiltration system provides for the use of chemicals, including coagulant, sodium hydroxide, sodium hypochlorite and hypochlorous acid (if necessary). The system will have a backwash tank.

To ensure the reduction of elements such as aluminium and iron and to remove most of the solids before they reach the UF system, a physico-chemical treatment is considered. This will optimise the UF process and reduce the frequency of backwashing. The system foresees the use of coagulant solution and polyelectrolytes as flocculant and dewatering agents and a sludge thickener will be provided.

The pre-treated water will be stored in the Service and Fire Fighting Water Storage Tank prior to further treatment. This tank will have a capacity of 6483 m^3 .

As shown in the Water Footprint of the Plant (**Figure 2.6.2.1.1.a** in **Section 2.6.2.1.1**), 242.70 m^3 /h will undergo pre-treatment, of which 218.43 m^3 /h will be destined for the intended uses (service water, fire fighting, potabilisation, and cooling) and 24.27 m^3 /h will be rejected. This water rejected in the pre-treatment will be sent to the Wastewater Treatment Plant (WWTP).

The pre-treatment system will depend on the quality of the raw water. A pretreatment efficiency of 90% is considered as a preliminary figure.

The effluent from the pre-treatment will be treated and concentrated in a sludge treatment plant.

2.6.2.2.2.2
Service Water Storage and Distribution System

The service and fire water tank will receive water at the outlet of the pre-treatment system. The purpose of the tank is to store sufficient water to always guarantee the minimum required by the fire-fighting system, plus a surplus of water to supply service water to the rest of the plant's consumers and to maintain the demand of the Raw Water Treatment Plant. A common storage

tank (fire fighting and service water storage) is considered to ensure that the water is always moving, thus preventing the growth of biological micro-organisms.

The control system shall ensure that the service water distribution pumps are stopped before all process water is consumed and the minimum fire water level is reached. It is considered physically impossible for other consumers to deplete the fire water reserve, given the location of the suction connections of the pumps (fire connections are always located below the service water connections).

2.6.2.2.2.3
Treatment System

Two main types of treatment will take place in the treatment system, which will be carried out in the units described below.

Potabilisation Unit

As previously mentioned, there is no drinking water service in the area, so the supply will be from service water (pre-treated water) subjected to potabilisation treatment.

For the sizing of the unit, 100 persons to be served and a consumption of 150 l/person/day have been considered.

The system shall be composed of:

- Two (2) 100% activated carbon filters, with all the equipment, instrumentation and control necessary for their correct operation.
- One (1) analyser rack for continuous analysis of free chlorine residual.
- One (1) sodium hypochlorite injection system, which can be shared with the proposed pre-treatment system, adding two (2) 100% capacity injection pumps for the Potabilisation Unit.

As shown in **Figure 2.6.2.1.1.a** in **Section 2.6.2.1.1**, 0.63 m^3 /h will be made potable and stored in a drinking water tank.

Demineralisation Unit

Water from the pre-treated service and fire protection water storage tank will be pumped to a Demineralisation Plant (DP) to obtain demineralised water of the quality required for the electrolysers and other production processes. A flow of 33.50 m^3 /h will be subjected to the demineralisation process.

To obtain demineralised water, the treatment will consist of reverse osmosis (RO) and electrodeionisation (EDI). The PD considers the following equipment in its design:

- Ultrafiltration water pumps;
- Ultrafiltration process;
- RO high pressure pumps;
- OI;
- EDI.

Before selecting this treatment configuration, another option, based on RO and Ion Exchange Resin Beds (CB+MB), was studied according to the study of alternatives presented in **Section 3.2.6.**

The quality of the demineralised water shall be in accordance with the requirements of **Table 2.6.2.2.2.2.a**.

Table 2.6.2.2.2.2.a
Quality of pre-treated and demineralised water

Parameter	Value
Pre-treated water	
Conductivity, ⍰S/cm	100-300
Total Suspended Solids, ppm	5
Turbidity, NTU	2
Demineralised water	
Conductivity of water, µS/cm	< 1
Fluoride, ppb	< 50
Aluminium, ppb	< 10
Calcium, ppb	< 20
Chloride, ppb	< 5
Chromium, ppb	< 5
Copper, ppb	< 3
Iron, ppb	< 10
Magnesium, ppb	< 5
Manganese, ppb	< 5
Molybdenum, ppb	< 5
Nickel, ppb	< 5
Potassium, ppb	< 20
Silica, ppb	< 20
TOC, ppb	< 30

Chemicals used for water purification (biocides, scale inhibitors, flocculants, coagulants, disinfectants) shall be injected from the chemical storage and dosing area.

1 l/h of demineralised water is considered necessary for every 1 Nm^3 /h of H_2 generated.

2.6.2.3
Demineralised Water Storage System

The demineralised water produced will be stored in the demineralised water storage tank, from where it will be distributed via a pumping system to the different consumers.

2.6.2.4
Water Cooling System

The water cooling system will supply cooling water to the H_2 generation plant, the USA, the NH production $plant_3$, the AN Plant, the SNA Plant and the GRAN Plant, to evacuate the thermal work of the different equipment. The system will be based on a wet cooling system (cooling tower) with two different circuits: an open circuit and a closed circuit. The flow rate to be used for the cooling system is 184.21 m /h.[3]

The key specifications of the cooling tower are:

- **Heat dissipation capacity:** high cooling capacity design to withstand the significant heat loads produced by each process.
- **Cooling mechanism:** The tower uses an evaporative cooling system to remove heat from industrial processes. Water circulates inside the tower and is distributed over the contact material, creating a large surface area for efficient evaporative heat transfer.
- **Water circulation system:** the tower is equipped with a robust water circulation system that ensures a continuous flow of cooling water.
- **Fan system:** The cooling tower employs a powerful fan system that draws in ambient air and creates an airflow inside the tower, enhancing the evaporation of the water and thus cooling the circulating water.
- **Water treatment and filtration:** To maintain the performance and efficiency of the cooling tower, a comprehensive water treatment and filtration system is applied. This ensures the removal of impurities such as debris, sediment and chemicals, preventing clogging and fouling problems in the tower and associated equipment.

Table 2.6.2.4.a below provides technical information on the cooling tower

Table 2.6.2.4.a
Cooling tower data sheet

Parameter	**Value**
Total system thermal load	112,036 kWt
Inlet temperature	40.9 ºC
Outlet temperature	30.9 ºC
Main cooling water system	
Tower make-up flow rate	184.2 m /h^3
Tower purge	45.33 m /h^3
Number of cycles of concentration	4
Energy consumption	300 kW
Main cooling water pumps (3x50%)	
Cooling water flow rate	4,861 m /h^3
TDH	20 m
Energy consumption	350 kW
Closed cooling water system	
Cooling water pumps closed (3x50%)	
Closed cooling water flow rate	4,861 m³/h
TDH	40 m
Energy consumption	700 kW
Plate heat exchangers	
Heat output	112,036 kWt
Maximum permissible cooling water temperature in the equipment input	34 ºC
Maximum permissible temperature difference	10 ºC
Electric *chiller*	
Thermal power	3,515 kWt
Maximum output temperature	9 ºC
Permissible temperature difference	5 ºC
Electricity consumption	1,172 kWe
Total electricity consumption	2,183 kWe
Total electricity consumption	**2,872 kWe**

According to the data in **Table 2.6.2.4.a**, the target is to achieve cooling water at 37ºC, at the inlet of the equipment to be cooled, with a maximum dry temperature of 32.9ºC and a relative humidity of 63.11%.

Open Circuit Cooling

It shall be composed of the following teams:

- Cooling tower (1 X 100%);
- Main cooling water pumps (3 X 50%);
- Plate heat exchanger plates (2 X 100%)
- Chemical dosing system.

Closed Circuit Refrigeration

It shall be composed of the following teams:

- Two closed cooling water pumps (2x100%);
- Expansion tank;
- Electric chiller.

The required cooling water shall be supplied from downstream of the feed water treatment and channelled through suitably specified pumps and discharged through the Feed Water Treatment Plant. Antifreeze shall be used to ensure circulation of the fluid, given the low temperatures that can be reached at the site.

2.6.2.5
Instrument and Plant Air System

The main purpose of the compressed air system is to continuously supply clean and dry (filtered) compressed air to the various hydrogen and NH_3 consumers to enable the correct and safe operation of the instrumentation, while the service air is used for cleaning and maintenance.

The compressed air shall be produced in the ASU plant during normal operation. The instrumentation air system shall be separate from the ASU and shall include an air compressor and a start-up tank.

2.6.2.6
Utility Nitrogen and Liquid Nitrogen System

The nitrogen required for purging the equipment will be supplied by the ASU plant.

In addition, liquid nitrogen will be supplied on site, both in bottles and stored in tanks. This will be used to provide a cryogenic refrigeration service in the cold box for the air separation process.

Cylinder supply will be considered for start-up and recharging, but tank storage may be necessary for liquid nitrogen produced from the ASU process to be used as a refrigerant in the condensers.

2.6.2.7
Fire Extinguishing System

A fire extinguishing system will be provided to eliminate fires in the plant. The system is currently in the design phase. Safe procedures will be established around systems with high electricity demand (such as electrolyser units) when fire water is used.

The fire fighting water shall come from the raw water pre-treatment system and shall be stored in a water tank. The purpose of the tank is to store sufficient water to always guarantee the minimum required by the fire fighting system and other uses.

The water system will consist of a fire water tank, electric and diesel pumps, and a diesel storage room (which can be shared with the diesel tank for the emergency generator). A secondary water tank fed by the existing deep tube well on the site is also under evaluation.

Pipelines (main rings) will be installed to enable the distribution of the fire water supply throughout the Plant.

The plant will have a fire station.

2.6.2.8
Waste Water Treatment Plant (WWTP)

Identification of Effluent Flows

The aqueous effluents from the process will be treated in a WWTP, where the main wastewater streams to be treated will come from:

- **Effluents from pre-treatment and demineralisation**: effluents from clarification (preliminary), filtration backwash and reverse osmosis rejection shall be collected and sent to the WWTP.
- **Oily network effluent**: the oily drain will collect all oily wastewater, including those with only trace oils, and channel it by gravity to the oil separator chamber to separate the water from the oil. It is assumed that 85% of the service water goes to the oily drainage network. After the grease/oil separator chamber, the oil-free water is circulated by gravity to the effluent chamber and pumped to the WWTP for homogenisation.
  Oily water from the plant could potentially occur in: i) floor washing of water treatment plants, ii) fire pumps, iii) floor washing of workshops and tanks, iv) demineralised water pumps, service water, cooling water, v) external areas (oily rainwater), vi) transformer area. The composition of the oily network water will be mainly service water with traces of oils, dust and suspended solids.
  Stormwater will be collected and circulated to an additional oil separator. It will then be sent to the WWTP.
- **Non-oily network effluents**: these effluents with an oil-free composition will be sent to the WWTP.
  These drains would come from: (i) demineralisation plant reject and chemical wash effluent, (ii) chemical storage area, shower and eyewash area drains, (iii) demineralised water tank and service/fire tank drains, (iv) cooling tower blowdown, (v) electrolyser drains, (vi) oil/water separator treated water sump pumping pit.
  These effluents will be collected, sent to and treated at the WWTP, where they will be homogenised and neutralised before being sent for discharge to the river.
  The chemical dosing reagent discharge area drains shall be controlled by a manual valve which shall remain open in normal operation to drain possible rainwater effluent and shall be closed in the event of a reagent discharge operation.
  Chemical tanks shall have a containment system that will confine any leakage of chemicals caused by ruptures of the container. In addition, the system shall be designed to contain chemicals from the platform, but these shall not be routed to the non-oil system.
- **Sanitary effluents**: generated in the toilets and which will be treated via the treatment plant for domestic effluents and sent to the WWTP.

These effluents will come from the administrative building, the access control booth and the storage area.
The treated water from the toilets will be sent to a treatment system where it will be homogenised and neutralised after discharge.

- **Effluents to be disposed of by authorised external handlers**: the following effluents will be handled by authorised handlers: i) sludge collected in oil separators, ii) sludge collected in the pretreatment system (if necessary), iii) sludge collected in the sanitary water treatment plant, iv) any oil discharge, v) chemical drains: electrolyser drain, bleach tank drain, NH plant drains$_3$, AN plant drains, SNA and GRAN plant drains, chemical storage tank drains, chemical storage tank drains.

All of these will be confined in pits, drums or containers; oils will be subsequently removed by authorised waste managers, while chemical run-off will be neutralised and subsequently removed by authorised waste managers.

Although the wastewater flow is not constant because it depends on the operation of the Plant, the following **Table 2.6.2.8.a** contains the main expected characteristics of the different effluents mentioned.

Table 2.6.2.8.a
Typical effluent flows

Flow	Effluent flows	
	Flow rate (m^3 /h)	Frequency
Treatment effluent (subject to pre-treatment and demineralisation efficiencies)	31.25	Continuo
Effluent from sanitary sewage treatment	0.63	Continuo
Oil separator effluents	0.085	Intermittent by pumping
Non-oily network effluents	0.635	Gravity flasher
Purging the cooling tower	45.33	Continuo

Additionally, other effluents are considered that would not be treated in the WWTP but would be specifically treated, stored and managed by companies authorised for this purpose, these are effluents with chemical residues, effluents with KOH, effluents with NH_3 , and effluents from the AN plant. No effluents are expected from the SNA and GRAN plants, considering that the design involves processes with zero effluent emissions.

Treatment Description

The purpose of the WWTP is to collect and condition the wastewater from the plant for subsequent discharge into the Paraguay River. The total flow of treated effluent to be discharged into the Paraguay river is 77.30 m^3 /h.

The ETAR shall be composed of the following subsystems, the components of which are described in **Table 2.6.2.8.b** below.

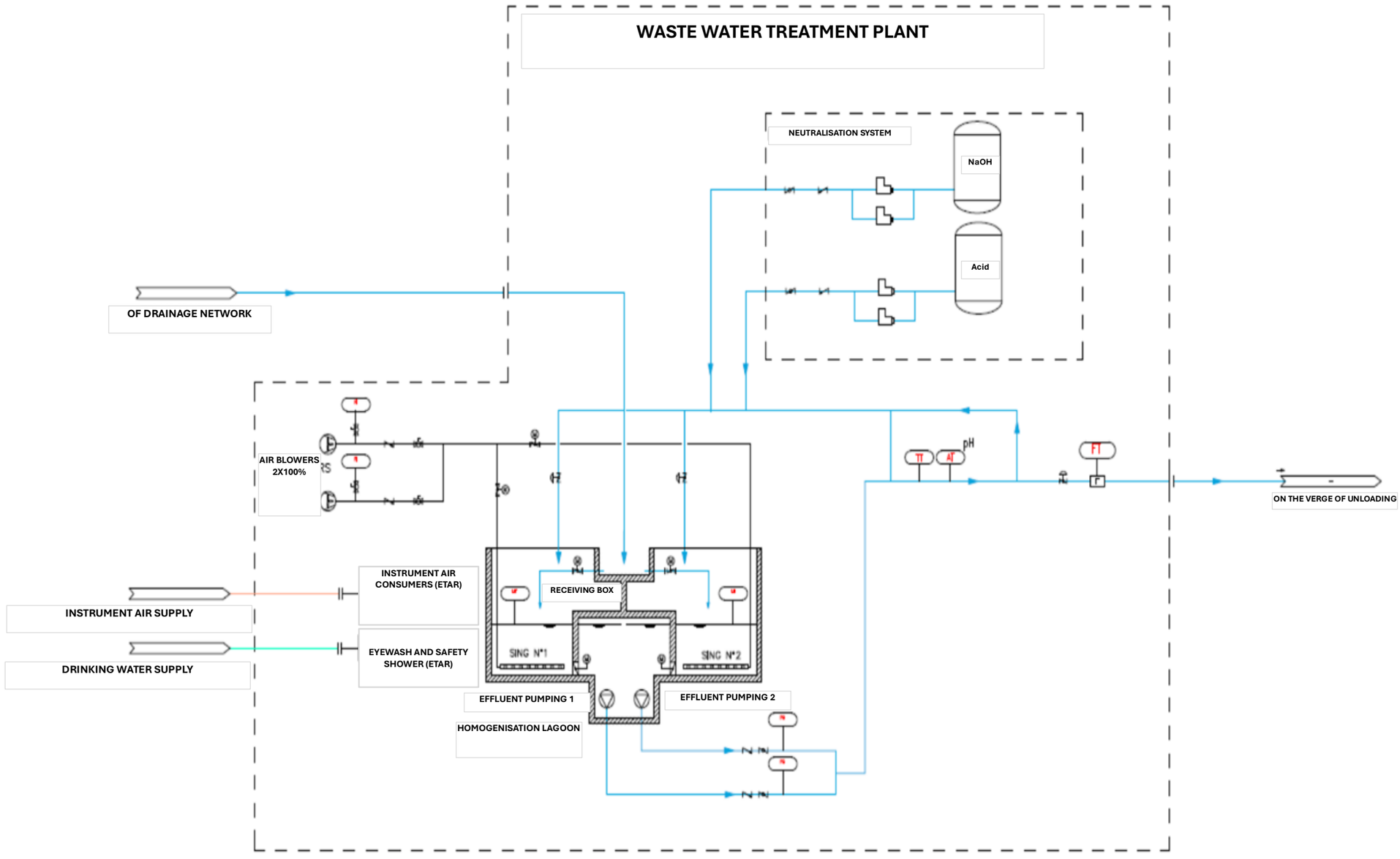
- Wastewater collection and equalisation subsystem.
- Wastewater conditioning, control and discharge subsystem.

Table 2.6.2.8.b
Components of the ETAR Subsystems

Wastewater collection and equalisation subsystem	**Wastewater conditioning, control and discharge subsystem**
It includes: (i) 1 tank for waste water collection divided into two compartments (estimated 150 m^3 each) and equipped with a distribution pit. (ii) 2 air blowers common to both compartments (100% with one on standby). (iii) 1 air distribution system for each compartment.	Includes all equipment for the dosing of neutralisation chemicals, including sulphuric acid and sodium hydroxide, to control the characteristics of the wastewater and its discharge to the discharge point. This subsystem will have: (i) 2 automatic valves, one at the outlet of each basin compartment, (ii) 2 automatic valves, in the recirculation lines of each basin compartment, (iii) 1 automatic valve on the final discharge line (pump discharge) to the evaporation basin, (iv) Outlet line from the recirculation/discharge pump manifold to the inlet manifold of the nearest evaporation basin, (v) Chemical dosing equipment for neutralisation, vi) 1 Sulphuric Acid storage tank (96-98%) with two dosing pumps and associated instrumentation, (vii) 1 caustic soda storage tank (50%), with two dosing pumps and associated instrumentation, (viii) 2-tank cargo transfer pump, one for each reagent. (ix) 2 pumps for effluent discharge to the evaporation basin or recirculation to the waste water collection compartment. (x) Instruments for continuous measurement of flow rate, temperature, pH and conductivity.

A schematic diagram is provided below (**Figure 2.6.2.8.a**).

Figure 2.6.2.8.a
Schematic of the Wastewater Treatment Plant - WWTP



Effluent Discharge

The potential effluent discharge location is considered to be the point close to the water catchment, but a few metres downstream, as shown in **Figure 2.6.2.8.b**. As highlighted, this position is estimated and can be modified during the executive design phase.

Figure 2.6.2.8.b
Point of discharge of treated effluent





The effluent flow produced by the plant is 77.3 m^3 /h, and may reach a peak of 84.20 m^3 /h. The output effluents processed at the WWTP will comply with the discharge limits established in Paraguayan legislation (Resolution N° 222/02) and in the IFC's Environment, Health and Safety Guidelines (MASS) and MASS Guidelines for the Production of Nitrogenous Fertilisers. Likewise, compliance with the noise emission limits established in Paraguayan Law N° 1100/97 and those established for residential areas in the aforementioned IFC Guidelines are considered as requirements for the design of the ETAR.

2.6.3
Other Facilities

2.6.3.1
Plant Substation

As mentioned in other sections, the power to be used by the Plant will come from ANDE's Buey Rodeo substation (SE), which will be interconnected to the Plant's internal SE by means of a 220 kV TL.

For this purpose, a new Air Insulated Substation (*AIS*) will be built at the ATOME Plant. The configuration of the electrical system at the new 220 kV AIS will be as follows:

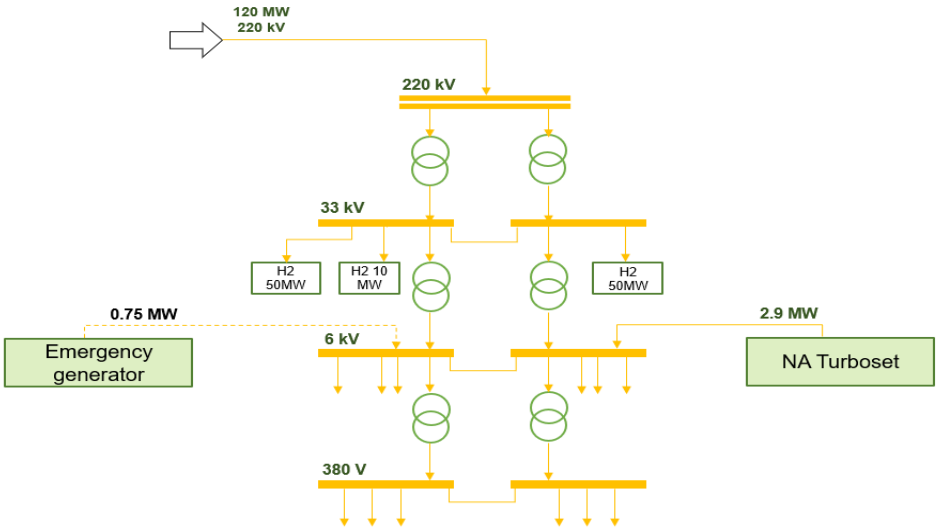
- Double 220 kV busbar layout with link circuit breaker.
- Four (4) bays:
  - Bay 1: Incoming line from Buey Rodeo Substation (OSBL);
  - Bay 2: Output feeder to main transformer BAT10;
  - Bay 3: feeder output to the main transformer BAT20;
  - Bay 4: Link circuit breaker.

Each bay can be connected to either of the two 220 kV busbars. This configuration provides high operational reliability, as it allows the incoming line or feeder outputs to be transferred from one busbar to the other without voltage interruption if the tie breaker closes. In addition, the double busbar scheme allows operation under normal conditions with each main transformer connected to a different busbar to ensure that a power failure on one side does not affect the other part of the power system.

As shown in **Figure 2.6.3.1.a**, the turboset is connected to the SUBSTATION, generating 2.9 MW. The turboset is capable of producing electricity for the AN-SNA-GRAN process, as well as additional power at 6 kV that can be used in the ammonia plant to reduce the grid power demand of the syngas compressors. This power is produced from the steam generation resulting from heat recovery at the AN Plant.

The plant includes full redundancy of HV/MV transformers, MV/MV transformers and MV/BV transformers, and includes an emergency generator to ensure **6 kV** power supply **to** critical systems during a complete plant shutdown or grid outage.

Figure 2.6.3.1.a
Simplified single-line diagram of the Villeta project



2.6.3.1.1
Main Components of the substation

All equipment will comply with ANDE's technical specifications for high voltage (HV) substations. The main components are:

- HV equipment to be installed outdoors in the AIS such as three-pole circuit breakers, three-pole disconnectors with earth wire.
- 220 kV on-site metallic structures for overhead line support, including incoming and outgoing metallic structures, busbar and equipment support, etc.
- Earthing and lightning protection systems.
- SUBSTATION building that will house the sets of electrical panels that provide power to the equipment and control, the measurement and protection cabinets in accordance with ANDE regulations, the local cabinet (including external power and control cabling) and the communication cabinet and equipment necessary to receive signals required by ANDE from the power plant for monitoring.
- Other components: cables and cable trays, outdoor lighting installations (normal and emergency), necessary spare parts.

2.6.3.1.2
Basic SUBSTATION Design Parameters

Although the final design of the SUBSTATION is not available, basic parameters have been defined with which it must comply (**Table 2.6.3.1.2.2.a**).

Table 2.6.3.1.2.2.a
Plant SUBSTATION Data

Substation Data	Features
Configuration	Double bar with lashing coupler
Type	Air Insulated (AIS)
220 kV grounding	Solidly earthed
Rated operating voltage	220 kV
Maximum rated voltage	245 kV
Frequency	50 Hz
Isolation (Power frequency - 1min/stroke)	460 kVrms/1050 kVpeak
Short-circuit current	40 kA, 1 s / 100 kApico
Rated current	1000 A
Area	0.105 ha (1,050 m)^2
Type of oil for equipment	Naphthenic
Gantry structures	Metal structure
Ground network	Copper cable
Foundations	222 m^3
Pavement of the SE area	Crushed stone
Containment tank	Coated masonry
Oil separator box	Coated masonry

The Plant's SUBSTATION will be installed near the access control booth 2, but will have a separate entrance for direct and unrestricted access by ANDE's operation and maintenance team, without the need to follow the Plant's entry control protocol, which will allow for greater agility, especially in emergency situations.

As can be seen in the plant layout, next to the SUBSTATION there is a general control room to be used by both ATOME's own team and ANDE's operating team. The ANDE and ATOME teams will remain in permanent contact. The maintenance of the SE of the Plant will be carried out by outsourced companies specialised in the area and contracted by ATOME, as may be the case of ANDE.

The General Arrangement Plant of the substation is presented in **Annex 1** of this ESIA, together with the single-line diagrams.

2.6.3.2
High Voltage Transmission Lines

To supply electricity to the ATOME plant, an overhead transmission line (TL) will be built with a total length of approximately 550 m, at a voltage of 220 kV, which will connect the ANDE Buey Rodeo substation (SE), located on the edge of National Route PY19, which joins the districts of Villeta and Alberdi, with the internal SE of the plant.

Easement Strip

The easement strip of the TL is regulated and established in the National Electricity Code - CNE (Supply 2011), in Rule 219.B Requirements of the Easement Strip, approved by R.M. Nº 214-2011-MEM/DM.

Easement strips on overhead lines are established in order to provide facilities for the installation, operation and maintenance of the electrical installations of the concessionary companies, as well as to safeguard public safety, i.e. the physical integrity of people and property, in the event of situations of electrical-mechanical risk.

According to the 2011 Supply 2011, the Ministry of Energy and Mines will impose easements on private property, whether privately or state-owned. Concessionaires are obliged to ensure compliance with the safety distances indicated in Section 23 of the NEC.

The minimum widths of the easement strip established by Art. 1 of Law Nº 6681/2020 (which amends Art. 1 of Law 976/1982) are indicated in **Table 2.6.3.2.2.a.**

Table 2.6.3.2.a
Minimum easement strip widths

Nominal voltage of the line (kV)	Distances in metres measured perpendicular
23	3"
66	9
220	25
500	35

Source: Law Nº 6681/2020 (Art. 1).

According to the above table, the safety zone or easement strip is 50 m wide for 220 kV TLs. Thus, considering the extension foreseen for the TL (550 m), the resulting surface of the easement constitutes 2.75 ha or 27,500 m^2 . However, the service strip to be established in the central part of the easement, where it will be necessary to clear the vegetation and the rice crop in order to lay the cables, will only be 6 m wide, which means an area of only 0.33 ha or 3,300 m^2 .

The maximum values for electric and magnetic fields, audible noise and radio interference at the 50 m easement line boundary to comply with IEC-60826 (*Overhead transmission lines - Design criteria*) and with national and international standards are given in **Table 2.6.3.2.b.**

Table 2.6.3.2.b
Electric and magnetic field and audible noise values

Electrical Effects	Maximum in the Belt and Gap	Values of the standard
Electric Field Strength	5 kV/m	4,2 kV/m (population)
Magnetic Flux Density	100 µT	83,3 µT (population)
Audible Noise	45 dB(A) at night	Law No. 1100/1997:
Radio Interference	32 dB	55 dB

Technical Characteristics of the LT

For the construction of the LT it is initially estimated that 4 self-supporting galvanised steel lattice towers will be used. **Figures 2.6.3.2.a** and **2.6.3.2.b** below show the drawings of the two types of towers A1 and D1 to be used.

Figure 2.6.3.2.2.a
Silhouette of lattice tower type A

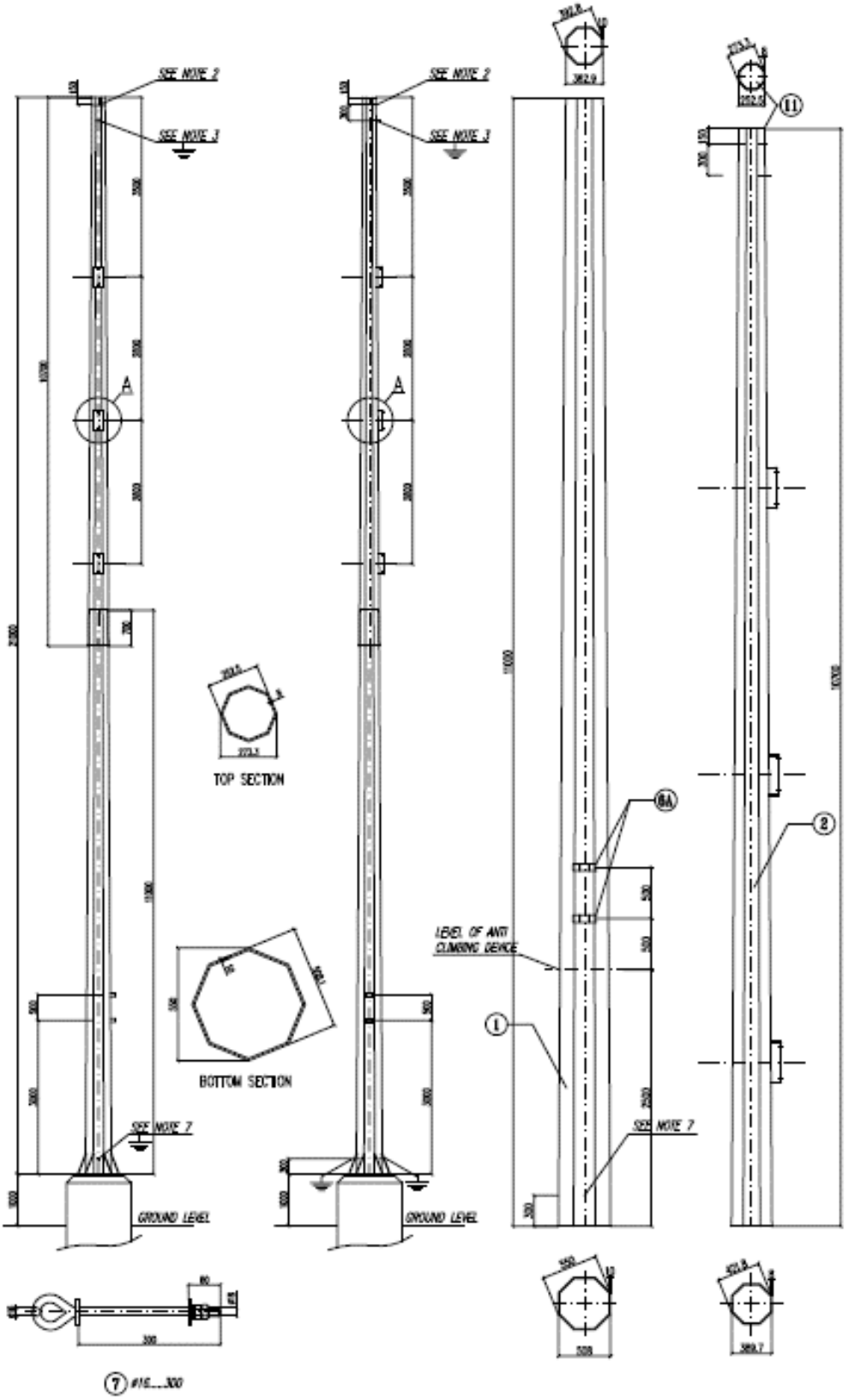
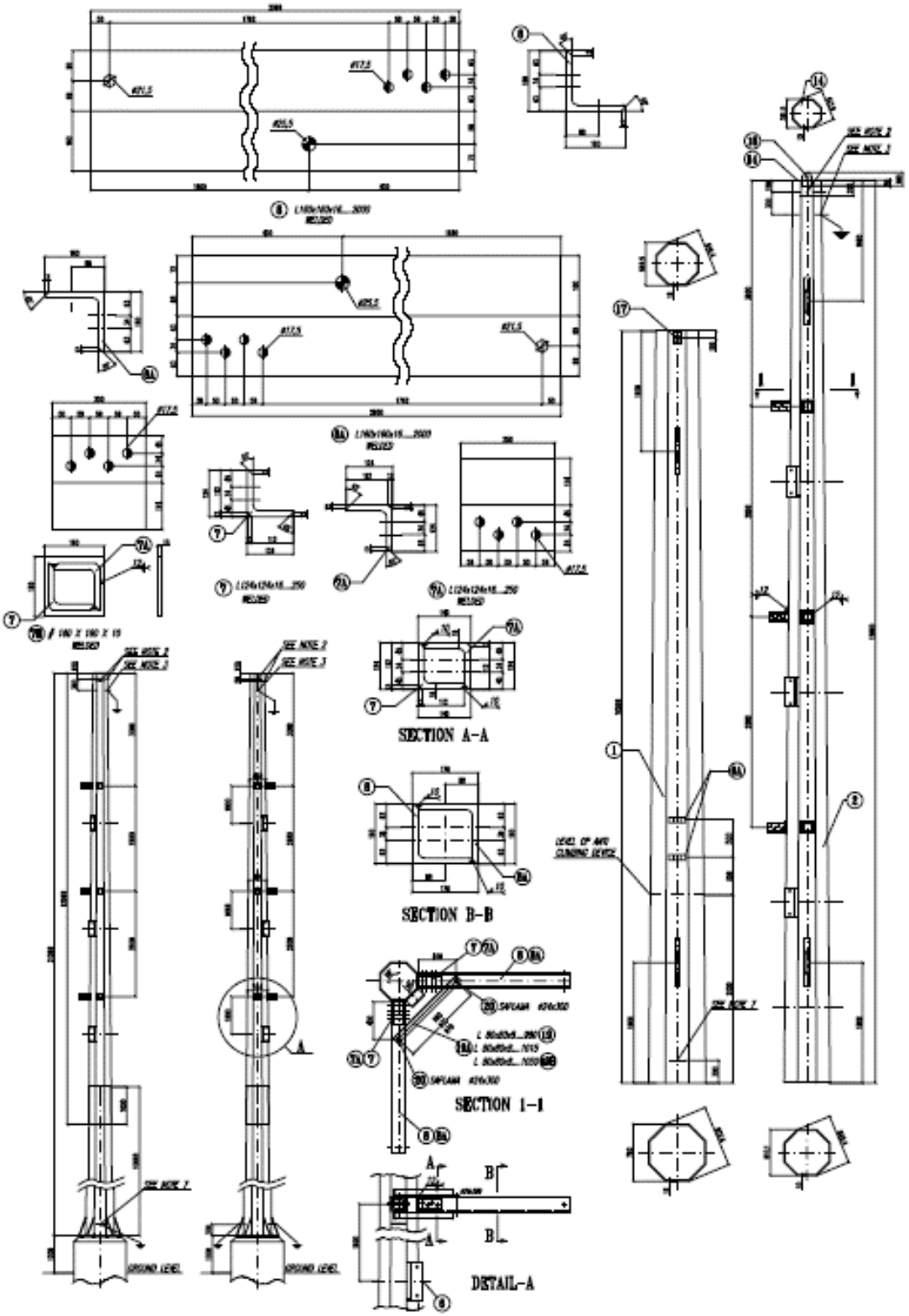


Figure 2.6.3.2.2.b
Silhouette of lattice tower type D1



In principle, an average area to be occupied by the base of the self-supporting towers of 36 m^2 (6 x 6 m) is foreseen.

As mentioned above, vegetation will not be removed over the entire width of the service strip, but only in a 6 m wide strip in the centre of the strip, provided that there are no tall trees that could cause damage to the installations in the event of a fall. This service strip shall be used for access and for the launching of cables.

The foundations to be used for the towers may be of the footing, tubular, pile or anchored block types, and their choice will depend on the soil type at the location of each tower. These foundation types are shown in **Figure 2.6.3.2.c** below.

Figure 2.6.3.2.c
Examples of types of foundations

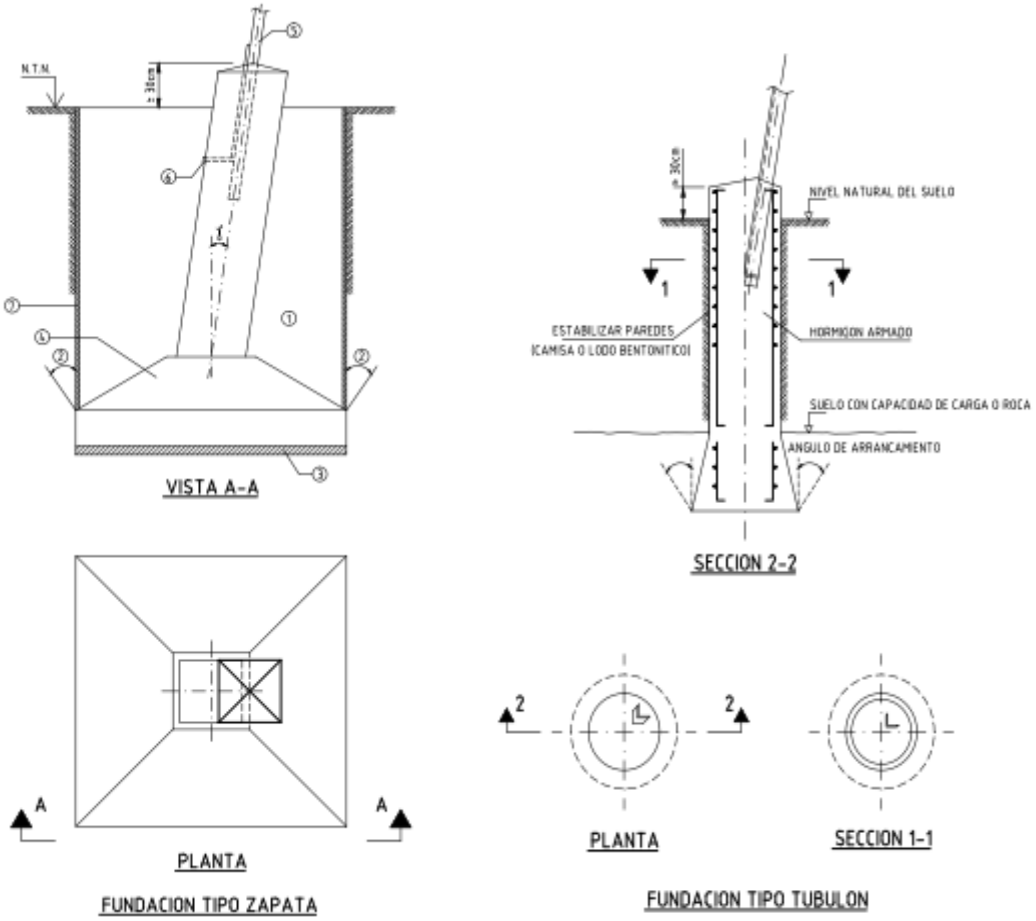
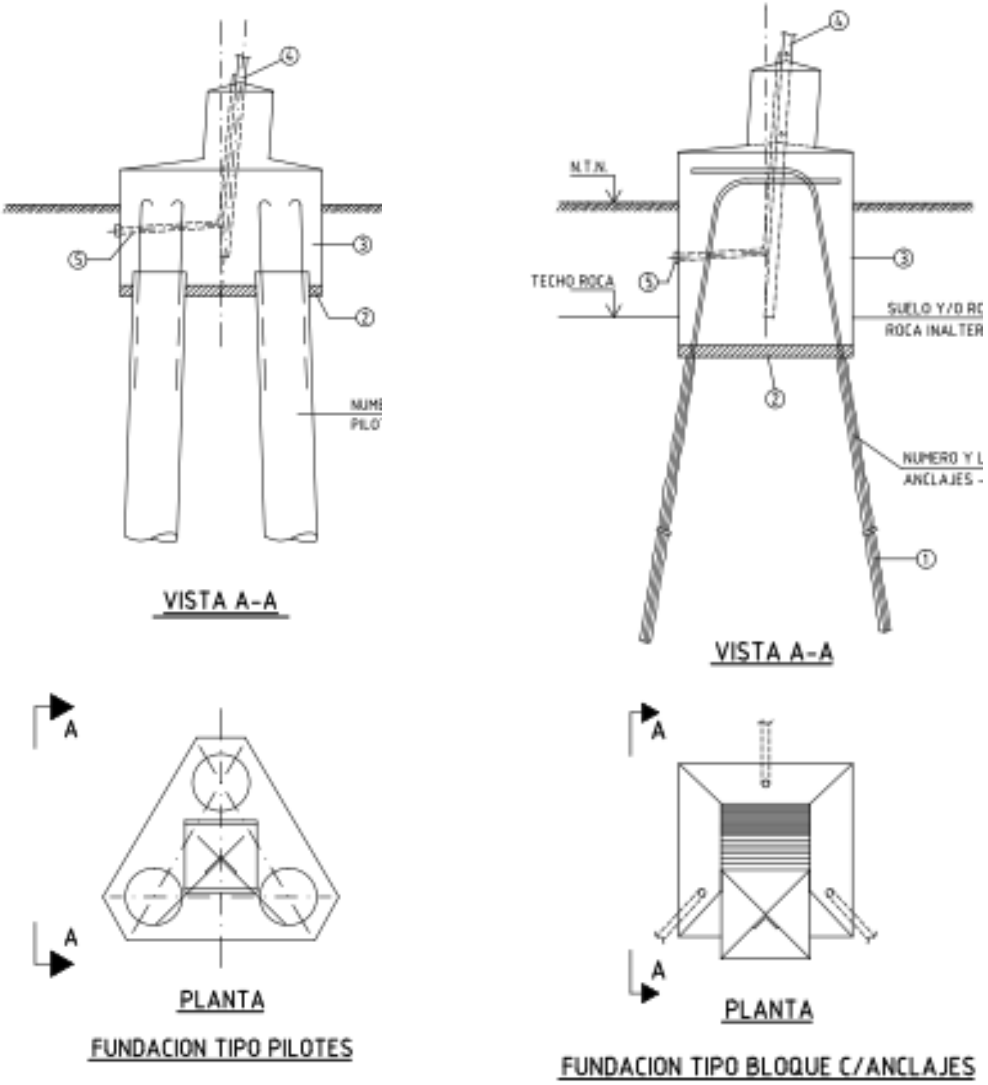


Figure 2.6.3.2.c
Examples of types of foundations



The resulting excavation material will be used to backfill the base of the foundation and the remaining material will be placed on the ground around the foundations and compacted, respecting the natural conformation of the ground.

In the event that the material extracted from the excavation is not suitable for backfilling and compaction of the tower foundation, this material must be deposited in a suitable area, previously identified.

The conductor cable to be used is of type ASCR 636 MCM. The guard cables shall be of type OPGW.

The power conductors need to be insulated with respect to the metal tower structures to avoid leakage to earth. Tempered glass insulators shall be used for this LT.

Lightning rod cables shall be used to protect and ensure good performance in terms of energy transport against atmospheric discharges (lightning), produced by the collision of large masses of electrically charged clouds of opposite poles. The cables to be used shall be of the galvanised steel type.

In addition, suspension assemblies, anchorages and general hardware will be used.

Safety distances

For 220 kV LTs the vertical safety clearances presented in **Table 2.6.3.2.c** must be respected.

Table 2.6.3.2.c
Minimum Safety Distance Values

Item	Minimum distances (m)
Minimum distance between conductors	3.5
Driver distance to ground or obstacles	
Premises accessible only to pedestrians	7.5
Streets and side roads	8.0
Motorways, roads, avenues	9.0
Transmission and distribution lines	4.0
Telephone lines	4.0
Lagoons	7.5

The distances described above shall be verified under the most unfavourable conditions for each case (maximum temperature, emergency temperature, minimum temperature, maximum wind, etc.).

2.7
Constructive Aspects

The following is a description of the main construction aspects to be used in the implementation of the H_2 , NH_3 and green CAN plant, with emphasis on the activities with the greatest potential impact. This description covers only the standard executive procedures for this type of works, excluding complementary tasks and/or the adequacy of procedures for impact mitigation purposes, which will be specified in detail in the description of the prevention, mitigation and compensation programmes and measures (see ESMP in **Chapter 7.0**).

For the impact assessment, project implementation activities are grouped as follows:

Table 2.7.a
Main Activities during the Construction Phase

Preliminary services	Stake out the construction footprint
	Delimitation of the easement strip
	Cutting and clearing of vegetation
	Implementation of access roads
	Implementation of support facilities
Civil works	Earthworks
	Execution of foundations
	Execution of buildings
Assembly	
Demobilisation and site recovery	

2.7.1
Preliminary Services

2.7.1.1
Construction Footprint Stakeout

The staking out of the construction footprint includes:

- Industrial plant and storage areas;
- Layout and final location of the transmission line axis and final location of towers, layout and location of water and effluent pipes;
- Location of the construction area of the outgoing positions of the transmission line within the Buey Rodeo Substation (SUBSTATION) and incoming at the Plant's SUBSTATION;
- The topography team will provide support to the other teams during the entire period of execution of the work. The stakeout will be adjusted to environmental conditions, in order to minimise additional impacts to those already related to the construction of the Project.

2.7.1.2
Delimitation of the Easement Easement Strip

The activities covered by this item are:

- Communication, negotiation and signing of contract with affected landowners for the establishment of easements (activity initiated);
- Definition of the layout of the LT and pipelines by the surveying team;
- Meetings of the ATOME team with affected landowners and people living or working near the easements;
- Carrying out of soil surveys in the LT route axis and pipeline area;
- Issuance of the approved final layout plan;
- Payment of compensation;
- Registration of public deed of right of way, which includes restrictions on use and occupation in the delimited area, or Contrato Particular de Servidumbre.

Negotiations with the landowner will be carried out in order to ensure the realisation of the agreement for the payment of the compensation due. The release of the areas for the execution of the transmission line and water and effluent pipelines will be simultaneous with the compensation

agreement. In case of dispute it will be decided by court action, or subject to expropriation process for public purposes.

It should be noted that for the LT there is a compensation amount agreed with the owner of the affected property. This amount is established in a clause of the contract of sale of the land acquired by ATOME for the Industrial Plant, due to the fact that it is the same owner. However, a specific contract will be concluded for the constitution of the right of way. The same will be done in the case of the pipelines and water collection system, whose contracts will be signed after agreement of the amount of compensation with the owners.

2.7.1.3
Vegetation Cutting and Clearing

Involves the cleaning of all areas to be affected by the project, such as:

- Access roads,
- Locations of buildings, tanks, reservoirs, tanks and pipelines.
- Installation area of buildings and other temporary facilities.
- Storage and stockpiling areas.
- Tower implementation areas (assembly areas), in the cable launching squares and in the easement strip, for surveying activities, launching of transmission line cables and for circulation. The easement strip will be 50 m wide, but vegetation clearing will be done in a strip just 6.0 m wide, in the centre of the easement, allowing for cable launching, circulation and future maintenance of the TL.
- Areas where effluent and raw water pipelines are to be laid.

While the temporary buildings and facilities would not cover the entire site, the 30 hectares of the property are expected to be affected due to the high requirements for storage and stockpiling areas during the construction phase. However, the intervention will be advanced as necessary to avoid environmental damage if possible (see **Figure 2.7.2.1.a** in **Section 2.7.2.1**).

Vegetation and trunk removal operations shall be carried out using appropriate equipment approved by environmental agencies. The above-mentioned tree removal shall be carried out in a careful manner and taking into account the following:

- Intervention for the removal of native vegetation will be done with the authorisation of the owners and within the limits and conditions approved by MADES and the Municipality of Villeta;
- Prior to vegetation clearance, measures for the rescue of germplasm of priority flora species and the pre-scaring and rescue of fauna will be implemented.
- Vegetation and stump removal services will be limited to previously authorised areas, on a selective basis, with demarcation of the trees to be removed;
- Prior to the commencement of work, site managers will be briefed on the areas authorised for vegetation clearance;
- The cutting of trees shall be done in the opposite direction to the body of the trees, in order to avoid unnecessary falling of other trees;
- The wood resulting from the cutting can be donated or used in the works;
- The branch material shall be chopped up and spread in previously defined areas and reported to the environmental and administrative body for disposal as vegetal waste.

2.7.1.4
Implementation of Access Roads

The access roads required for the Project will comprise the temporary roads constructed from National Route PY19 to the work fronts within the Plant site, to allow the transit of equipment and vehicles for the work.

The access roads on site will allow access to the different parts proposed for the execution of the works during the time of activity of each of them. It is foreseen that during this period the roads will be paved with gravel, so measures to avoid and control the raising of dust, mainly during the dry seasons, will have to be considered. The criteria followed for the execution of the accesses to the construction site are as follows:

Table 2.7.1.4.a
Design Parameters for Access Roads

Geometric Values	**Detail**
Minimum radius in plan	15 m
Minimum vertical base	150 m
Minimum vertical base length	7.5 m
Maximum longitudinal slope	15%
Typical Section	**Detail**
Achura	4 m
Pumping	2%

The execution of the access roads will include the preliminary activities of cutting and clearing of vegetation described above, as well as the levelling of the subsoil in order to form the final embankment layer through cuts or fills, ensuring adequate conditions in terms of geometry and compaction. Excavators, disc tractors, front loaders and dump trucks shall be used where necessary. Roads must have the necessary slope, development and drainage conditions for the proper use of equipment and vehicles.

Subsoil levelling, where necessary, shall comprise the following activities:

- Scarification and shaping, whose work will be guided by topographical milestones;
- Homogenisation and water spraying of dry soils with tractor-driven discs;
- Correction and homogenisation of soil moisture content;
- Compaction.

The following environmental preservation procedures will be adopted for the implementation of accesses:

- Access roads will only be executed with environmental monitoring and supervision;
- In the execution of earthworks, local soil weaknesses will be considered in order to minimise environmental impacts;
- Erosion control measures will be taken, as well as permanent stormwater runoff treatment;
- Drainage devices and surface protection with vegetation cover will be implemented;
- The access roads will be permanently maintained during the construction period;
- For existing roads to be used, trafficability and safety conditions shall be ensured.

For the pedestrian walkways, concrete pavements at least 1 m wide will be built around the perimeter of all buildings. In addition, the necessary steps will be installed for access to the huts that are elevated on the foundation supports and everything necessary to ensure safe and easy access to the buildings.

2.7.1.5
Implementation of Support Facilities

To support the construction works, the Project considers auxiliary facilities in the working environment. These facilities include a machinery park, a work camp exclusively for EPC workers, a machinery park, an earth and materials storage area, the latter of which would be used for the industrial plant, the TL and the water collection system and water and effluent pipes.

The location of these areas has been defined taking into account the ease of access to these facilities, the environmental suitability of the spaces affected, as well as the minimum interference with existing services and plots.

Perimeter fencing

Enclosure has been planned for the areas affected during construction, to avoid
the entry of people and animals. The type of fence adopted is the so-called "ecological or hunting" fence, consisting of a 2.30 metre high metal mesh supported by metal posts at 4 metre intervals.

The mesh is rectangular, 15 cm wide and variable in height from bottom to top, thicker at the bottom. The lower 30 cm remain underground. The foundations of the posts are made of 40x40x60 cm mass concrete. End, intermediate (or central) and corner posts will be placed. The pipes will have an outer diameter of 48 mm with a thickness of 1.5 mm and will be 2.45 m high. The tubes supporting the main tubes are 42 mm outside diameter and 1.5 mm thick. At the base of the enclosure, a reinforcement consisting of a 30 cm high electro-welded mesh.

Signposting and beaconing of the site

The signalling and marking during the works will be carried out in accordance with the Highway Manual of the Ministry of Public Works and Communications (MOPC) of Paraguay. In addition to adequate signage, in accordance with the aforementioned manual, the following shall be required to reduce the risk of accidents in the area of access to the site:

- Warning signs;
- Additional speed limitation.

Buildings on the Property

Accommodation is not considered on site. Hotel accommodation and flats in Asunción or Villeta will be used, and some of the workers will be hired from the municipality itself, so it is expected that they will live in the area.

Therefore, the buildings considered during this stage will be temporary prefabricated modules that will constitute offices for the EPCistas, CASALE and ATOME, with changing rooms, canteen, canteen. These buildings will have the following facilities:

- First aid/nursing room.
- Temporary parking.
- Temporary lighting.
- Toilets.
- Collection area.
- On-site workshop.
- Communications connection.
- Sanitary water supply.
- Drinking water supply. It will be carried out by means of an elevated tank with a capacity of at least 15,000 litres. The choice of the specific equipment and its installation will be the responsibility of the Contractor, who must guarantee sufficient pressure to supply the sanitation facilities.
- Power (generator set) with diesel tank, transformers and protections.
- Drainage.
- Septic tank. It will be connected to a network that will carry the effluent from the temporary buildings to the septic tank, with a capacity of at least 21,000 litres, calculated for the primary treatment of wastewater from 105 users. The installation of the pit will be underground, with the necessary vents and connections for its operation. As an alternative, biological filters will be evaluated if available on site.

Figures 2.7.1.5.a and **2.7.1.5.b** below show details of the above installations.

It should be noted that the above-mentioned number of users of the septic tank and drinking water supply are dimensioned for the use by the EPC contractors and technicians of the package suppliers that make up the fertiliser plant H_2 , USA, cooling tower, among others. For the labour load during the construction phase, it will be a condition of the contract for subcontractors to take the necessary additional measures for the provision of drinking water and waste water treatment, such as the supply of drinking water with trucks and dispensers with jerry cans for consumption and the installation of portable WWTPs and the use of portable chemical toilets, respectively.

The air-conditioning systems inside the temporary facilities will be defined in order to keep them at a suitable temperature and in accordance with the Paraguayan and international regulations applicable to the project concerning work sites. It will also be responsible for the definition of furniture, lighting distribution, data distribution network and hot water devices to be established a posteriori.

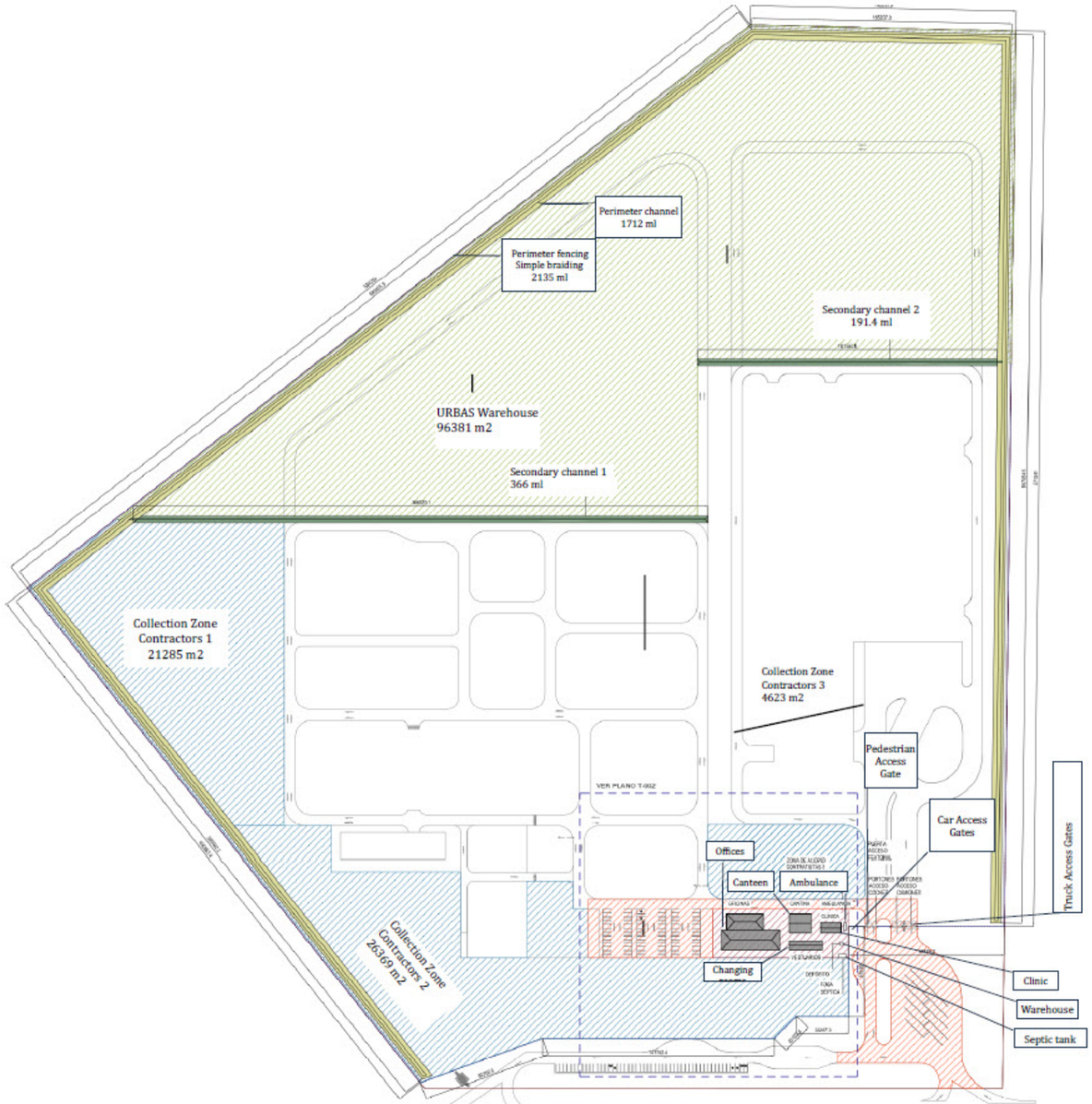
For the installation of the temporary buildings, the foundations are to be laid with concrete cubes of the necessary dimensions to guarantee the aeration of the underside of the temporary installations and the seating of the same. Their dimensions will be subject to the Contractor's criteria, but they must guarantee a free space of at least 30 cm below the installations and, on the other hand, ensure the minimum slope of the grey and black water drainage pipes.

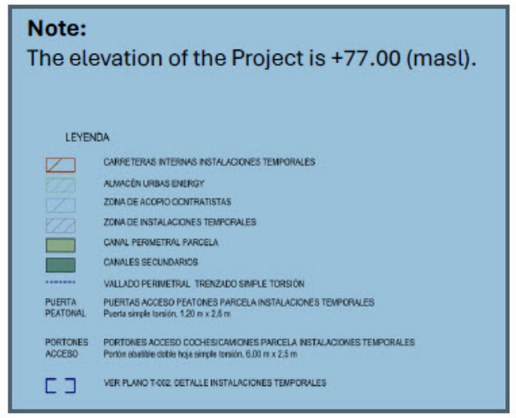
Foundation works shall be carried out in accordance with standard good practice, such as:

- Level the areas where the temporary facilities will be located as much as possible in order to execute the foundations of the buildings in a safe and efficient manner.

- Lay out temporary facilities (offices, canteen, changing rooms, clinic, etc.) as shown in **Figure 2.7.1.5.a,** so that there is always sufficient space between them to circulate along all their facades.
- Execute the foundations.

Figure 2.7.1.5.a
Layout of Temporary Facilities







DETALLE EN SECCIÓN DEL CANAL PERIMETRAL
ESCALA 1/75

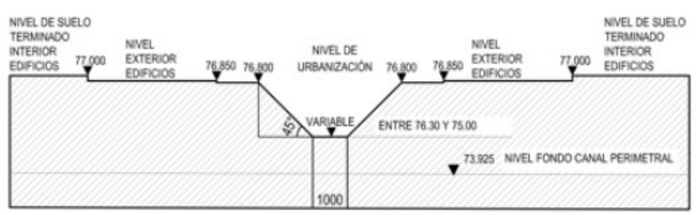
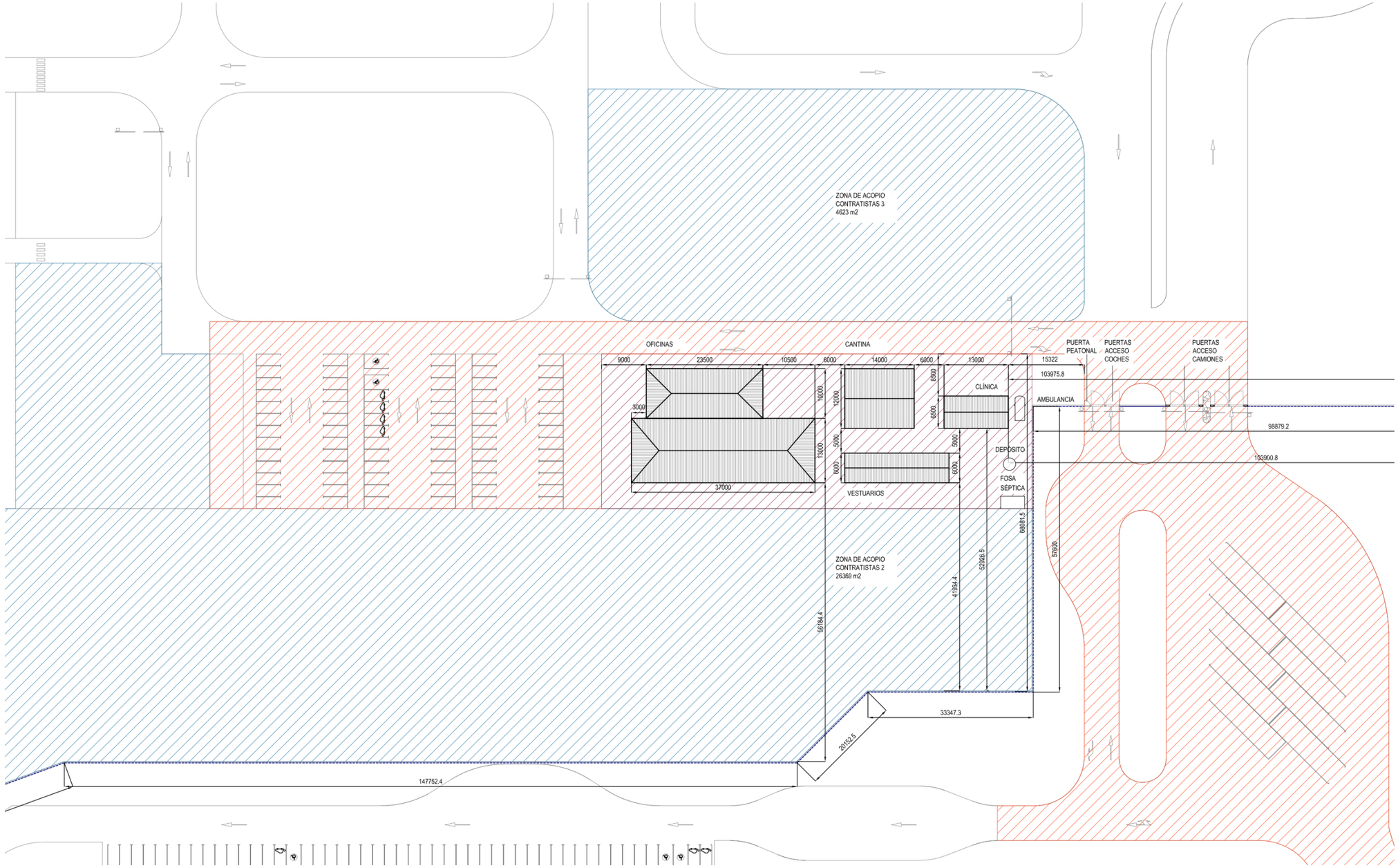


Figure 2.7.1.5.b
Close-up of Buildings



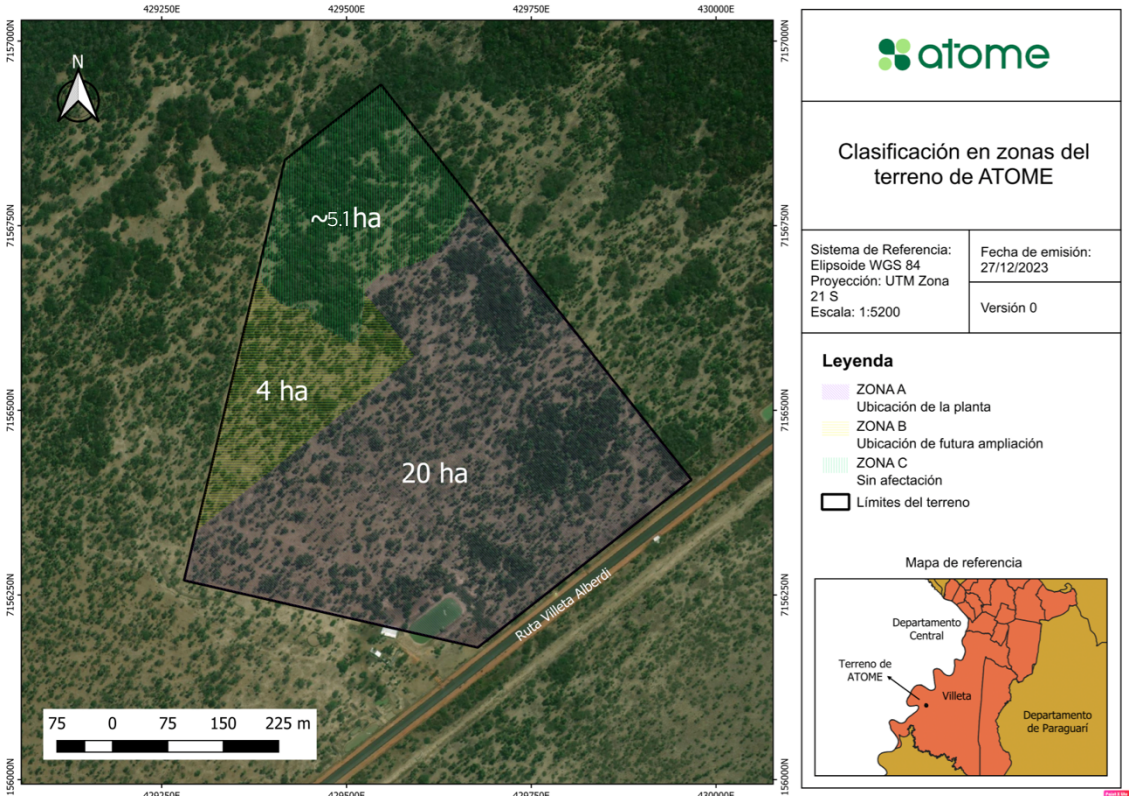
2.7.2
Civil Works

2.7.2.1
Earthworks

As mentioned in **Section 2.7.1.3**, it is considered that it will be necessary to clear vegetation, excavate and fill the entire Atome property. However, it is intended to carry out the interventions in stages in order to minimise impacts on biodiversity primarily, where possible.

To this end, it is proposed to proceed with the interventions in stages. Initially, it is considered necessary to intervene in zones A and B without fail. Subsequently, depending on the need, intervention will ultimately be carried out in zone C, which contains the most compact and dense wooded area (**Figure 2.7.2.1.a**).

Figure 2.7.2.1.a
Vegetation clearance and backfill areas



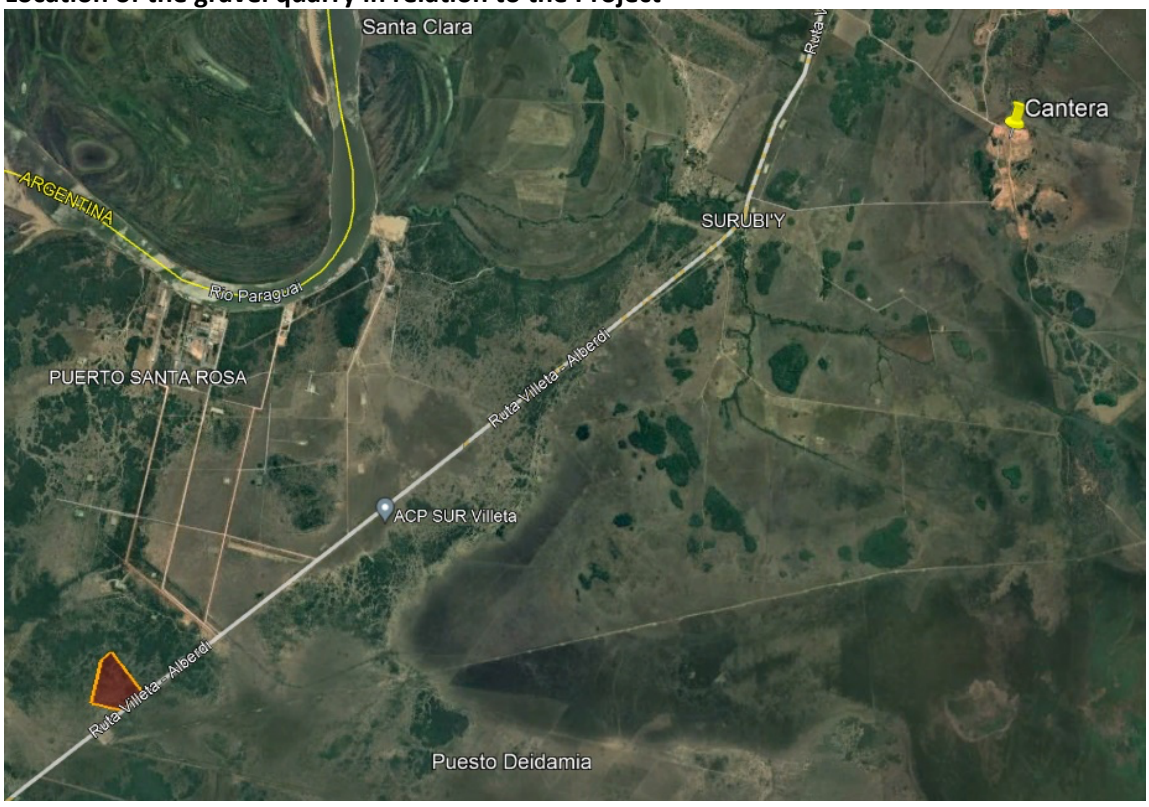
The planned backfill area is 255,000 m^2 , and the backfill height is 0.6 m. The existing cutwater will also be filled. The required volume of backfill material is 153,000 m^3 .

General excavations to be carried out include, but are not limited to, those for grading and compaction of plant or construction areas, for cutting embankments, for construction of yards, roads, pavements, canals, foundations, etc.

General excavations of 102,000 m^3 are foreseen, producing material that cannot be used for backfill because soil analyses have shown that the soil is not in a suitable condition.

The first option evaluated to obtain the material for the fill is a gravel quarry in Surubi'y, which is shown in **Figure 2.7.2.1.b** below. A second option is also evaluated, which would be the re-filling with sand from sediment banks in the Paraguay river. If this option is chosen, the necessary complementary environmental and social studies will be carried out and submitted to MADES in due course.

Figure 2.7.2.1.b
Location of the gravel quarry in relation to the Project



Equipment for compaction of the backfill will consist of sprinklers, equipped with a spreader bar to ensure uniform distribution of water, and compaction units, consisting of a compacting roller and a tractor. To protect the ground surface, drainage devices will be installed to channel rainwater.

The backfill must be protected against erosion and maintained in such a way as to ensure effective drainage by means of a temporary drainage system.

2.7.2.2
Execution of Foundations

<u>Excavation for foundation work and trenches</u>

Excavations of limited section shall be made for footings, continuous foundations, foundations

for machinery, equipment and metallic structures, pits, walls, concrete trenches, etc. These will be carried out in accordance with the dimensions, dimensions and slopes indicated in the design. Trench excavations are also foreseen for the laying of sewers, aqueducts, underground pipes, conduits for electrical cables and instruments or other underground services.

The limited excavations are estimated to reach a volume of 102,000 m^3 of the backfill material used on the site.

Material from the excavation, if deemed suitable, in the quantity/volume required for backfilling, after completion of the excavation work, shall normally be spread close to the excavation, after it has been verified that all safety requirements regarding minimum distances from the edge of the excavation have been strictly adhered to. Materials that cannot be reused or are considered unsuitable for other work shall be removed from the plant and/or site area to an authorised site.

When the foundation level has been reached, the bottom will be cleaned.

For the LT, the works include excavation of the foundations of three towers along the right of way.

For the burial of water and effluent pipes, excavations of approximately 2,300 m^3 are foreseen. In the case of the water collection infrastructure, excavations will have to be made in the coastal river bed, the volume to be determined in the executive project.

Shoring

In areas where the soil does not have the capacity to support the excavation walls, shoring with wooden planks shall be used. Basically, continuous or discontinuous shoring shall be used, which shall be carried out in the following situations:

- Continuous shoring: to be used when the soil has low shear strength or is below the water table or under other circumstances requiring a retaining wall in the excavated trench. In this case, wooden planks with sockets or metal planks with supports shall be used;

- Discontinuous shoring: to be used when the soil in the excavation has good cohesion and is located above the water table. The supports shall be spaced a maximum of 50 cm apart.

Drainage

If necessary, drainage of water from excavations shall be carried out using suitable equipment such as motor-driven suction pumps, submersible pumps, well point systems, etc., and shall continue until completion of the works. Surface water run-off shall be directed to internal drainage ditches and channels.

In addition, considering the characteristics of the soil, EPC contractors will implement earthworks management measures as part of the Construction Environmental Control Programme , including erosion and sediment control measures, considering items such as:

- Land delimitation to minimise impact.
- Reduction of cleared areas to the minimum possible and stabilisation of slopes. Cleared areas shall be revegetated as soon as possible.
- Drainage control to avoid guttering.
- Implementation of barrier and capture methods such as silt fences, check dams, sediment ponds, or mechanical sediment removal methods such as siltbuster or culvert addition, as necessary, to ensure that the existing drainage regime is disrupted as little as possible.

The devices to be implemented to control erosion will be finally defined by the EPCists.

Filling

Filling can be classified into two types:

- Structural backfill: for general area backfill and for embankments up to design elevations in areas that will subsequently be used to support the following:
  - Reinforced concrete foundations (footings, raft, etc.)
  - Buildings
  - Reinforced concrete ponds and ditches
  - Storage tanks
  - Sub-bases and base layers for roads, parking areas, truck operation areas
  - cranes, etc.
  - Local replacement of unsuitable material
  - Paved areas
  - Pipelines
  - etc.
- Non-structural backfill: for non-structural embankments, e.g. retaining walls for storage tanks, basins, evaporation ponds, etc. To be used for design elevations of areas that will not be used later for support, gravel areas, open areas where backfill is required only to achieve design elevations.

Execution of foundations

The foundations shall be of reinforced concrete.

The foundations shall be laid on a bed of lean concrete at least 5 cm thick to even out the ground level. The use of lean concrete and the preparation of the base must be carried out in drained areas, and pumping is not permitted when the concrete is being applied. Once the bedding has been done, the reinforcement and timber forms are assembled and the concrete is poured directly from the mixing machines. The concrete will be allowed to cure for a period of time and then the wooden forms will be removed.

In the case of the LT, the foundations that will form the foundations of the three towers will also be made of reinforced concrete.

Execution of buildings

The works will consist of the construction of all the main, auxiliary and other facilities, which are shown in the Plant Layout.

Buildings

As for the buildings, the characteristics will be as follows:

- Reinforced concrete structures in columns, beams and slabs;
- Coverage of metal tiles;
- Aluminium openings;
- Burnt concrete or tiled floors;
- Embedded electrical installation.

The following conditions shall apply to pavement finishes:

Pathways

Primary roads for truck traffic will be concrete paved lanes with concrete kerbs and drains on each side. Secondary roads for light traffic circulation shall be asphalt paved lanes with concrete kerbs and drains on each side.

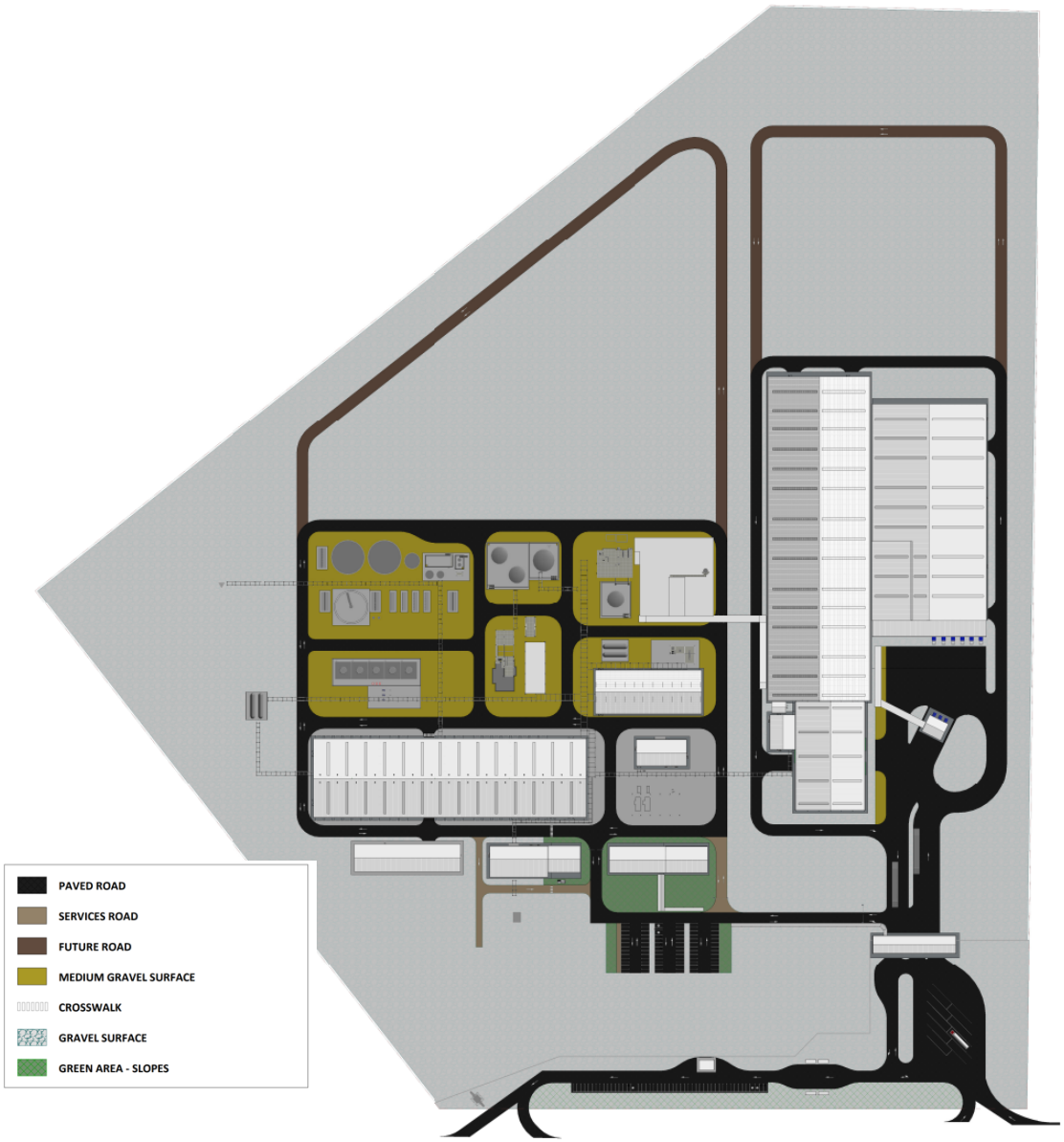
Unpaved Areas

- Continuous concrete paving around the social buildings.
- Native vegetation.
- Gravel pavement composed of maximum 40 mm crushed rocks or gravels of approved grading and quality, densely compacted to a thickness of 100 mm. If the gravel pavement is applied as a roadway, it shall be overlaid with gravel to form a reasonably smooth and serviceable roadway.

Green Zones

Green areas composed of hydroseeding, shrubs and trees native to the area, typical of the flora of Villeta and the AID.

Figure 2.7.2.2.2.a
Pavement finishes



Perimeter Security and Fencing

Controlled access gates will be installed to secure areas of the plant, as well as security fencing along the site boundaries.

The perimeter fence shall not exceed 2.5 m in total height. Two types of fence are planned:

- Main entrance fence: this will consist of a reinforced concrete wall no higher than 50 cm above ground level, on a continuous footing. Galvanised posts with plastic coating will be anchored to which the electro-welded panels will be fixed.
- Rest of plot fencing: 2 m high, 50 mm mesh, galvanised steel posts, 2 m high, embedded in mass concrete footings in shafts dug in the ground.

2.7.3
Assembly

Once the buildings have been constructed, the assembly of the machinery, equipment and tank installations for the various production processes will be carried out.

These are activities that involve the handling of heavy equipment using cranes and also require the use of cutting equipment, welding machines, drilling machines, fasteners and complementary accessories.

Only radioactive sources shall be used for weld inspection. The use of this technique shall be limited as much as possible, replacing it wherever possible with alternative methods. If necessary, it shall be carried out outside working hours, with prior notice and closure of the affected area. Sensitive material shall not be stored on site.

Erection, installation and laying of towers and of the water collection and effluent discharge system and pipes

This includes the installation and assembly of the prefabricated steel towers in each location established in the plans. It also includes the laying of conductors. Subsequently, testing and commissioning work is carried out.

It also includes the installation and assembly of the water collection and effluent discharge system, piping, testing and commissioning works.

2.7.4
Construction and Demolition Wastes

Tables 2.7.4.a and **2.7.4.b** below show the estimated quantities of construction and demolition waste and packaging waste to be generated on site. The waste is coded according to the European list of waste published by Order MAM/304/2002, of 8 February, or on the basis of equivalent regulations applicable in Paraguay. Waste marked with an asterisk (*) in both lists is considered hazardous in accordance with Directive 91/689/EEC.

It should be noted that the estimation of quantities is considered initial for the purpose of waste management decisions, but it will be the end of the works that will ultimately determine the waste obtained.

Table 2.7.4.a
Packaging Waste

Código	RESIDUOS DE ENVASES	t	m³
15 01	ENVASES		
15 01 01	Envases de papel y cartón	-	40
15 01 02	Envases de plástico	-	10
15 01 03	Envases de madera	-	30
15 01 04	Envases metálicos	-	10
15 01 05	Envases compuestos	-	10
15 01 06	Envases mezclados	-	20
15 01 07	Envases de vidrio	-	5
15 01 09	Envases textiles	-	15
15 01 10 *	Envases que contienen restos de sustancias peligrosas o están contaminados por ellas	-	1
15 01 11 *	Envases metálicos, incluidos los recipientes a presión vacíos, que contienen una matriz porosa sólida peligrosa (por ejemplo, amianto)	-	

Table 2.7.4.b
Construction and Demolition Waste

Código	RESIDUOS DE CONSTRUCCIÓN Y DEMOLICIÓN	t	m³
17 01	**HORMIGÓN, LADRILLOS, TEJAS Y MATERIALES CERÁMICOS**		
17 01 01	Hormigón	-	20
17 01 07	Mezclas de hormigón, ladrillos, tejas y materiales cerámicos, distintas a las especificadas en el código 17 01 06	-	5
17 01 06 *	Mezclas, o fracciones separadas, de hormigón, ladrillos, tejas y materiales cerámicos, que contienen sustancias peligrosas	-	
17 02 02	Vidrio	-	4
17 02	**MADERA, VIDRIO Y PLÁSTICO**		
17 02 01	Madera	-	4
17 02 02	Vidrio	-	6
17 02 03	Plástico	-	20
17 02 04 *	Vidrio, plástico y madera que contienen sustancias peligrosas o están contaminados por ellas	-	2
17 03	**MEZCLAS BITUMINOSAS, ALQUITRÁN, HULLA Y OTROS PROD. ALQUITRANADOS**		
17 03 01 *	Mezclas bituminosas que contienen alquitrán de hulla		4
17 03 02	Mezclas bituminosas distintas a las especificadas en el cód. 17 03 01	-	4
17 03 03 *	Alquitrán de hulla y productos alquitranados	-	2
17 04	**METALES**		
17 04 01	Cobre, bronce, latón	-	2
17 04 02	Aluminio	-	10
17 04 03	Plomo	-	1
17 04 04	Zinc	-	1
17 04 05	Hierro y acero	40	5
17 04 06	Estaño	-	1
17 04 07	Metales mezclados	-	3
17 04 09 *	Residuos metálicos contaminados con sustancias peligrosas	-	1
17 04 10 *	Cables que contienen hidrocarburos, alquitrán de hulla y otras sustancias peligrosas	-	
17 04 11	Cables distintos a los especificados en el código 17 04 10	-	10
17 06	**MATERIALES DE AISLAMIENTO Y MATERIALES DE CONSTRUCCIÓN CON AMIANTO**		
17 06 01 *	Materiales de aislamiento que contienen amianto	-	
17 06 03 *	Otros materiales de aislamiento que consisten en, o contienen, sustancias peligrosas	-	
17 06 04	Materiales de aislamiento distintos a los especificados en los códigos 17 06 01 y 17 06 03	-	25
17 06 05 *	Materiales de construcción que contienen amianto	-	
17 08	**MATERIALES DE CONSTRUCCIÓN A PARTIR DE YESO**		
17 08 01 *	Materiales de construcción a partir de yeso contaminados con sustancias peligrosas	-	
17 08 02	Materiales de construcción a partir de yeso distintos a los especificados en el código 17 08 01	-	15
17 09	**OTROS RESIDUOS DE CONSTRUCCIÓN O DEMOLICIÓN**		
17 09 01 *	Residuos de construcción y demolición que contienen mercurio	-	
17 09 02 *	Residuos de construcción y demolición que contienen PCB (por ejemplo, sellantes que contienen PCB, revestimientos de suelo a partir de resinas que contienen PCB, acristalamientos dobles que contienen PCB, condensadores que contienen PCB)	-	6
17 09 03 *	Otros residuos de construcción y demolición (incluidos los residuos mezclados) que contienen sustancias peligrosas	-	1
17 09 04	Residuos mezclados de construcción y demolición distintos a los especificados en los códigos 17 09 01, 17 09 02 y 17 09 03	-	4

In addition to uncontaminated soil and stones from excavation, which may be reused for land reclamation and/or backfilling operations, metals in carbon steel will also be reused, with an estimated generation of 40 t or 5 m^3 .

2.7.5
Demobilisation and Site Recovery

On all work fronts, the environmental recovery of the area will be carried out, with the removal of all equipment and material remains from the works. Subsequently, the original vegetation cover or vegetation covering in areas of exposed soil will be restored. The recovery of the work areas used is an integral part of the construction services and is the responsibility of the Contractors.

Temporary facilities will be demobilised at the end of each company's activities, be it construction or assembly. Their demobilisation will include the reclamation of the area where they were installed so that the site's terrain is restored to its original characteristics. More details on the activities to be carried out in this regard can be found in the Degraded Area Reclamation Programme of the ESMP (**Chapter 7.0**).

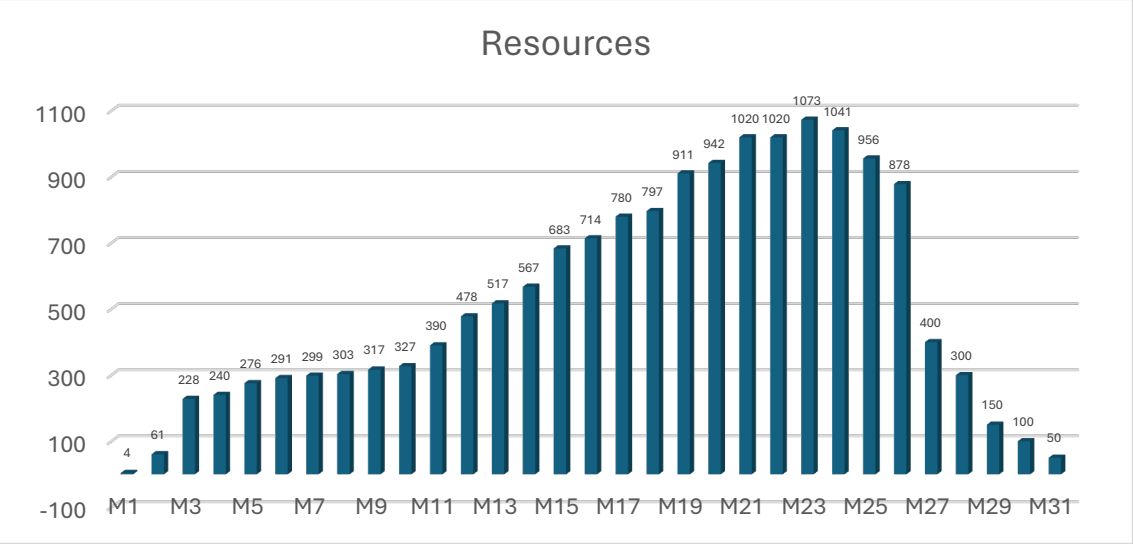
The workforce contracted for the Project will also be gradually demobilised in accordance with the schedule of activities. During the termination of the contract of the professionals, the procedures established by the Paraguayan labour legislation will be followed, guaranteeing them all due rights.

2.7.6
Construction Labour, Equipment and Machinery

Plant Labour

3,190,532.57 man-hours will be employed, with peak staffing in months 21-24 of 1,020 to 1,073 people according to the following curve (**Figure 2.7.6.a**).

Figure 2.7.6.a
Plant Construction Workforce



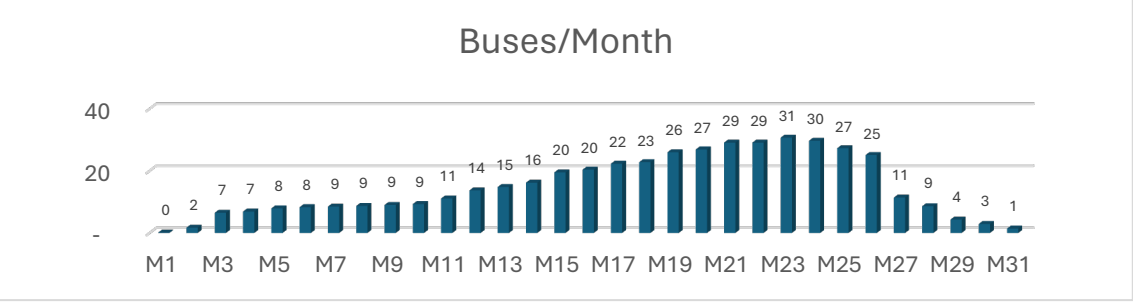
LT Labour and Water Catchment System and Water and Effluent Pipelines

For the construction and assembly of the LT and water catchment system and water and effluent piping, it is estimated that 40-50 workers will be needed for each component at most, varying in number during the months of construction, being 8-12 during month 1 of construction and 15-20 during commissioning.

Transport

As previously mentioned, no on-site accommodation for workers is foreseen. Workers will be transported to the worksite by bus. The estimated number of buses required (considering a capacity of 35 per bus) is shown in **Figure 2.7.6.b** below. It is estimated that the buses will leave from the Asunción Bus Station (Avenida Fernando de la Mora, Asunción) and will go to the plant via National Route PY19 (Villeta - Alberdi), with intermediate stops to be defined in later phases.

Figure 2.7.6.b
Number of buses for transporting workers during construction works



Equipment and Machinery

The amount of equipment and machinery to be used depends mainly on the timeframe, but the following numbers are preliminarily considered:

- Bulldozer (2x)
- Loader (x4)
- Backhoe (x3)
- Mototrailer (1x)
- Compactor 10 tn (3x)
- Trucks (10x)

Transport

As for the oversized cargo to be transported to the Project site during the construction phase, the expected list is shown in **Table 2.7.6** below. The equipment is collected at different origins and from these locations it is transported by sea to Montevideo. In Montevideo, they are transferred to a river barge that transports them to the Terport port in Villeta. From the Terport port, they are transported along National Route PY19 to the Project location in container trucks for containerised cargo and in ro-ro or special barge trucks for those pieces whose dimensions or weights exceed the limits established by the regulations in force in Paraguay.

Table 2.7.6.a
Oversized loads to be transported to the site

Unit - Section	Description	Quantity	Size per Unit (m x m x m)	Unit Weight (Tn)	Origin
2- SE Plant	HV transformers	2	7 x 5 x 5	120	Hamburg
7 - CAN storage	Band rolls	15	3.5D x 1.5	3	Port of Coruña
	Scraper mast	2	5 (height) x 3 (width) x 17 (length)	15	Port Turkey
13 - Electrolysis Plant	Electrolyser 1 x 1000 Nm3/h	22	6,90 x 2,41 x 2,80	50 tn / each	China
	Transformer	22	5,00 x 4,00 x 4,20	20 tn/each	China
20 - AN Plant	Absorption Tower	1	3,6 D x 25 m	78	Rotterdam or Antwerp
	Absorption Tower	1	3,6 D x 25 m	78	Rotterdam or Antwerp
	Bleaching Tower	1	2,3 D x 6,5	95	Rotterdam or Antwerp
	Steam turbine condenser	1	8,8 x 2,3 x 2,9	24	Rotterdam
	Evaporator	1	6.8D x 6.8	56	Antwerp
	Oil cooler	1	8,76 x 4,41 x 4,22	28.8	Rotterdam
	Ammonia burner	1	5,2 D x 4,5	13.6	Antwerp
	Air compressor	1	vendor	104	Rotterdam
	Nitrous gas compressor	1	vendor	53.3	Rotterdam
	Motorgenerator	1		18.8	Rotterdam
20B -Planta de SNA	Process condensate tank	1	3.0D x 4.23	8.5	Shanghai
20F - Plant BIG	Tank washer drier	1	4.67D x 5.17		Turkey
	Solids Silo	1	15 m3		Turkey
	Liquid effluent tank	1	5,5 D x 4,35		Turkey
	Air chimney	1	5,7D x 47		Turkey

Table 2.7.6.a
Oversized loads to be transported to the site

Unit - Section	Description	Quantity	Size per Unit (m x m x m)	Unit Weight (Tn)	Origin
21 - Buffer tank farm H_2	H2 storage tanks	2	3.0D x 20 m		Gijón
22 - USA	Buffer 200 m2	1	22 x 0,5 x 0,5		International seaport
	Cold box	1	15,1 x 4,75 x 4,7	47.5	International seaport
25 - NH Synthesis Unit$_3$	NH3 converter	1	1,5 D X 15	116.0	Genoa / Porto Marghera
	NH3 converter - internal	1	1,5 D x 15	25.0	Genoa / Porto Marghera
	Ammonia refrigeration compressor	1	9 x 3,3 x h	30.0	Porto Marghera
	Ammonia refrigeration compressor	1	10,2 x 4,2 x h	5.0	Porto Marghera
	Ammonia refrigeration compressor	1	4,5 x 4,5xh	5.0	Porto Marghera
Various	WWTP Thickeners	2	4D x 4.8		Valencia
	Overhead crane - Turboset	1	24	12	India
	Overhead crane - WHB	1	16	6	India

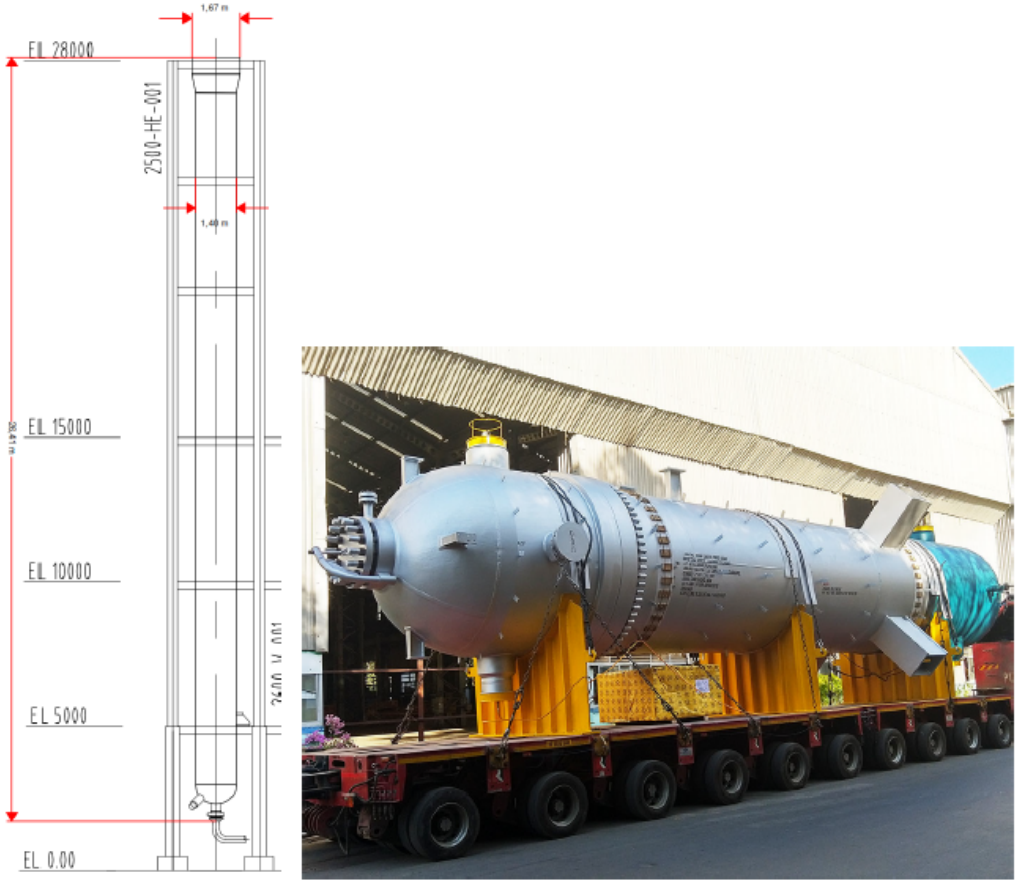
The following frequencies are foreseen for the transport of raw materials:

- **Dolomite:** 1 incoming truckload every 4 days.
- **Spare parts, consumables and other:** 1 lorry per day + 1 van per day

The EPCists will carry out analyses of the road conditions to be used for the transport of the oversized cargoes, assessing each section of the route between the Plant site and the port to see if there are any points where the passage of the cargoes would encounter obstacles that would require some adjustment depending on the characteristics of the cargo. Possible obstacles include, for example, very narrow stretches of road, height limitation due to the presence of LT cables crossing the road, or other obstacles.

In the case of the LT and the water collection system and water and effluent pipes, transport of oversized loads is not considered, considering that the components are assembled on site. However, the transport of oversized vehicles such as cranes and the purchase and transport of supplies from the local market such as metallic structures and accessories and conductors, iron fittings and other imported supplies are foreseen for the first component mentioned.
Due to the fact that both projects are at a very basic pre-project level, no further information on transport is available.

Figure 2.7.6.c
Illustrative photo of NH_3 reactor transport



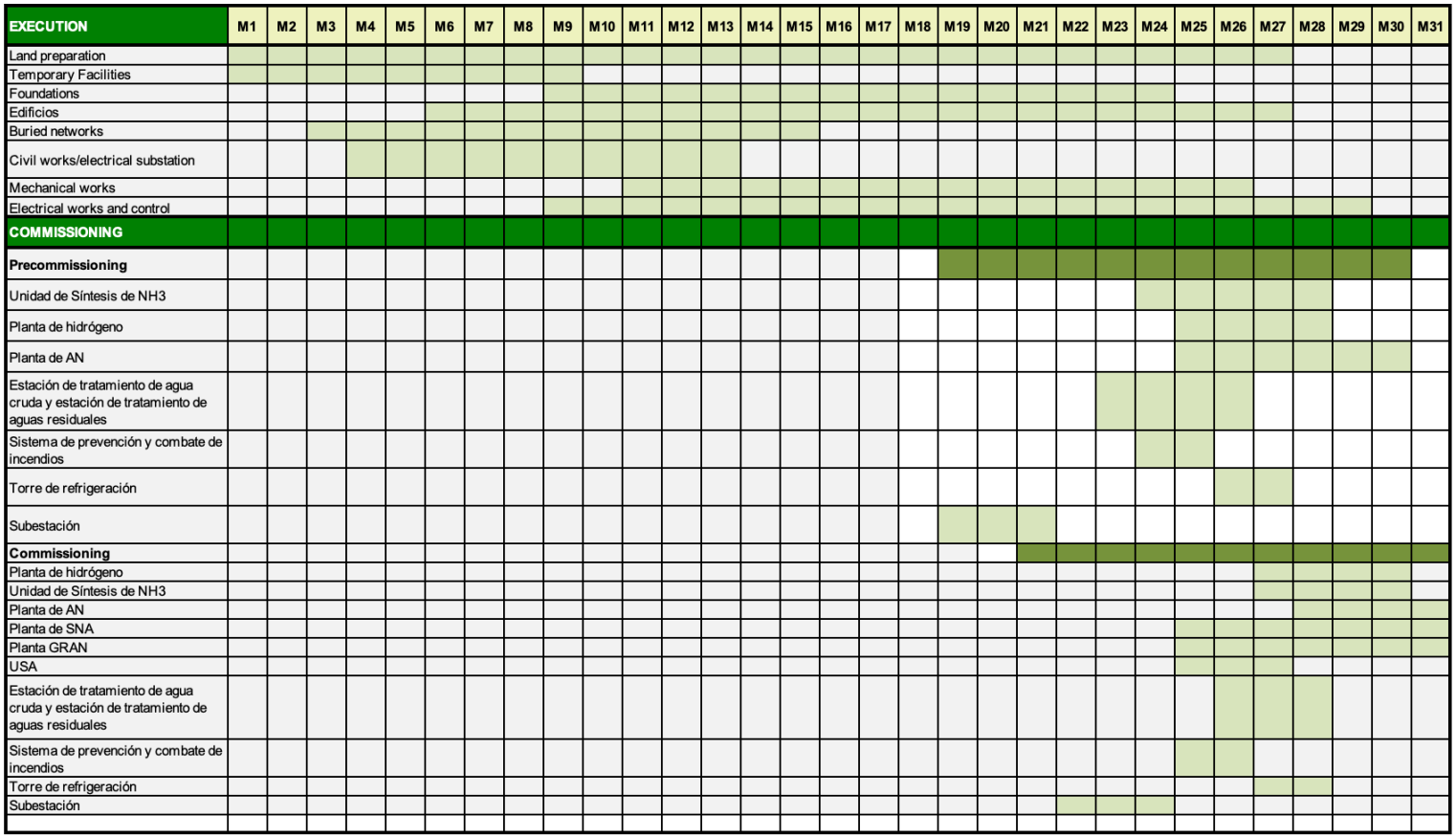
Soil Movement (backfilling)

A fleet of 10 trucks is estimated for landfill, with a duration of 90.5 days, which is equivalent to about 6 round trips per truck per day on National Route PY19 (Villeta - Alberdi). A fleet of 5 trucks is also planned for transporting containers with imported goods, with intermittent duration over 5 months, depending on arrivals at the port Terport.

2.7.7
Works Schedule

The implementation of the project is estimated to last 31 months. The works and electromechanical assembly are estimated to last 29 months. Pre-commissioning would start in month 19 and commissioning in month 21 with a duration of 11 months (see **Figure 2.7.7.a**). For the LT, the construction period is estimated at 140 days (about 4.5 months) (**Figure 2.7.7.b**). Details of the schedule for the water catchment system and water and effluent piping are not yet available.

Figure 2.7.7.a
Tentative schedule for civil works and electromechanical assembly



EXECUTION	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31
Land preparation																															
Temporary Facilities																															
Foundations																															
Edificios																															
Buried networks																															
Civil works/electrical substation																															
Mechanical works																															
Electrical works and control																															
COMMISSIONING																															
Precommissioning																															
Unidad de Síntesis de NH3																															
Planta de hidrógeno																															
Planta de AN																															
Estación de tratamiento de agua cruda y estación de tratamiento de aguas residuales																															
Sistema de prevención y combate de incendios																															
Torre de refrigeración																															
Subestación																															
Commissioning																															
Planta de hidrógeno																															
Unidad de Síntesis de NH3																															
Planta de AN																															
Planta de SNA																															
Planta GRAN																															
USA																															
Estación de tratamiento de agua cruda y estación de tratamiento de aguas residuales																															
Sistema de prevención y combate de incendios																															
Torre de refrigeración																															
Subestación																															

Figure 2.7.7.b
Tentative transmission line schedule

ACTIVIDADES	DURACION (días)	M1	M2	M3	M4	M5	M6	M7
CONSTRUCCION	140							
Obras civiles	70							
Obras electromecánicas	60							
PRUEBAS Y PUESTA EN SERVICIO	60							

2.8
Operation and Maintenance Aspects

2.8.1
Plant Operation

2.8.1.1
Productive Capacity

Table 2.8.1.1.a
Information on the production capacity of each unit of the plant.

H_2 Production rate	1,802.0 kg/h
N production rate$_2$ (for process)	8,363 kg/h
NH production$_3$	10,165 kg/h
AN production (dry basis)	18,333 kg/h
Production AN (solution)	29,542 kg/h
SNA Production rate (dry basis)	23,208 kg/h
SNA Production rate (solution)	24,458 kg/h
CAN production rate	31,958 kg/h

2.8.1.2
Performance Profile

Table 2.8.1.2.a
Performance Profile per hour/day and day/year of each Process Block

Process Block	Value	Units
Plant H2		
Performance profile	24 350	h/day day/year
ASU Plant		
Performance profile	24 350	h/day day/year
NH Plant$_3$		
Performance profile	24 350	h/day day/year
AN Plant		
Performance profile	24 350	h/day day/year
SNA plant		
Performance profile	24 350	h/day day/year
BIG Plant		
Performance profile	22 330	h/day day/year

2.8.1.3
Products

The Plant's product is CAN fertiliser, produced from NH_3 which is made up of H_2 and N_2 (see **Sections 2.6.1.1** and **2.6.1.2**).

As mentioned in **Section 2.8.1.1**, the Plant is designed to produce about 10,165 kg of NH_3 per hour and 31,958 kg of CAN per hour.

Argon and O_2 , gases that have commercial values, and could therefore be stored and exported, are also generated as by-products. However, the ATOME Plant will not be designed to recover argon, which will be vented back into the atmosphere. Provision will be made for the recovery of O_2 in the future.

2.8.1.4
Transport and Marketing of the Products

The final product will be transported by land and inland waterways.

Land Transport

- **CAN:** 50 truck trips (empty + loaded) for the export of the 770 ton/day (total count for production in big bags or bulk).

The most commonly used truck type configuration in the country for fertiliser transport is Scania type tractor + semi-trailer with lengths of 16 m, even shorter. The maximum length of this configuration is 18.15 m (**Figure 2.8.1.4.a**). Transport is in big bags of 1,000 kg each, totalling loads of up to 30,000 kg (30 big bags). The maximum that can be loaded is 33 tonnes.

Figure 2.8.1.4.a
Scania tractor truck with semitrailer



According to the business plan assessments under development, final destination options for CAN fertiliser transport by road include the cities of Cascavel and Dourados in Brazil, and the cities of San Salvador de Jujuy and San Miguel de Tucumán in Argentina.

Inland waterway transport

The transport and marketing of the final product (fertiliser) is still under study and will be defined according to the business model under development.

One of the options evaluated is road transport to the port of Terport, in Villeta. The Terport port is located 33 km upstream from the plant site by river, and approximately 15 km along the Villeta - Alberdi road. From Terport Port, the product is transported to the port of Nueva Palmira, in Uruguay.

2.8.1.5
Effluents and Solid Waste

It is estimated that the following types of waste will be generated in the operation of the Plant, with the quantities preliminarily estimated:

- Sludge: 900 m^3/year
- Used compressor, transformer and motor oil: 60 m^3
- NH contaminated process water$_3$: 40 m^3/year
- Process water contaminated with KOH: 150 m^3/year
- Process water contaminated with chemical cooling additives / or water treatment: 200 m^3 /year. Process water is not discharged directly but is directed to the WWTP for homogenisation and stabilisation prior to discharge into the drainage network.
- Rubbish (organic waste generated by plant personnel): 8,000 kg/year
- Rubbish (solid waste generated by plant personnel): 30,000 kg/year
- Electrical waste: 800 kg/year
- Mechanical waste (filters, metal parts, scrap, plastics, consumables...): 5,000 kg/year

2.8.2
Plant Maintenance

For the maintenance activities of the Plant's equipment and facilities, in addition to the vehicles that are part of the operation, i.e. those that bring raw materials and other inputs and those in which the products are shipped, the Plant design foresees a warehouse and workshop area (see **General Layout** in **Figure 2.6.a**).

The specific maintenance requirements are summarised in **Table 2.8.2.a**. An annual outage of 15 days is foreseen to execute major maintenance tasks. The plant, its equipment and systems are designed for a useful life of 25 years.

Table 2.8.3.a
Maintenance requirements

Block	Periodicity	Minor maintenance	Major Maintenance	Total downtime
Electrolysis	24 h/d Year: 10x: 330 d/year	No impact	Every 10 years: 4 stops of 33% sequentially	4 weeks/10 years
USA	24 h/d 350+ d/year	No impact	No impact (full redundancy)	No impact (full redundancy)
Syngas compressors	24 h/d	No impact	No impact (full redundancy)	No impact (full redundancy)
NH3 Synthesis Unit	24 h/d 350 d/year	3 days per stop	Every 10 years: 4 weeks	14 days/year 4 weeks/10 years
AN Plant	24 h/d 350 d/year	3 days every 200 days of operation	30 days every 3 years	45 days/3 years
SNA plant	24 h/d 350 d/year	1 day every 6 months	14 days each year	15 days/year
BIG Plant	22 h/d 330 d/year	2 h/day + 30 days spread over the year	21 days each year (worst case scenario)	2 h/d 35 days/year

Buffer tanks between each process in the plant are designed to provide:

- Sufficient volume of synthesis gas (H +N_{22}) for emergency reduction and safe start-up of the ammonia circuit. These 2 buffers are intended to be bypassed during normal operation.

- Sufficient volume of NH_3 , NA and ANS to run the rest of the process during normal minor maintenance, and during the daily cleaning shutdowns of the granulation plant (2h/day). The NH_3 and NA tanks are sized for a production capacity of 4 days, and the ANS tank for a production capacity of 2 days.

All elements of the Plant will be subject to maintenance, including chillers, blowers, filters, pumps, as well as infrastructure elements of the Plant, such as stairs, walkways, internal access, tank integrity and concrete structures, etc.

2.8.3
Maintenance of the LT

Preventive (periodic) and corrective (outage restoration) maintenance services of the TL will be carried out by the maintenance team of a specialised company to be contracted by Atome, which may be ANDE itself.

During inspections of the TL, the condition of the equipment, the access to the towers and the location of the easement strip shall be observed in order to preserve the installations and the functioning of the TL.

2.8.4
Operation and Maintenance Manpower

The operation of the plant will involve operators in the different process blocks, the raw water treatment plant and the ETAR, the dispatch of products, the plant's SE (which will belong to ANDE), as well as workers in the administrative and mechanical areas, among others.

It is estimated that the following direct and indirect jobs will be generated in this phase:

- 90 permanent positions for the O&M of the plant.
- Up to 25 permanent positions in subcontracting work.
- Up to 30 temporary positions for subcontracted work.

In addition, similar plants require professionals to oversee operations, such as environmental engineers, chemical and laboratory technicians, logistics and supply chain staff, managers, senior staff, HR specialists, legal, commercial and administrative staff, among others. This translates into the creation of some 290 indirect jobs.

With the expansion of ATOME's value chain to CAN, an estimated 80 direct jobs and 584 indirect jobs will be created.

Therefore, the total number of direct workers hired in this phase is 240, of which 195 are permanent and 45 temporary. The total number of indirect jobs to be created could reach 874.

3.0 Study of Alternatives

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Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

SUMMARY

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3.0
Study of Alternatives

3.1
Siting Alternatives

3.1.1
Site Alternatives for Plant Implementation

3.1.1.1
Alternatives Evaluated

Three land alternatives were evaluated for the construction of the ATOME green H_2, NH_3 and CAN Plant, which are shown in **Figure 3.1.1.1.1.**below. The three alternatives studied are suitable for the development of industrial undertakings requiring high electricity consumption, all three sites being close to electricity substations.

In addition to being close to a substation, other characteristics that were taken into account in the search for land alternatives were proximity to water sources with certain quality and quantity requirements, and proximity to road and port networks for the shipment of final products.

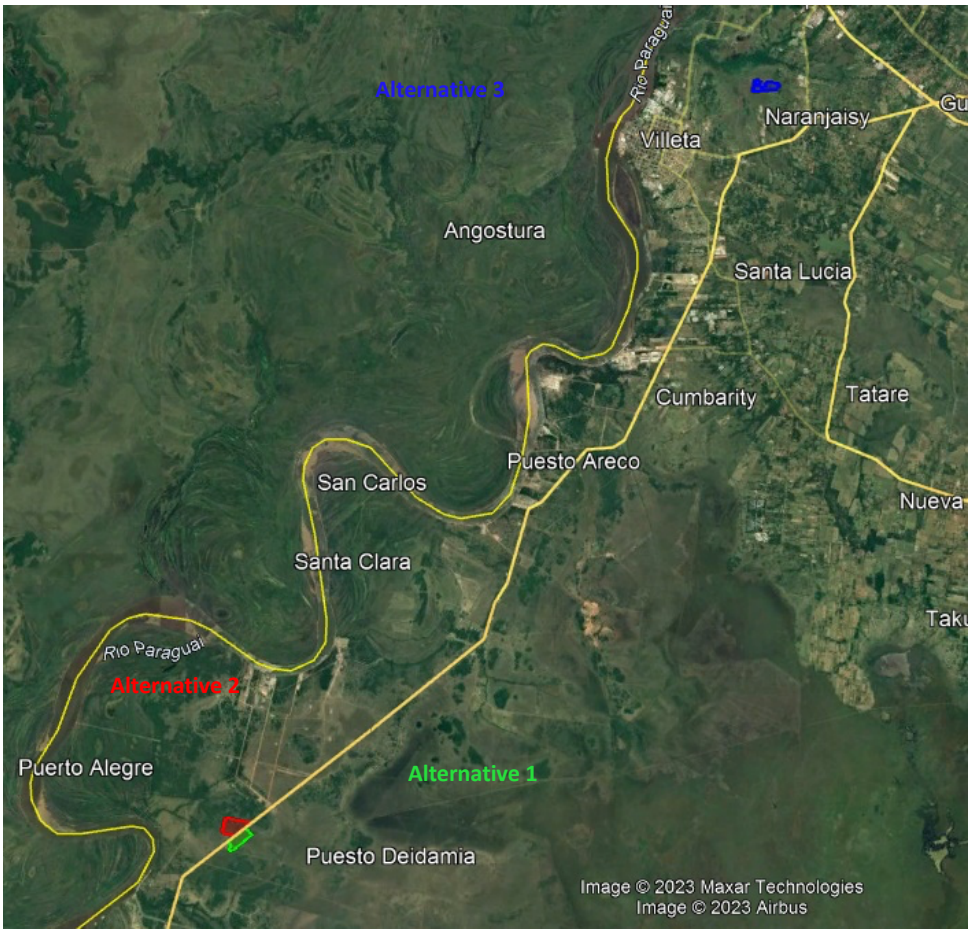
As shown in **Figure 3.1.1.1.1.a**, Alternatives 1 and 2 are closest to each other, both near the Buey Rodeo Substation (SE) (see Detail 1 of the Figure), located in the District of Villeta, in the place called Ype Kaé, Central Department, on the edge of the fully asphalted National Route PY19, which links the districts of Villeta and Alberdi.

Alternative 3, on the other hand, is further away from the other two, located in Naranjaisy, near the Villeta headquarters (see Detail 2 of the Figure), adjacent to the SE "ADM" and close to the Unilever Paraguay Distribution Centre. The property has access from the asphalted Ypané-Villeta road.

After the first offer, Alternative 2 was offered again to ATOME with the configuration shown in **Figure 3.1.1.1.b** below. As can be seen, this owner's Padrón 8369 land was divided into 7 fractions, being Fraction 1 with 18.64 ha, Fraction 2 with 11.36 ha, Fraction 3, 4, 5 and 6 with 13.56 ha each and Fraction 7 with 22.85 ha.

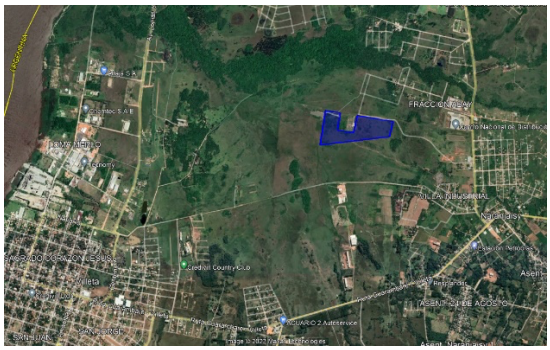
Alternative 2 finally compared to the others was a union of Fraction 1 and Fraction 2, with the following configuration shown in **Figure 3.1.1.1.1.c**.

Figure 3.1.1.1.1.a
Location of land alternatives 1 to 3





Detail 1



Detail 2

Figure 3.1.1.1.1.b
Alternative 2 finally offered to ATOME



Figure 3.1.1.1.c
Alternative 2 in the initial (red) and final (orange) configuration

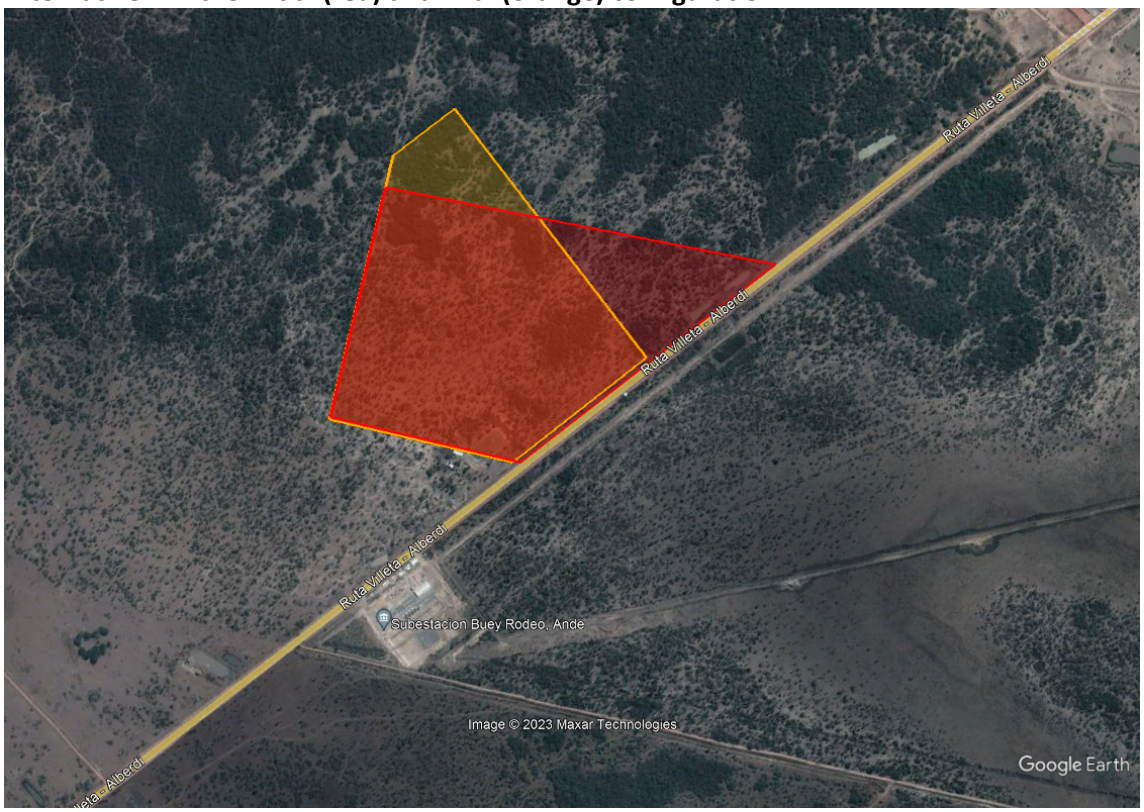


Table 3.1.1.1.1.a below shows the ownership and area data for the 3 land alternatives evaluated.

Table 3.1.1.1.1.a
Data of the evaluated land alternatives

Alternatives	Owner	Surface
1	El Arreglo S.A.	22 ha (5,200 m)^2
2	Monteclaro S.A.	30 ha (7,800 m)^2
3	CDD Construcciones S.A.	18 ha (8,800 m)^2

3.1.1.2
Comparative Analysis

One of the technical criteria considered in the land analysis was the availability of surface area and the format of the plots for the equipment and infrastructure necessary for CAN production. As can be seen, Alternatives 1 and 3 have a much smaller surface area than Alternative 2. Although the Plant *layout* does not cover the 30 ha available in Alternative 2, and must be built on an area of 24.75 ha corresponding to zones A and B in **Figure 2.7.2.1.a** of **Section 2.7.2.1**, the rest of the land, where most of the existing sub-humid forest on the site is located, will in principle be conserved and only ultimately used for future extensions. As for Alternatives 1 and 3, with smaller areas, almost all of the land would be used (Alternative 3) or the area would be insufficient, requiring the layout to be compacted (Alternative 1).

In addition, in Alternatives 1 and 3 the site layout is elongated and shallow, which would lead to the main Plant facilities being too close to the road.

Another criterion assessed was the use and occupation of the land environment. As has been observed, Alternative 3 is located in an area with an unoccupied immediate environment, but is close to the headquarters of the municipality of Villeta, surrounded by urban areas and urban sprawl. For this reason, it is understood that this alternative is more disadvantageous than the others, as the occupied areas could expand in its direction, increasing the number of communities in close proximity and which could be susceptible to disturbance from an industrial plant, such as the proposed project, mainly in the construction phase. Alternatives 1 and 2, on the other hand, are located in a region with a very unoccupied environment, with only one rural residence in the vicinity.

The advantage of Alternatives 1 and 3 is their proximity to the substation (ES), which would greatly reduce the length of the transmission line (TL) that would have to be built. However, this proximity is also disadvantageous, as the configuration of the land occupies almost the entire surroundings of the ES, mainly in Alternative 3, which would prevent a future extension of the ES. Furthermore, in both cases, the land is already being cut by existing TLs, in the case of Alternative 1, a 220 kV TL.

In the case of Alternative 1, the part of the land in front of the inlet *bays* could not be occupied, which would reduce the available land area that could be occupied by the plant structures. Finally, it is important to mention that in the area of Alternative 1 there is a water pipeline for irrigation of rice plantations.

The three alternatives for the location of the Plant site were also assessed in relation to aspects of the Physical Environment, such as geology, hydrogeology, soils, relief and hydrography. The characteristics of each alternative in relation to these aspects are listed in **Table 3.1.1.2.a** below.

Table 3.1.1.2.a
Comparative analysis of the Alternatives in relation to aspects of the Physical Environment

	Alternative 1	Alternative 2	Alternative 3
Geology	Sands, silts, clays, gravels and conglomerate organisms	Sands, silts, clays, gravels and conglomerate organisms	Fine to medium friable sandstones
Hydrogeological units/ Productivity	Quaternary sediment/ Normally low but locally Moderate. Water supply to meet local supply or private consumption.	Quaternary sediment/ Normally low but locally Moderate. Water supply to meet local supply or private consumption.	Patiño-Caacupé/ Normally low but locally Moderate. Water supply to meet local supply or private consumption.

Table 3.1.1.2.a
Comparative analysis of the Alternatives in relation to aspects of the Physical Environment

	Alternative 1	Alternative 2	Alternative 3
Soils	FLdy - Dystric Fluvisols Soils developed in river deposits, without groundwater, sometimes naturally flooded, suitable for crops with controlled irrigation (low fertility).	FLdy - Dystric Fluvisols Soils developed in river deposits, without groundwater, sometimes naturally flooded, suitable for crops with controlled irrigation (low fertility).	LPli-ACpl: Lithic Leptosols and Plintic Acrisols. Leptosols comprise very thin soils on rock and rich in coarse fragments. Acrisols are acid soils with higher clay content in the subsurface. Both are susceptible to erosion processes when exposed.
Altitudes in metres above sea level	Approximately 61 to 65 m	Approximately between 62 and 67 m	Approximately between 64 and 81 m
Shortest distance from main river	2.2 km from the Paraguay River	2.0 km from Paraguay River	3.0 km from Paraguay River
Shortest distance from secondary streams	7.6 km from Paray Stream and 7.2 from Surubiy Stream	7.3 km from Paray Stream and 7 km from Surubiy Stream	0.7 km from Abay Creek

Source: Google Earth Pro (GOOGLE, 2023); MADES (2022).

Looking at **Table 3.1.1.2.a**, it can be seen that, in terms of the Physical Environment aspects, Alternatives 1 and 2 are equivalent. In turn, Alternative 3 has disadvantages with respect to the others, except for hydrogeology. Although Alternative 3 is located in an area with a different aquifer, namely the Patiño/Caacupé Aquifer system, it has approximately the same productivity classification as the aquifers in the area of Alternatives 1 and 2. On the other hand, considering that Alternative 3 has a more urbanised environment, there is a greater possibility of exploitation of the local aquifer.

With respect to geology, while the soils in Alternatives 1 and 2 also have sandy layers in addition to silt and clay, the sandstones mapped in the Alternative 3 area are extremely friable and susceptible to erosion when exposed in sections of the terrain. The soils mapped in the Alternative 3 area are also shallow and texturally differentiated, resulting in increased susceptibility to erosion, especially when exposed to rainfall.

In terms of relief, Alternative 3 presents a greater slope, as it is located at altitudes between approximately 64 m and 81 m, resulting in a maximum slope of 17 m between the extremes of the terrain. Thus, in contrast to Alternatives 1 and 2, which have slopes of less than 5 m, for Alternative 3 the earthworks would be greater, requiring larger cuts and a larger area for deposition of excess soil, or greater demand for volumes of borrowed material, the extraction areas of which can also generate related environmental impacts.

With respect to hydrography, the three alternatives are located at a short distance from the Paraguay River, with Alternatives 1 and 2 being approximately 2.2 km and 2 km, respectively, from that body of water, and Alternative 3 being approximately 3 km away. In any case,

considering that water from the Paraguay River will be used, Alternative 2 is closer and has an advantage in this respect.

On the other hand, although none of the alternatives are located near secondary streams, Alternative 3 is located at a shorter distance, about 0.7 km from Abay Creek, and Alternatives 1 and 2 are located 7 km from Surubiy and Paray Creeks. Thus, Alternatives 1 and 2 are considered less likely to have indirect impacts on hydrologically sensitive areas.

Table 3.1.1.2.b presents the characteristics of the land alternatives analysed in relation to vegetation cover and land use. This issue is important, as it will be necessary to remove vegetation on about 20 ha in order to install the Plant's structures.

Table 3.1.1.2.b
Land cover and land use

	Alternative 1	Alternative 2	Alternative 3
Coverage and current use (year 2023)	Hydro morphic savannahs wooded with black palm or Karanda'y (*Copernicia alba*) and forest islands, with recent livestock use, with some more depressed areas that constitute the natural drainage of the clay soils on very flat relief.	Hydro morphic savannahs wooded with black palm or Karanda'y (*Copernicia alba*) and forest islands, with recent livestock use, with many more depressed areas that constitute the natural drainage of the clay soils on very flat relief.	In 2023 the fraction was occupied with cultivated rice fields, on flooded plots with surrounding taipas, built earlier, most likely between 2020 and 2022, as they were covered by growing rice crops.

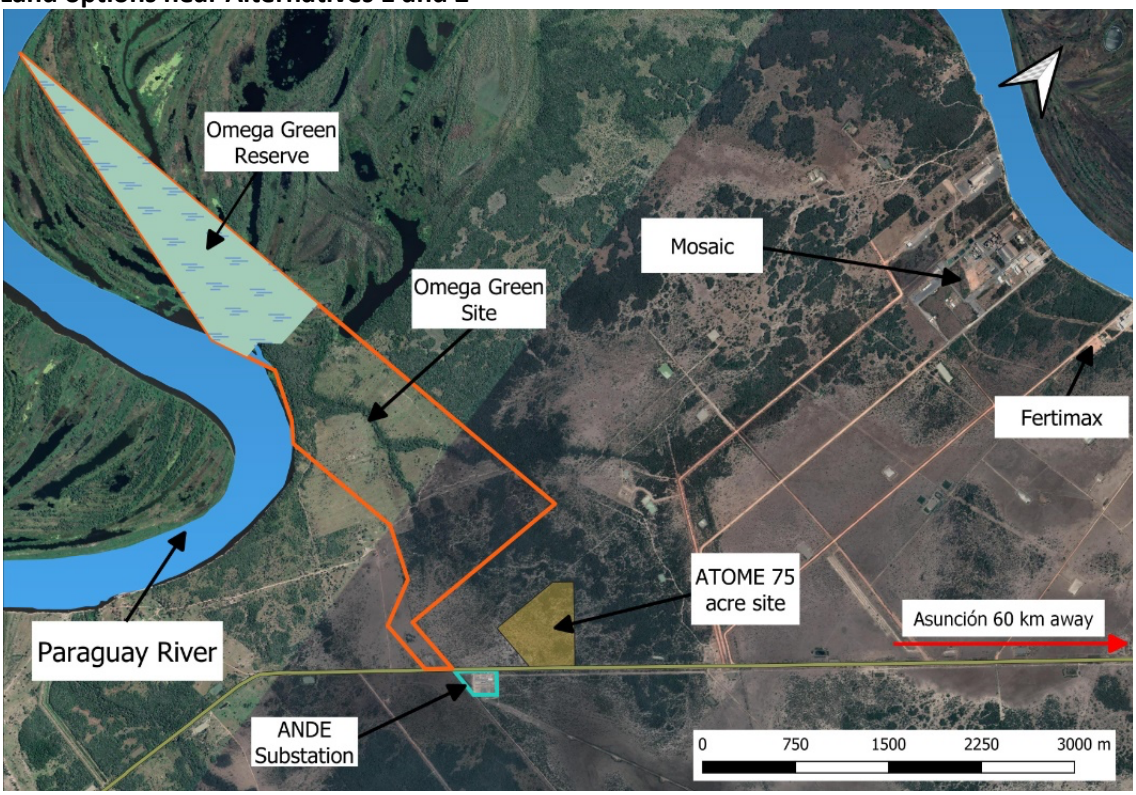
It can be seen that, from a vegetation point of view, Alternative 3 is more advantageous, as it has an agricultural use, while the other two are areas already used as pasture, but have native vegetation.

In any case, a comparison of Alternatives 1 and 2 shows that Alternative 2 has an advantage, as it has a surplus surface area in relation to the needs of the project, which could be retained .... In Alternative 1, with 22 ha, all the land would be occupied by the project structures, and the layout would even have to be compressed.

In the vicinity of Alternative 2, on the northeast side, there are plots of land closer to, but with similar characteristics to Alternative 2, and others more anthropised, but further away from the SE Buey Rodeo (see yellow polygon in **Figure 3.1.1.2.2.a**), increasing the length of the TL to be built, as well as not being for sale.

On the southwest side, there is the neighbouring landowner's land (see purple polygon in **Figure 3.1.1.2.a**), where the only existing residence in this area is located, followed by part of the Omega Green company's land (see red polygon). The other existing options in the direction of the Paraguay River have similar conditions to the land of Alternative 2.

Figure 3.1.1.2.a
Land options near Alternatives 1 and 2



Taking into account the above reasons, Alternative 2 has been chosen as the most advantageous.

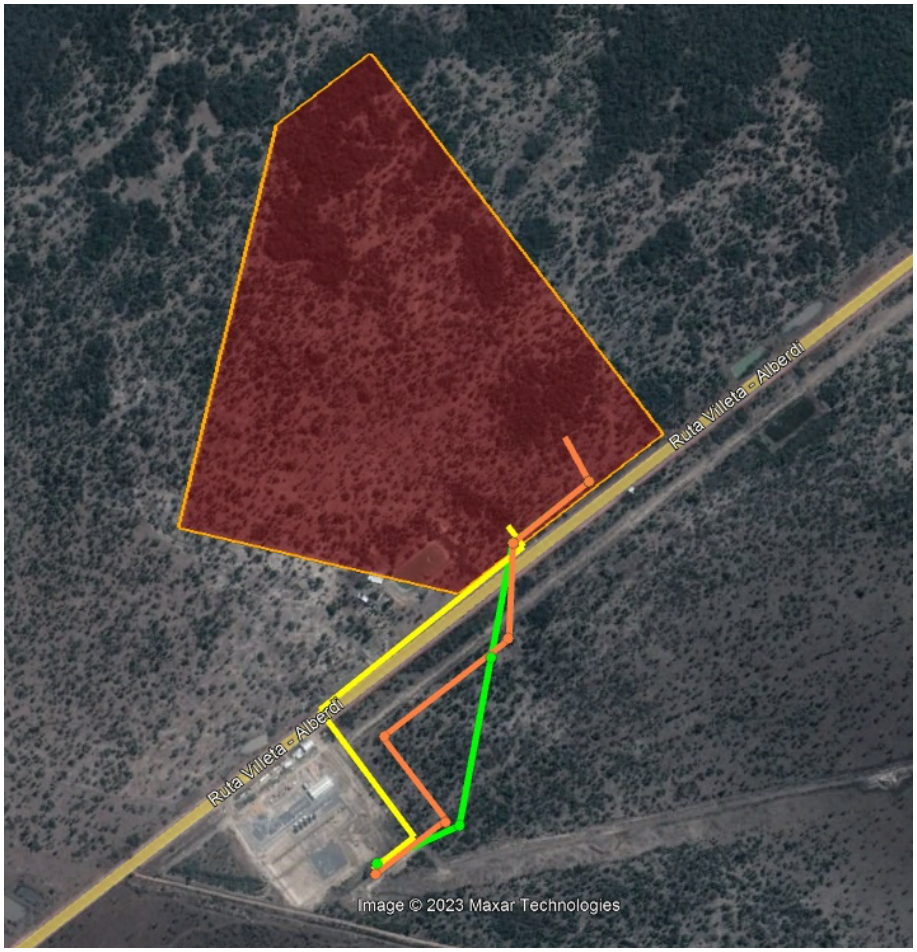
3.1.2
Transmission Line Route Alternatives

3.1.2.1
Alternatives Evaluated

Once Alternative 2 was chosen for the site where the Plant will be built, the layout alternatives for the Transmission Line (TL) linking the ANDE Buey Rodeo Substation (SE) to the Plant's SE were studied.

Three alternatives were evaluated and are shown in **Figure 3.1.2.1.a**, below.

Figure 3.1.2.1.a
Route alternatives for the LT



Caption:

Alternative 1
Alternative 2
Alternative 3

Alternative 1, in yellow, leaves the Buey Rodeo ES in a north-easterly direction, turns north-west immediately after and continues very close to the eastern side of the ES, crossing the existing 66 kV TL (in blue in **Figure 3.1.2.1.a**) and then the road. At this point it turns northeast again and continues for about 370 m on the road domain strip, skirting the outer boundary of the land adjacent to the plant site, turning northeast again to reach the ES.

Alternative 2, coloured orange, leaves the Buey Rodeo ES also in a north-easterly direction, but follows a slightly longer section in this direction, also turning off to the north-west and continuing in this direction a little further away from the limits of the ES for about 150 m until it turns off again to the north-east and continues for another about 225 m parallel to the existing 66 kV TL. At this point it turns north, crosses the 66 kV TL and the road and continues to the plant site, having to make a further deviation to the north-west to reach the ES.

Alternative 3, shown in green in **Figure 3.1.2.1.a**, leaves SE Buey Rodeo in almost the same direction as the other alternatives, and after about 130 m turns northeast, following directly to the entry point at the plant site, crossing the 66 kV TL and the road at a different angle of 90º.

Alternatives 2 and 3 are located within the same property (**Figure 3.1.2.1.b**), Fraction 1B shown in **Figure 3.1.2.1.b** in **Section 3.1.1.1**, with 22.52 ha, owned by El Arreglo S.A. Alternative 1 also crosses this same property up to the point where it crosses the road, then follows the road right-of-way close to the boundary of the farm next to the plant.

Figure 3.1.2.1.1.b
Property-related layout alternatives



3.1.2.2
Comparative Analysis

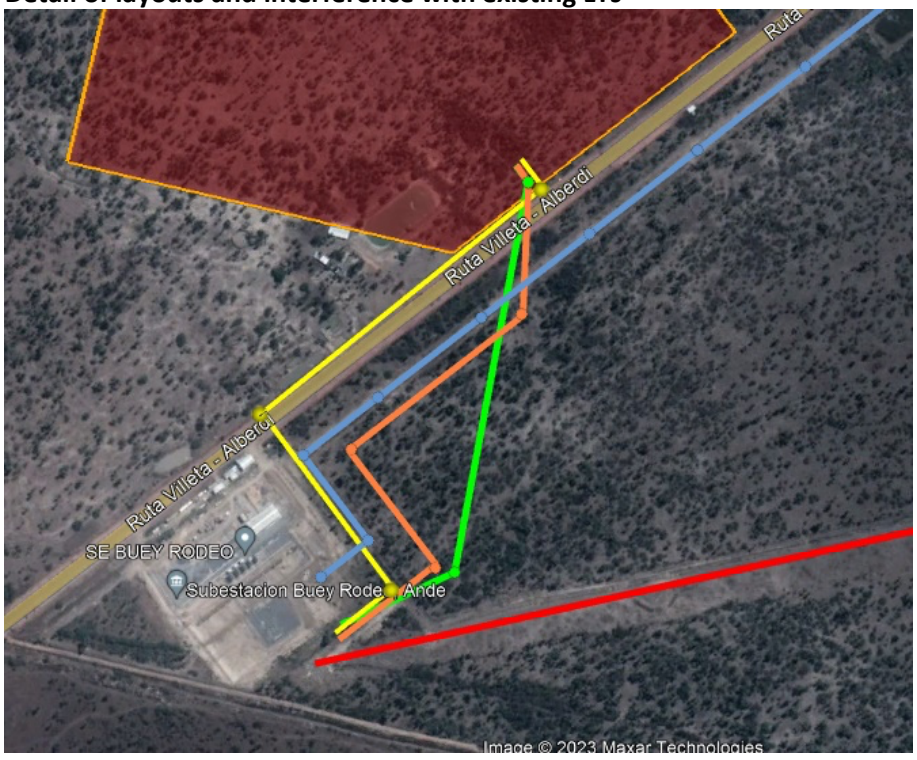
Table 3.1.2.2.a compares the length and number of vertices of the three route alternatives evaluated. As can be seen, Alternative 3 is the shortest and has the fewest vertices. In addition, it has the advantage of making deviations at a more favourable angle than the other two, which make deviations at 90º.

Table 3.1.2.2.a
Length and number of vertices of the Alternatives

Layout	Length	Number of vertices
Alternative 1	~ 692 m	3
Alternative 2	~ 642 m	4
Alternative 3	~ 550 m	2

As shown in **Figure 3.1.2.1.c** and discussed in the previous section, all three routes need to cross the existing 66 kV TL, shown in blue in the figure. None of the routes need to cross the existing 220 kV TL, shown in red.

Figure 3.1.2.1.c
Detail of layouts and interference with existing LTs



Caption:

Alternative 1
Alternative 2
Alternative 3
Existing LT 66 kV
Existing 220 kV TL

All three routes pass through flat, non-flooded areas and do not interfere with improvements, protected areas or large patches of vegetation.

Comparing the alternatives in relation to interference with some of the most important land use categories resulting from the mapping carried out in the area of direct influence of the project (see **Figure 3.1.2.1.d**), it can be seen that Alternative 1 is the one that crosses the most anthropised areas, with a route in this use almost three times greater than the other two alternatives. Alternatives 2 and 3 intersect fewer areas of anthropogenic use, but this is not reflected in a greater impact on native vegetation, as all three routes interfere with the Savannah in similar amounts, slightly more in Alternative 2, as shown in **Table 3.1.2.2.b.**

Figure 3.1.2.1.d
Land use and land cover along the Route Alternatives for the LT



Caption:
SA - Native vegetation - Savannah US - Silvopastoral use
CA - Rice cultivation UA - Anthropic use

Alternative 1, turning northwest just after leaving the SE and following parallel to the substation until it crosses the road, avoids the rice-growing areas and basically crosses anthropised areas and small areas of savannah. This route, being the only one that leads to the plant on the north-western edge of the road, is the alternative that is closest to the neighbour's house. With this proximity between the work fronts for the implantation of the TL and the residence, this alternative is the most unfavourable in relation to the risk of impacts and nuisances for these residents, such as those caused by noise and dust emissions, and those which may derive from contact with the workers.

Table 3.1.2.2.b
Area (ha) of interception of the different land uses by the service strip (6 m) of the Alternatives

Layout	Anthropic uses	Savannah	Rice cultivation
Alternative 1	0.34	0.06	0.00
Alternative 2	0.09	0.08	0.22
Alternative 3	0.1	0.06	0.17

In view of the above, the route chosen for the LT was Alternative 3 (green).

3.1.3
Routing Alternatives for Treated Water and Effluent Pipelines

3.1.3.1
Alternatives Evaluated

Three alternative routes were evaluated for the passage of the water and treated effluent pipes, which will connect the plant site with the Paraguay river, where the water for the process will be collected and the treated effluent will be discharged. **Figure 3.1.3.1.1.a** shows the 3 alternatives evaluated, which are described below.

- Alternative 1 (in green in **Figure 3.1.3.1.1.a**) - a route that follows a south-westerly direction, then turns north-west and then west, until it reaches the point on the Paraguay River where the water catchment and effluent discharge is planned, at UTM coordinates 427.052.08 m E and 7,156,478.89 m S. This route follows within the property where the Omega Green biofuel production plant is planned, following the edge of the land, crossing mainly the planned green areas (see detail 2 of **Figure 3.1.3.1.1.a**).
- Alternative 2 (in blue in **Figure 3.1.3.1.1.a**) - a route that follows a predominantly south-westerly direction, crossing part of the planned Omega Green plant facilities, but then leaves this project area and crosses another property to reach the effluent collection and discharge point into the Paraguay River, at UTM coordinates 427,219.50 m E and 7,155,988.00 m S.
- Alternative 3 (in red in **Figure 3.1.3.1.1.a**) - a route that continues north, avoiding the Omega Green project area. It follows parallel to a rural road and the outer boundary of the Biofuel Production Industrial Complex/ECB Group property, until it reaches the point where the effluent is collected and discharged into the Paraguay River, at UTM coordinates 430,099.45 m E and 7,161,869.49 m S.

Figure 3.1.3.1.1.a
Route alternatives evaluated for water and effluent pipelines



Caption:

Alternative 1
Alternative 2
Alternative 3

3.1.3.2
Comparative Analysis

Three different sets of criteria were used to compare the alternatives. They are as follows:

- Hydraulic criterion: this consists of assessing the head losses, speeds, pipe dimensions and pump power required for each alternative;
- Social criterion: refers to the number of properties that each line passes through;
- Environmental criterion: assesses the environmental sensitivity of the areas crossed by each route.

In order to compare the lines according to each set of criteria above, some information on each alternative was collected and is shown in **Table 3.1.3.2.2** below:

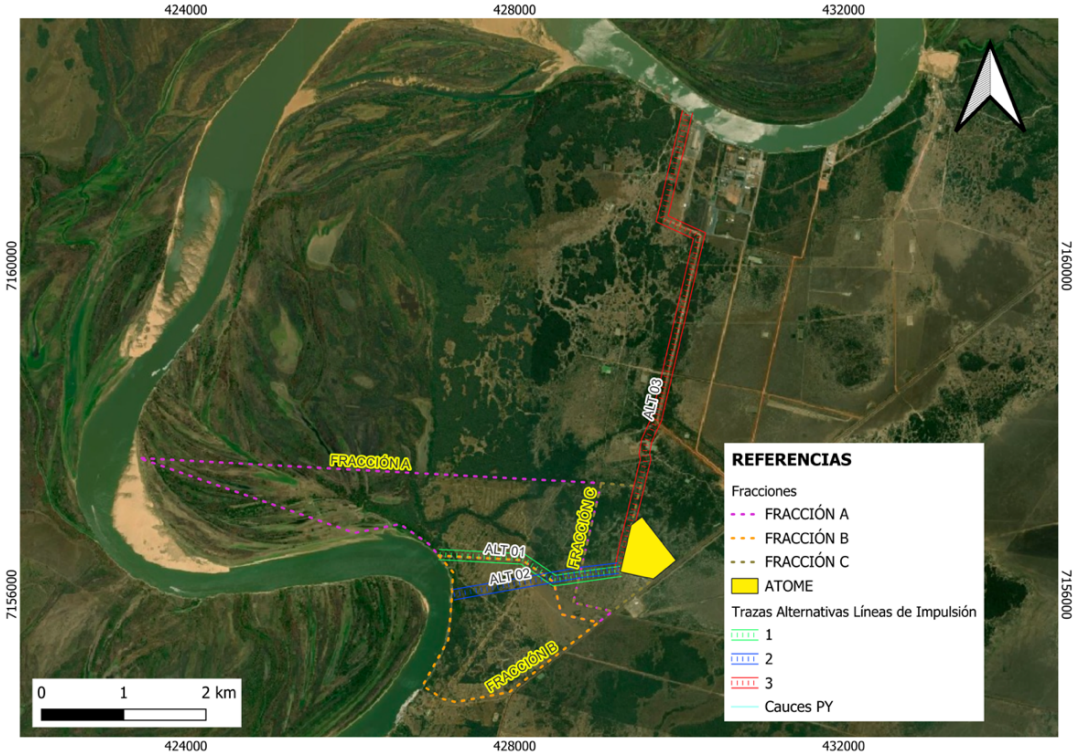
Table 3.1.3.2.a
Comparative analysis between the alternatives

	Length (m)	Number of properties it passes through	Number of watercourses crossed	Extent of forest crossed (m)
Alternative 1	2,297.20	2	0	266.58
Alternative 2	2,026.80	3	0	531.81
Alternative 3	6,015.72	more than 3	1	3,374.34

As can be seen in **Table 3.1.3.2.a**, with regard to the length parameter, Alternatives 1 and 2 are similar, with a length between 2 and 2.3 km, while Alternative 3 is practically three times longer than the previous ones. The longer length of Alternative 3 compared to the others has the disadvantage that friction losses will be considerably higher on this route, which implies higher pump power, higher energy/fuel use, and thus higher costs.

If the parameter relating to the number of properties crossed is considered, the same situation occurs. Alternative 1 mainly crosses through Fraction A shown in **Figure 3.1.3.2.2 below**, owned by the Omega Green company, plus a small tract of land just after leaving the Plant site, owned by [redacted] the same owner of Fraction B also shown in the figure.

Figure 3.1.3.2.a
Drawing alternatives in relation to the properties traversed

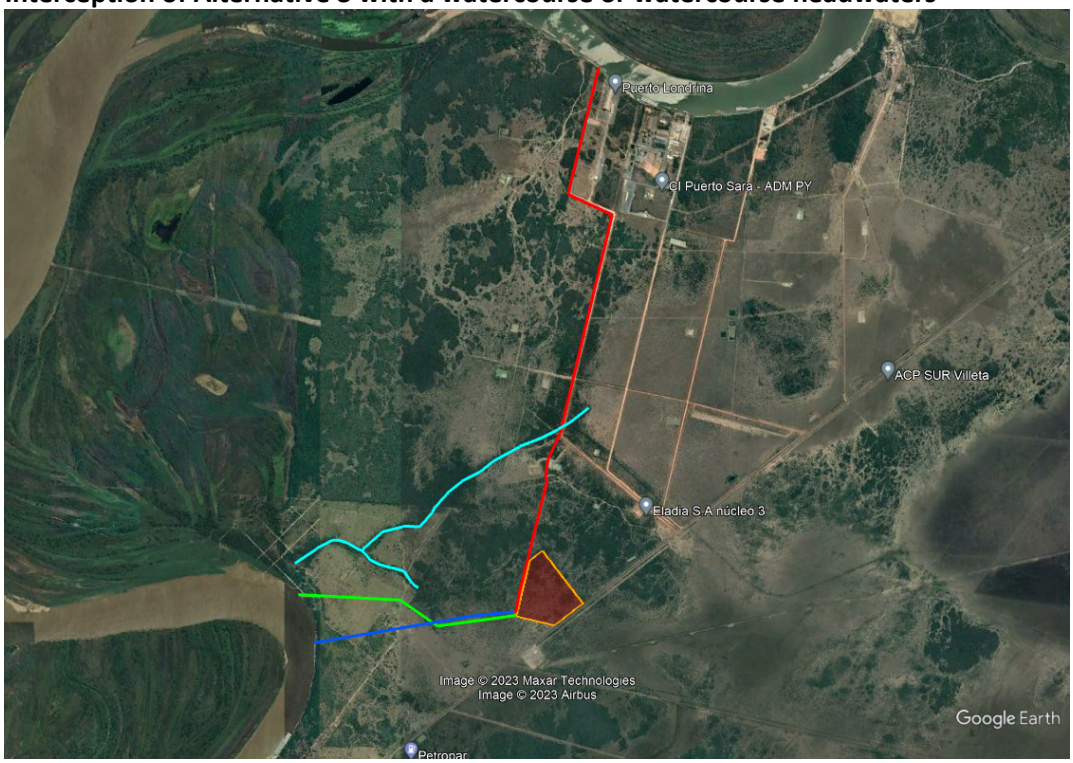


Source: Alternatives for the layout of the Paraguay River Water Extraction and Return of Treated Water. Report.

Alternative 2, on the other hand, also crosses that small tract of [redacted] land and then Fractions A and B. Alternative 3, in turn, due to its greater length, would cross a large number of properties.

In addition to the aforementioned shortcomings of Alternative 3, it is also worth considering the fact that it would cross a stream or spring about halfway along its route, a situation that is not observed for Alternatives 1 and 2, as shown in **Figure 3.1.3.2.b.**

Figure 3.1.3.2.b
Interception of Alternative 3 with a watercourse or watercourse headwaters



Caption:

Alternative 1
Alternative 2
Alternative 3
Source or headwaters

As already mentioned in **Table 3.1.3.2.a**, Alternative 3 crosses more sensitive areas from the point of view of interference with native vegetation. As can be seen in **Table 3.1.3.2.b** below, which shows in detail the quantitative data for the different land use and land cover categories along the route of each of the alternatives, the sub-humid forest interception in Alternative 3 is 12.5 times higher than in Alternative 1, and slightly more than 6 times higher than in Alternative 2. Considering the Savanna interception, Alternative 2 is the most advantageous, with 17% less intervention than Alternative 1 and 9% less than Alternative 3.

Table 3.1.3.2.b
Land use and land cover along the alternatives

Categories	Alternative 1		Alternative 2		Alternative 3	
	Ext. (m)	Ext. (%)	Ext. (m)	Ext. (%)	Ext. (m)	Ext. (%)
Sub-humid forest	266.58	12%	531.81	26%	3,374.34	56%
Savannah	1,111.52	48%	918.42	45%	1,011.52	17%
Other anthropic uses	919.09	40%	576.57	28%	1,629.86	27%
Total	2,297.20	100%	2,026.80	100%	6,015.72	100%

Considering the two types of native vegetation together, Alternative 1 is the most advantageous, with a total of 1,378.1 m or 60% of the route, followed by Alternative 2, with 1,450.23 m or 71% of the route. The worst in this respect is undoubtedly Alternative 3, with 73% of its route intercepting native vegetation, and of this total, 56% is sub-humid forest. In the case of the other two, interference with the forest represents 12% and 26% of the route, respectively.

Alternative 1 is the route that sought to interfere with anthropogenic areas as much as possible, with 40% of the route in this category, while Alternatives 2 and 3 have 28% and 27%, respectively.

In view of the above, Alternative 3 was discarded, leaving only Alternatives 1 and 2 as options.

As mentioned, the routes of Alternatives 1 and 2 are very similar in length and consequently in costs and pumping requirements. Although Alternative 1 is slightly longer than Alternative 2, the variation is minor and would not result in a change in pumping requirements (pump power) and head losses.

Both routes do not cross water bodies or interfere with sub-humid forest vegetation, intercepting only savannah vegetation.

Therefore, the decisive parameter in the choice of route was the number of properties crossed by both alternatives and the interference with improvements. Alternative 1 was chosen because it is more favourable as it crosses only a section of [redacted] property and only a section of fraction A, then runs along the boundary to the Paraguay River. In this way, although part of the easement strip overlaps Fraction B, all the works will be carried out only within Fraction A. In addition to this, the route adopted by Alternative 1 does not directly interfere with or approach dwellings or any other type of rural improvement. Alternative 2 in turn crosses the [redacted] property, and Fractions A and B, with the works affecting all three properties. In addition, this Alternative 2 route directly affects a house and shed on the Estancia Lola property (see **Figure 3.1.3.2.2.c**).

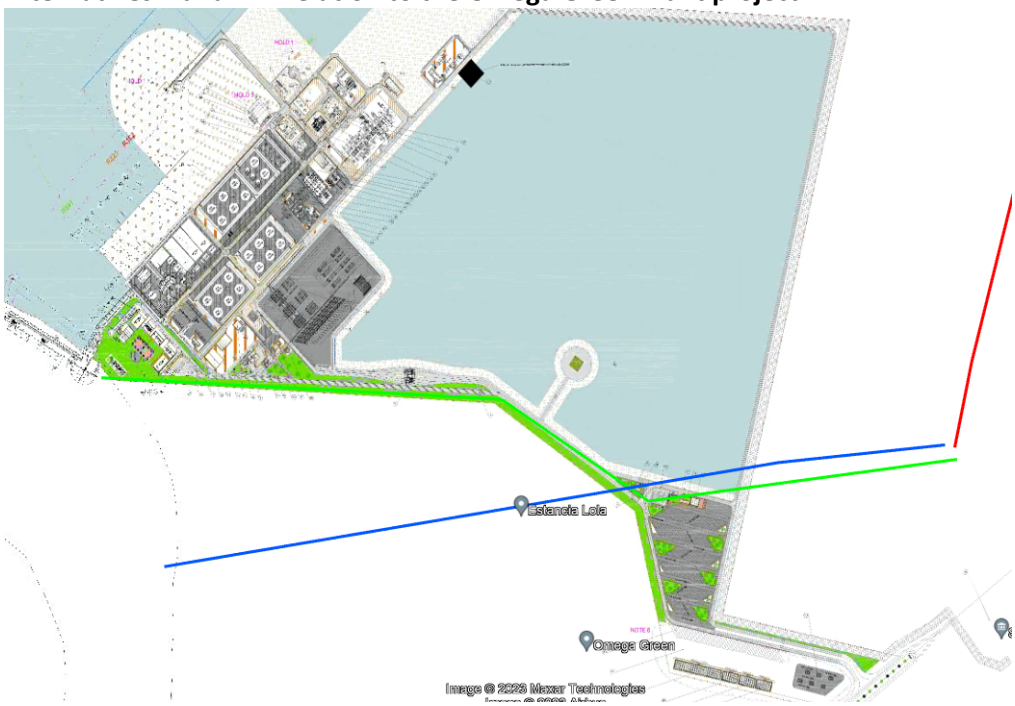
Figure 3.1.3.2.c
Interference of Alternative 2 with improvements



Caption:
Alternative 2

As mentioned at the beginning of this section, when crossing Fraction A, both Alternative 1 and Alternative 2 cross the area where the Omega Green biofuel plant is planned, as shown in **Figure 3.1.3.2.d** below. While Alternative 1 only passes through green areas (details 1 and 2 in the Figure) and under the reception and security hut (number 12 in detail 1 in the Figure), Alternative 2, although it crosses a smaller section of the project area, crosses precisely where the hydrosanitary system structures (40), the reception and dispatch area (4), the check-in sector and shipping office (19) and the truck reception building (23) are planned (see detail in the Figure).

Figure 3.1.3.2.d
Alternatives 1 and 2 in relation to the Omega Green Plant project



Detail 1



Detail 2



Caption:

Alternative 1
Alternative 2

On the basis of the above, taking into account the technical, financial, social and environmental criteria, Alternative 1 was selected for the water and effluent pipeline corridor.

3.2
Technological and Economic Alternatives

Studies of technological and economic alternatives were carried out for the following elements of the process:

- Electrolysis of H_2
- Recovery of products from air
- Synthesis of NH_3
- CAN storage
- Cooling system
- Water treatment
- Water source for the process

For the Nitric Acid (NA), Ammonium Nitrate Solution (ANS) and Granulation (GRAN) production processes no alternatives were evaluated, as those adopted in the Project are the best available in technical, environmental and economic terms. **Sections 2.6.1** and **2.6.2** of this ESIA describe the technologies adopted for the above processes.

3.2.1
Alternative H_2

3.2.1.1
Evaluated Technologies

The H_2 electrolysis technology alternatives evaluated were:

- Pressurised Polymer Electrolyte Membrane (PEM)
- MEP Atmospheric
- Alkaline Pressurised
- Alkaline Atmospheric
- Solid Oxide Electrolyzer Stack (SSEP)
- Anion Exchange Membrane (AEM)

Pressurised polymer electrolyte membrane (PEM)

Polymer electrolyte membrane electrolysis (PEM) of water is a process of decomposition/dissociation of water into its elementary molecules (H_2 and O_2) in a cell equipped with a solid polymer electrolyte that provides proton conduction, separation of the product gases and electrical isolation of the electrodes. The reaction is an improvement on traditional alkaline electrolysis that avoids the use of electrolyte, producing purer crude hydrogen with slightly higher efficiency.

The reaction takes place in a pressurised electrolysis stack and (typically at 30 barg), which reduces the overall dimensions of the equipment (see example in **Figure 3.2.1.1.a**) and avoids or reduces the subsequent compression requirements.

Figure 3.2.1.1.a
Example of pressurised MEP electrolyser stacks

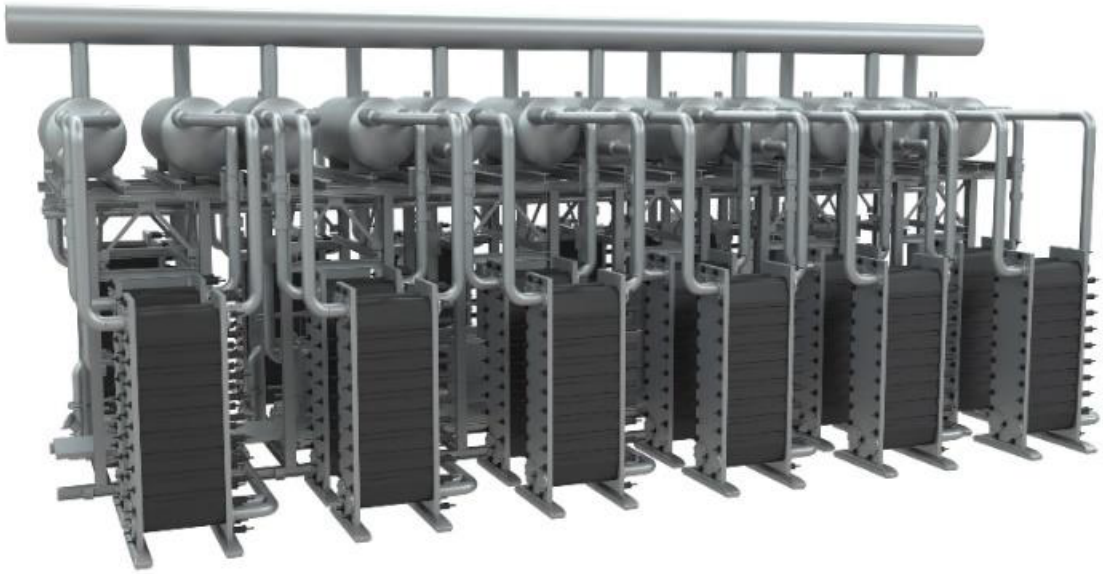


Source: http://itm-power.com.

Atmospheric MEP

Same technology as pressurised PEM, except that the reaction takes place in a non-pressurised electrolysis stack (usually at atmospheric pressure), which increases the overall dimensions of the equipment (see example in **Figure 3.2.1.1.b**) and usually requires a downstream hydrogen compressor unit.

Figure 3.2.1.1.b
Example of atmospheric MEP electrolyser stacks



Source: https://new.siemens.com/

Pressurised alkaline

The alkaline electrolysis of water is a process of decomposition / dissociation of water into its elementary molecules (H_2 and O_2) by the action of an electric current. For this to be possible, the demineralised water must be in contact with an electrolyte that promotes the circulation of electrons through the fluid (usually KOH or NaOH).

The electrolyte is not consumed directly, but is recovered during the process and re-injected into a closed circuit.

The reaction takes place in a pressurised electrolysis stack (typically between 15 and 30 barg depending on the manufacturer), reducing the overall dimensions of the equipment (see example in **Figure 3.2.1.1.c**), and avoiding or reducing further compression requirements.

The final streams of H_2 and O_2 circulate separately through a different separation and purification unit to reduce the impurity content of the electrolyte and condense any traces of water in order to obtain purer streams.

Figure 3.2.1.1.c
Example of pressurised ALK electrolyser stack



Source: https://www.longi.com/

Atmospheric alkaline

Same technology as pressurised alkaline, except that the reaction takes place in a non-pressurised electrolysis cell (usually at atmospheric pressure), which increases the overall dimensions of the equipment (see example in **Figure 3.2.1.1.d**) and usually requires a downstream hydrogen compressor unit.

Figure 3.2.1.1.d
Example of atmospheric ALK electrolyser



Source: www.thyssenkrupp.com

Solid Oxide Electrolyzer Stack (SSEP)

A PEOS is a solid oxide fuel cell that operates in regenerative mode to achieve electrolysis of water using a solid oxide, or ceramic, electrolyte to produce hydrogen gas and oxygen. The reaction takes place at high temperature (500 - 850 °C). The separated, unreacted vapour is recycled back to the electrolysis cells.

PEOS is one of the most promising methods of hydrogen production due to its high conversion efficiency and relatively low energy input compared to other mature technologies.

Current commercial models of PEOS (see example in **Figure 3.2.1.1.e**) experience performance problems and low availability. The technology is being improved.

Figure 3.2.1.1.e
Example of a pilot PEOS electrolyser



Source: www.sunfire.de

Anion exchange membrane (AEM)

MIA electrolysis is the electrolysis of water using a semi-permeable membrane that conducts hydroxide (OH-) ions called an anion exchange membrane. Like a proton exchange membrane (PEM), the membrane separates the products, provides electrical isolation between the electrodes and conducts the ions.

MIA is seen as a promising intermediate solution (in terms of cost and performance) between alkaline and MEP.

Unlike MEP, MIA conducts hydroxide ions. The main advantage of MIA water electrolysis is that it does not require a high-cost noble metal catalyst, but a low-cost transition metal catalyst.

MIA electrolysis is similar to alkaline water electrolysis, which uses a non-selective ion separator instead of an anion exchange membrane. Current commercial MIA models (see example in **Figure 3.2.1.1.f**) are only suitable for small-scale applications. Augmentation technology is under development.

Figure 3.2.1.1.f
MIA electrolyser concept



Source: www.enapter.com

3.2.1.2
Comparative analysis

After evaluation of the mature technologies available on a large scale, pressurised alkaline electrolysis was selected as the most cost-effective solution, with reduced price, high reliability, proven technology on a large scale and reduced electrical compression load requirements.

The result of the comparative study is as follows:

Figure 3.2.1.2.a
BoL efficiency of different electrolyser technologies

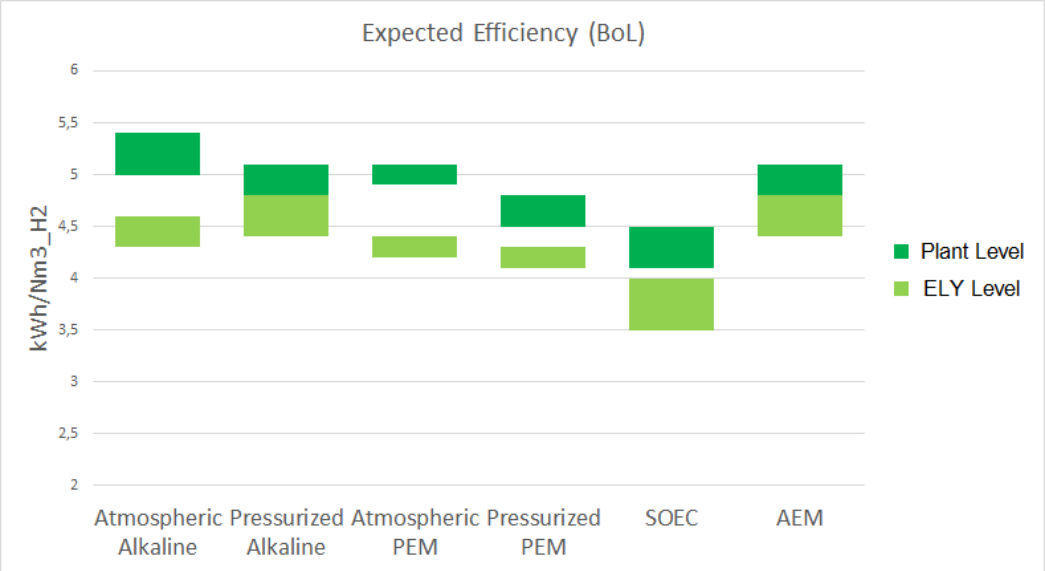
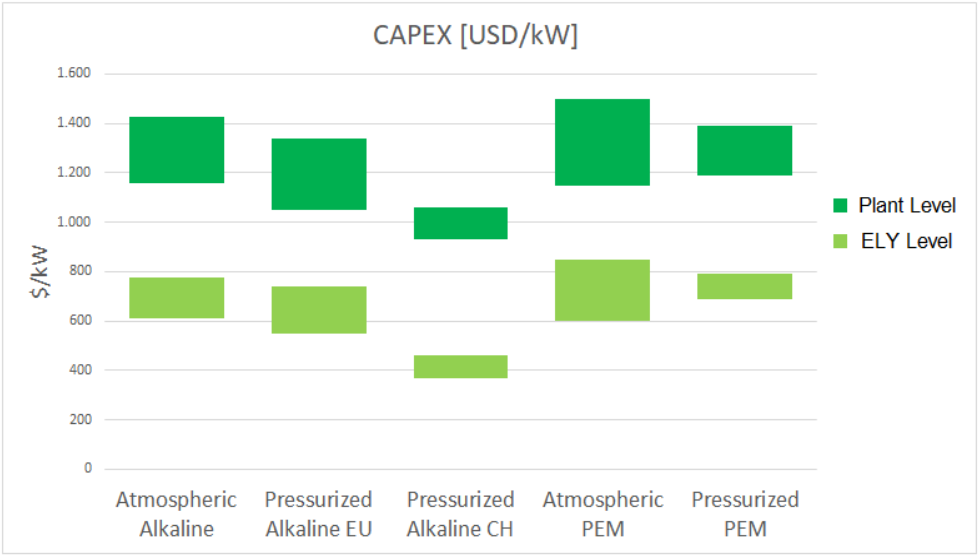
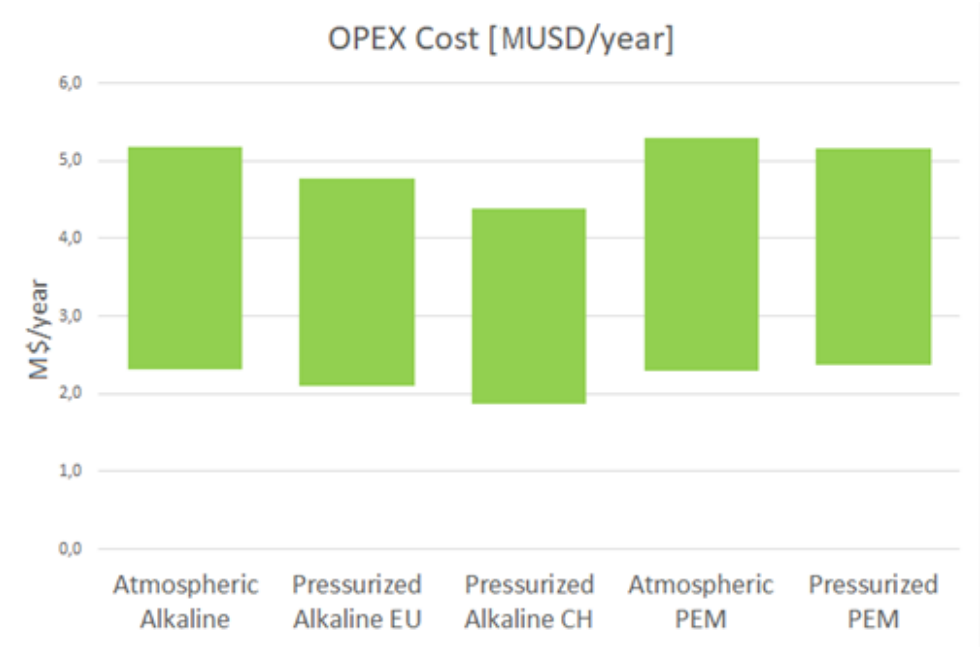


Figure 3.2.1.2.b
CAPEX and OPEX of the different electrolyser technologies for the Villeta project





Alkaline water electrolysis is a mature technology for producing hydrogen using electricity and is perfectly suited for base-load energy input. Alkaline technology has been used for more than a century in its atmospheric version, and for two decades in its pressurised version.

3.2.2
Air Product Recovery Alternatives

3.2.1.1
Options Assessed

Recovery options were assessed for the following air products:

- Oxygen from electrolysis
- Oxygen-enriched process air from the Air Separation Unit (USA)
- Argon-enriched process air from the ASU

Oxygen from electrolysis

The plant's electrolysers produce:

- Gross O_2 flow rate: 16,200 kg/h of raw oxygen
- O_2 pressure : 15~30 bar
- Purity of O_2 : 98.5% (typical)

Oxygen is vented to the atmosphere, however, the design shall provide for the allocation of space for future equipment necessary to purify and dry, compress and store or pipe the oxygen produced.

Optionally, a liquefaction unit can be installed to produce liquid oxygen (LOx).

Oxygen contaminants can be removed by a DeOxo-Dryer Unit.

After purification, the oxygen will have the following purity:

- Purity of O_2 : > 99.99 % by weight
- Contaminants: H_2 and H O_2

Oxygen from air separation unit (USA)

The plant's USA will be prepared to produce oxygen as a by-product of the process. The proposed USA produces raw air without nitrogen, and is not capable of producing oxygen as a further separation stage is required and is not included in the design.

The USA Plant can produce:

- O_2 flow rate : >2,800 kg/h
- O_2 pressure : 6 bar
- Purity of O_2 : > 99.9 % by weight
- Contaminants: H_2 O, N_2 and Ar

The layout will provide space for future equipment needed to add a new separation stage in the USA, purify and dry, compress and store or pipeline the oxygen produced.

As an option, a liquefaction unit can be provided to produce liquid oxygen (LOx). This unit can be shared with the Oxygen Liquefaction Plant of the Electrolyser Plant.

USA Oxygen and Electrolysis combined

As a combination of the above O2 recovery systems, a common liquefaction plant can be provided to recover a total of 19,000 kg/h (2800 kg/h from USA and 16,200 kg/h from electrolysis).

The USA will require a new distillation column, and the electrolysis plant will require a new O_2 purification unit. The liquefaction, storage and export stage is shared for both streams.

Argon from the ASU

The USA produces argon as a by-product of the process. However, the design does not provide for an argon separation stage so the plant will not be ready to produce argon as a product.

The characteristics of the argon generated are:

- Flow rate of O_2 : to be defined.
- O_2 pressure : 6 bar (preliminary)
- Purity of the O_2 : > 99.995 % by weight
- Pollutants: H_2 O and O_2

3.2.1.2
Comparative Analysis

Investment costs (CAPEX)

The scope of the evaluation considers:

Cost no. 1 - Recovery of O_2 from electrolysers:

- O_2 DeOxo dryer (purification unit)
- O_2 liquefaction unit and liquid O_2 storage tanks, vertical cylinder type
- LO storage$_2$
- LO export terminal$_2$
- Piping, wiring, instrumentation and control system

Cost No. 2 - Recovery of O_2 from USA:

- USA O_2 separation stage unit (additional distillation column)
- O_2 liquefaction unit and liquid O_2 storage tanks, vertical cylinder type
- LO storage$_2$
- LO Export Terminal $_2$
- Piping, wiring, instrumentation and control system

Cost No. 3 - Recovery of O_2 from USA and electrolysers:

- Electrolysis O_2 DeOxo dryer (purification unit)
- USA O_2 separation stage unit (additional distillation column)
- O_2 liquefaction unit and liquid O_2 storage tanks, vertical cylinder type
- O export terminal$_2$
- O_2 liquefaction unit and liquid O_2 storage tanks, vertical cylinder type
- LO storage$_2$
- LO export terminal$_2$
- Piping, wiring, instrumentation and control system

Table 3.2.1.2.2.a
baseline CAPEX for oxygen recovery, conditioning, storage and export alternatives

Alternatives	Cost 1 (Electrolyser)	Cost 2 (USA)	Cost 3 (Electrolyser+USA)
Amount of O_2	16,200 kg/h 388 ton/d 137k ton/year	2,800 kg/h 67 ton/d 23k ton/year	19,000 kg/h 460 ton/d 160k ton/year
CAPEX	7 m$	4 m$	10 m$

Operating costs (OPEX)

Table 3.2.1.2.b below shows the OPEX parameters of the different NH storage solutions$_3$.

Table 3.2.1.2.b
Benchmark OPEX for different storage solutions

Alternatives	Cost 1 (Electrolyser)	Cost 2 (USA)	Cost 3 (Electrolyser+USA)
Amount of O_2	16,200 kg/h 388 ton/d 137k ton/year	2,800 kg/h 67 ton/d 23k ton/year	19,000 kg/h 460 ton/d 160k ton/year
Fixed OPEX	140,000 $/year	80,000 $/year	200,000 $/year
Variable OPEX	1.5 kWh/kg		

3.2.3
Alternative NH_3 Synthesis Technologies

3.2.3.1
Technologies Evaluated

The NH_3 synthesis technology alternatives$_3$ evaluated were:

- Haber-Bosch (mature technology)
- Electrochemical synthesis (emerging technology)
- Non-Thermal Plasma Synthesis (emerging technology)
- Solid State Ammonia Synthesis (incipient technology)

Haber-Bosch (mature technology)

The Haber-Bosch process is a well-established N fixation process$_2$ that has been used to produce NH_3 on an industrial scale since the early 20th century. Traditionally, the process is steam-driven, but this ATOME Plant will adopt an electrically driven process alteration to eliminate the need for on-site steam production.

H_2 and N_2 enter the NH synthesis unit$_3$ from the electrolysis unit and the air separation unit, respectively. The two gas streams are compressed by multi-stage compression at 15-25 MPa. The compressed stream is mixed with a recycle stream coming from the reactor containing H_2 and unreacted N_2 . This stream is preheated in the feed heat exchanger using the output stream of the Haber Bosch reactor (see example in **Figure 3.2.3.1.a**). During start-up, an electric heater can be used to heat this current. This mixed stream then enters the Haber-Bosch reactor for the synthesis of NH_3 using an excess of N_2 in a ratio N_2 : H_2 of 1:2. The reaction is normally carried out at 15°C. The reaction is normally carried out at 15 - 25 MPa and 400 - 450°C using an iron-based catalyst.

A stream of produced NH_3 and unreacted H_2 and N_2 leaves the Haber-Bosch reactor and is cooled in the reactor feed heat exchanger and in the secondary cooler. The cooled stream then enters a condenser where the NH_3 product is condensed, separated and sent to storage. Unreacted gaseous H_2 and N_2 leave the condenser and are recycled to mix with the incoming H_2 and N_2 feed stream.

A purge stream is supplied to the flare to avoid accumulation of unreacted traces in the system. A vapour recovery system shall be installed in this purge stream to extract unreacted H_2 and recycled NH_3 as valuable reagent and product.

Figure 3.2.3.1.a
Example of a Haber-Bosch ammonia reactor from CASALE



Electrochemical synthesis (emerging technology)

Electrochemical NH production technologies[3] are divided into three categories depending on the operating temperature range of the electrochemical cell: low temperature, below 100°C, intermediate temperature in the range of 100-400°C and high temperature in the range of 400-750°C. The preliminary advantages of electrochemical technology compared to thermochemical (Haber-Bosch) are in four main areas:

1) Increased efficiency, which saves energy.
2) Increased selectivity, which means less purification is required.
3) Lower temperatures and pressures, resulting in lower CAPEX costs due to a lower balance of plant.
4) Modularity, which makes these plants suitable for small and medium scale use.

There are several routes for the production of NH_3 by electrochemical processes, depending on the electrolytes used and the operating temperatures:

1) Liquid electrolyte operating near ambient temperature;
2) Molten salts operating at intermediate temperatures of 180-500°C;
3) Composite membranes consisting of a conventional solid electrolyte mixed with a low-melting salt, operating in the 300-700°C temperature range;
4) Solid-state electrolytes with a wide operating temperature range, from approximately room temperature up to 700-800°C, depending on the type of electrolyte membrane used.

Non-thermal plasma synthesis (emerging technology)

NH_3 synthesis[3] or plasma-assisted synthesis operates at low temperatures (about 50°C) and at pressure conditions of about 1 atm. This technology can solve some of the problems associated with the Haber-Bosch process, such as high capital costs.

The two most critical challenges of this technology are:

1) Nitrogen gas fixation;
2) Retrospective reactions;
3) The need to improve conversion rates and efficiency, as this technology is still in the research and development phase (available on a small scale).

However, the advantages of this system are the low capital cost and that it has a small physical footprint. This process is more compatible for distributed production of NH_3 locally and NH_3 can be produced constantly at atmospheric pressure through this method. The microwave plasma process is able to activate both N_2 and H_2 , and produce ions and free radicals that react on the catalyst surface to produce NH_3 . One of the advantages of this process is that, under the right conditions, microwave heating is able to selectively heat the catalyst to the required temperature without the need for reactions and without heating the environment. This arrangement of a high-temperature catalyst within a cold environment results in lower overall reaction temperatures and improves energy efficiency. In addition, the simplified design of this process is due to its low operating pressure. The low operating pressure of this process allows it to be better adapted to renewable energy sources, as the system can reportedly be easily switched on and off.

Solid state ammonia synthesis (incipient technology)

Solid state ammonia synthesis means any electrochemical technology for the direct production of NH_3 using a solid electrolyte. In this case, "direct" means that no H_2 is produced: NH_3 is synthesised directly from H_2O (water) and N_2 (nitrogen, from the air) without intermediate steps. Although many variations of this technology are being developed around the world, no such system is currently commercially available.

High temperature solid-state ammonia synthesis technologies are evaluated in two categories, which are distinguished according to whether the electrolyte conducts protons (H+) or oxygen ions (O_2 -).

The production of gaseous NH_3 has been achieved using solid-state ammonia synthesis at high and low temperatures with varying levels of success, but current research data are still 1-2 orders of magnitude too low.

3.2.3.2
Comparative Analysis

The technology selected is the Haber-Bosch process, as it is the only mature and well-established nitrogen fixation process that has been used to produce ammonia on an industrial scale since the early 20th century. The process is traditionally steam-fired, but this plant will adopt an electrically heated modernisation of the process developed and tested by Casale, to eliminate the requirement to produce steam on site for start-up.

Other advantages of this technology are:

CASALE's Flexigreen solution is a specific application of CASALE's conventional ammonia solutions to the emerging green H /NH_{23} market. CASALE has developed several improvements to adapt the traditional NH_3 grey plant design running on base load to the new NH_3 green plant projects with power and load fluctuation.

Key aspects:

- NH circuit$_3$ flexible
- Minimisation of power outage
- Standby power supply
- Minimum load
- Maximum ramps
- Capacity factor
- Availability

CASALE's enhancements to NH's green projects$_3$ include:

- Adopt the AmoMaxTM-CASALE catalyst to the new synthesis conditions and minimise poisoning. It is a CASALE proprietary design, manufactured by Clariant;
- Best-in-class charging response, from 10% to 100% charge in one hour and vice versa;
- Fast electric heating (no gas boiler required);
- Design adapted for continuous and stable operation at low loads;
- Frequent start-up and shut-down;
- Dynamic modelling and optimisation of the process package.

The results show an overall improvement of 8-10% in CAPEX-OPEX, and a potential reduction of up to 15% in the levelised cost of ammonia.

3.2.4
CAN Storage Technology Alternatives

3.2.4.1
Evaluated Technologies

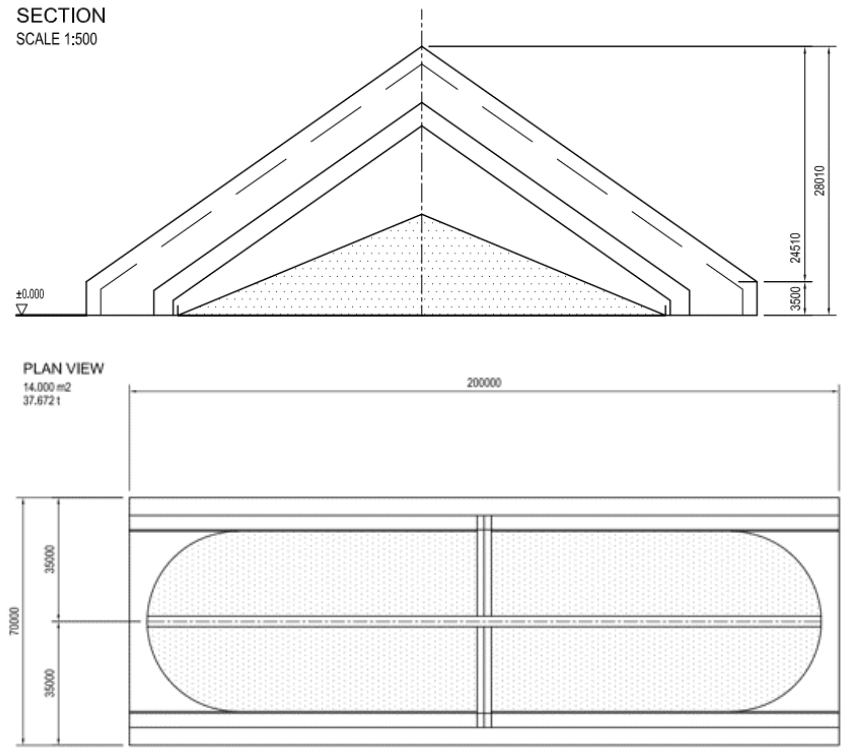
The following types of storage are being analysed:

- Long-term
  - Horizontal silo, bulk;
  - Vertical silo, bulk.
- Short-term
  - Warehouse for storage of packaged CAN, up to a stack of big bags.

Horizontal silo

This option refers to a 14,000 m silo[2] with a capacity to store up to 37,672 tonnes of CAN in bulk. Its storage capacity is up to 50 days.

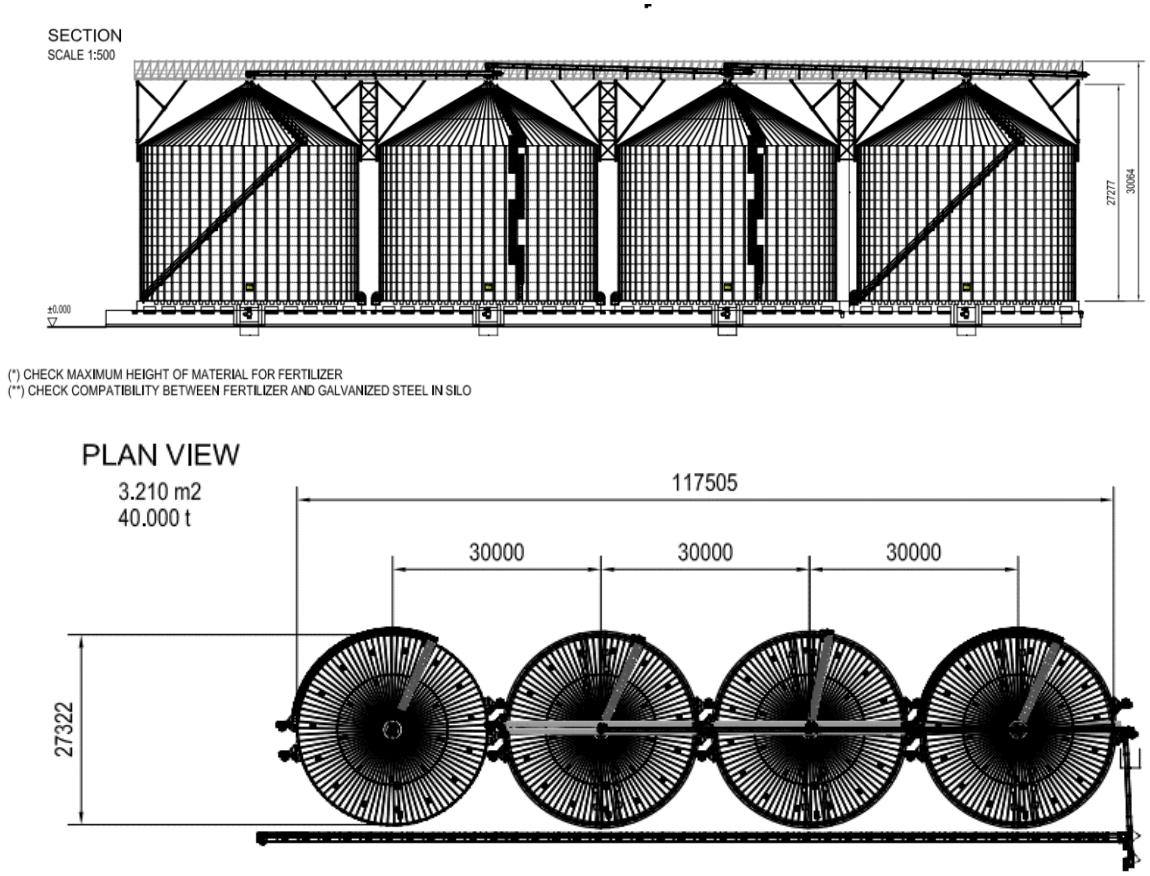
Figure 3.2.4.1.a
Detail of horizontal silo



Vertical silo

This option refers to a 3,210 m silo[2] with a capacity to store up to 40,000 tonnes of CAN in bulk. Its storage capacity is up to 50 days.

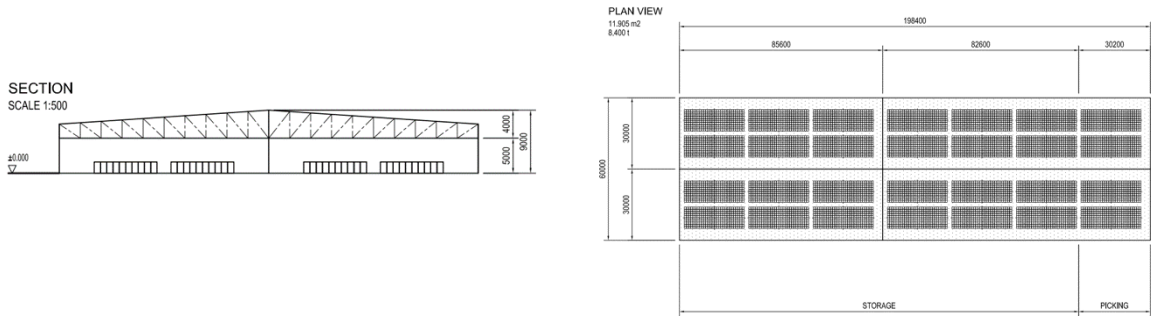
Figure 3.2.4.1.b
Detail of vertical silo



Warehouse for storage of packaged CAN

The depot would be built to store CAN packaged in big bags, with a storage capacity of up to 8,400 tonnes or 7,127 big bags. Its storage capacity is up to 10 days. The total surface area of the depot would be 11,905 m^2 .

Figure 3.2.4.1.c
Detail of tank for Big Bags



3.2.4.2
Comparative Analysis

Costs

Table 3.2.4.2.2.a
Cost comparison of storage types

Type of storage	Building costs (€/t)	Labour required
Horizontal silo	150	• 3 persons in total: 1 in storage 1 for preparation for shipment 1 for truck loading
Vertical silo	110 =	• 3 persons in total: 1 in storage 1 for preparation for shipment • 1 for truck loading
Packaged CAN depot	550	• 10 people in total: 4 in storage 4 for preparation for shipment 2 for truck loading

3.2.5
Cooling System Alternatives

3.2.5.1
Evaluated Technologies

The two technologies evaluated for the cooling system were:

- Wet cooling system: cooling tower
- Dry cooling system: air coolers

Wet cooling system: cooling tower

The Cooling Tower based option will be composed of two different circuits: an open circuit (the circulating water is in direct contact with the ambient air) and a closed circuit (the water inside the circuit is cooled by the main circulating water in a plate heat exchanger).

The circulating water of the open circuit is service water (pre-treated river water), while the circulating water of the closed cooling water is demineralised water.

- Open circuit: this system consists of the following equipment:
  - Cooling tower (1 X 100%): The cooling tower will be a multi-cell, mechanically rotating, counter-current flow type. When water falls through the tower, it is cooled by evaporation. A percentage of the circulating water is evacuated to the Plant drainage system - tower blowdown.
    Purging of the tower is necessary to avoid mineral concentration that is high due to evaporation. There is also a make-up water stream to the tower to replace the water lost through evaporation and blowdown.
  - Cooling water main pumps (2 X 100%): these pumps drive the cooling water from the tower tank to the heat exchanger plates.
  - Plate heat exchangers (2 X 100%): these heat exchangers cool the circulating water through the closed cooling water circuit.

- Closed circuit: this system consists of the following equipment:
  - Two closed cooling water pumps (2x100%): these pumps circulate the cooling water from the plate heat exchanger to the equipment to be cooled.
  - Expansion vessel: its function is to absorb the variations in volume of the cooling water, keeping the pressure in the circuit constant.
  - Electric chiller: it is necessary to reach the temperature required by the H_2 scrubber.

Dry cooling system: air coolers

Air Coolers are the main equipment of a closed dry cooling system. In this case the ambient air is not in direct contact with the fluid to be cooled.

Dry coolers feature a simple and robust design that includes a heat exchanger (typically finned tube coils or microchannels) and fans that direct airflow through the heat exchanger to cool the cooling water in the circuit passing through it.

The main components of the system are as follows:

- Fin fan (1 x 100%): this equipment dissipates the thermal load of the circuit, through a system of fans, cooling the water inside the tubes with the environment;
- Two closed cooling pumps (2x100%): these pumps circulate the cooling water from the plate heat exchanger to the equipment to be cooled;
- Expansion tank: its function is to absorb variations in the volume of the cooling water, keeping the pressure in the circuit constant;

- Chemical dosing system: consists of corrosion inhibitors and an antifreeze dosing skid;
- Electric cooler: it is necessary to reach the temperature required by the H_2 scrubber.

3.2.5.2
Comparative analysis

Regarding the two cooling systems analysed (wet and dry systems), the following **table 3.2.5.2.2.a** summarises the main advantages and disadvantages of each of them:

Table 3.2.5.2.2.a
Advantages and disadvantages of alternative refrigeration systems

Cooling System	Advantages	Disadvantages
Cooling Tower	Ability to cool water below the dry bulb temperature	High water consumption
	Reliable operation in hot ambient conditions	Two cooling water circuits are required with the following associated equipment
	Moderate electricity consumption	High cost of equipment, installation and civil works
	Relatively small equipment footprint	High operating cost
Air Coolers	No water loss, no water replenishment required.	Cannot cool process water below dry bulb temperature (without adiabatic pre-cooling)
	Only one cooling water circuit	High electricity consumption
	Low operating costs	Large surface area occupied by the equipment
	Low installation cost	

According to the above table, standard air coolers cannot cool the circulating water below the ambient dry bulb temperature, so considering that this ambient temperature is 37.2ºC, it will not be possible to achieve the required cooling water temperature for the Plant below 37ºC.

There is a modern design, which could be a solution, called an "adiabatic cooling system", which is similar to dry cooling systems, but with the incorporation of a pre-cooling system, either adiabatic spray or wet pad. Evaporative pre-cooling allows the process fluid to be cooled below the dry bulb temperature by increasing the heat rejected from the cooling water stream.

This system operates as a dry system when the ambient temperature is below a certain value (30°C), and the adiabatic system is activated when the ambient temperature is higher. In addition, other disadvantages of the adiabatic air cooler are water consumption and higher costs.
In relation to the above table, and taking into account the ambient conditions, system calculations and water availability, it is concluded that the cooling system should be the "Wet cooling system based on a cooling tower", as with a dry cooling system (air coolers) it is not possible to reach the maximum allowed temperature at the inlet of the equipment (37°C).

Investment costs (CAPEX)

Table 3.2.5.2.b below gives the budget breakdown for the selected alternative.

Table 3.2.5.2.b
Summary of CAPEX for the cooling system alternatives

Item	Outreach	$
Wet cooling system		
Cooling tower (1)	• Structure • Interiors • Mechanical group (fans, drives, etc.) • Instrumentation • Technical documentation	1,810,400
Cooling tower tank	Tank	300,000
Main cooling pumps	Pumps and motors	717,348
Closed cooling water pumps	Pumps and motors	1,279,985
Plate heat exchangers		667,851.82
Electric refrigerator		705,292
Construction		150,000
TOTAL		5.630,877

(1) External devices (risers, expansion joints...) are excluded.

3.2.6
Water Treatment Alternatives

The water treatment system includes pre-treatment, potabilisation and demineralisation. For pre-treatment, ultrafiltration (UF) and physico-chemical treatment are foreseen. For potabilisation, activated carbon filtration and chlorination are foreseen. For demineralisation treatment, two options have been evaluated, as mentioned above:

1) Water treatment station (WTS) based on reverse osmosis (RO) and electrodeionisation (EDI).
2) ETA based on RO and ion exchange resin beds (CB+MB).

3.2.6.1
Evaluated Technologies

ETA based on reverse osmosis (RO) and electrodeionisation (EDI)

The Reverse Osmosis (RO) and Electro Deionisation (EDI) based WWTP will consist of two (2) 100% trains to produce demineralised water from service water (i.e. pre-treated water). The two (2) trains will be able to operate simultaneously. The demineralisation plant shall be based on two (2) reverse osmosis stages and one electrodeionisation stage, consisting of the following components:

- Two (2) 100% pumps to supply service water to the filters;
- Two (2) 100% cartridge filters, each with 100% capacity (one on standby) for pre-treated water with an effective particle diameter of 5 microns;
- Two (2) high pressure pumps of 100% capacity to feed the demineralisation trains, one of them as a back-up;
- Two (2) reverse osmosis trains of 100% capacity. The supplier shall define the optimal number of steps and stages to obtain the required water quality;
- One (1) osmosis water storage tank (optional);
- Two (2) 100% EDI feed water pumps, one as a back-up;
- Two (2) EDI polishing equipment with a net output of 20 m^3 /h per train. In normal operation one, one EDI train will be in operation and the second on standby.
- One (1) on-line EDI analyser;
- Specific conductivity, pH and silica analysers where necessary for the proper functioning of the system;
- One (1) cleaning-in-place system for cleaning the osmosis modules, including chemical tank, cartridge filter and pumps for flushing and cleaning the osmosis membranes;
- One (1) antifouling injection system (if required), including one (1) chemical storage tank, two (2) 100% injection pumps and one (1) loading pump and associated instrumentation;
- One (1) sodium bisulphite injection system, including one (1) chemical storage tank, two (2) 100% injection pumps and one (1) charge pump, and associated instrumentation;
- One (1) sodium hydroxide injection system, including one (1) chemical storage tank, two (2) 100% injection pumps and one (1) charge pump and associated instrumentation;
- Any chemical reagent storage and dosing equipment deemed necessary for operation, where different from the equipment used in the desalination stage. Each chemical dosing system shall include a tank, 2 pumps 100% for each service and a centrifugal filling pump.

As can be seen, this option will use antifouling (if necessary), sodium bisulphite and sodium hydroxide as chemicals.

ETA based on RO and ion exchange resin beds (CB+MB)

As with Option 1), the RO and Ion Exchange Resin Beds (CB+MB) based WWTP will consist of two (2) 100% trains to produce demineralised water from service water (i.e. pre-treated water). The two (2) trains may operate simultaneously. In this option, the demineralisation plant will be based on reverse osmosis treatment and ion exchange resins (Cationic Beds and Mixed Beds), consisting of the following components:

- Two (2) 100% pumps to supply service water to the filters;
- Two (2) 100% cartridge filters, each with 100% capacity (one on standby) for pre-treated water with an effective particle diameter of 5 microns;
- Two (2) high pressure pumps of 100% capacity to feed the demineralisation trains, one of them as a back-up;
- Two (2) reverse osmosis trains of 100% capacity. The supplier shall define the optimal number of steps and stages to obtain the required water quality;
- One (1) osmosis water storage tank (optional);
- Two (2) 100% ion exchanger feed water pumps, one as a back-up;
- Two (2) 100% trains (one in operation and the other in regeneration or standby) with all the equipment, components, piping, valves, fittings, instrumentation and control necessary for its correct operation and regeneration. Each train is equipped with:
  - Cation Resin Ion Exchanger;
  - Mixed Bed Ion Exchanger.
- Two (2) recirculation pumps at 100%;
- Resin trapping filters at the outlet of each cationic resin and mixed bed demineraliser;
- Automatic valves and control valves for the correct operation of the plant;
- One (1) Subsystem for resin regeneration with all equipment, components, piping, valves, fittings, instrumentation and control necessary for proper operation. This includes:
  - Chemical dosing equipment for regeneration;
  - Hydrochloric acid: including two (2) storage tanks, three (3) 100% dosing pumps (one in reserve), two (2) 100% charge pumps, one (1) gas scrubber tank, one (1) mixing tee, one (1) flexible hose for connection of the acid tank wagon and associated instrumentation;
  - Caustic soda: includes two (2) storage tanks, three (3) 100% dosing pumps (one at 100% (one on standby), two (2) 100% charge pumps, one (1) mixing tee, one (1) flexible caustic soda tank wagon connection hose and associated instrumentation;
  - Two (2) 100% blowers for regeneration of the mixed bed;
  - Two (2) centrifugal pumps for 100% regeneration.
- One (1) neutralisation pit (third-party civil works) with a complete mixing system with water jets fed through the pressurised circulation line of the neutralisation pumps;
- Two (2) 100% regeneration effluent transfer pumps;
- Specific conductivity and silica analysers where necessary for the proper functioning of the system;
- One (1) cleaning-in-place system for the cleaning of the osmosis modules, including chemical tank, cartridge filter and osmosis membrane flushing and cleaning pumps/

- One (1) antifouling injection system, including one (1) chemical storage tank, two (2) 100% injection pumps and one (1) loading pump and associated instrumentation;
- One (1) sodium bisulphite injection system, including one (1) chemical storage tank, two (2) 100% injection pumps and one (1) loading pump and associated instrumentation;
- One (1) sodium hydroxide injection system, including one (1) chemical storage tank, two (2) 100% injection pumps and one (1) charge pump and associated instrumentation.

Under Option 2, in addition to the antiscalant, sodium bisulphite and sodium hydroxide used in Option 1, hydrochloric acid and caustic soda shall also be used.

3.2.6.2
Comparative Analysis

Investment costs (CAPEX)

Table 3.2.6.2.2.a presents the comparison between the investment costs (CAPEX) of each of the evaluated water treatment options.

Table 3.2.6.2.2.a
Comparison of the CAPEX of water treatment system options

Item	Option 1 - ETA OI + EDI	Option 2 - ETA OI + CB+MB
Pre-treatment (Clarification + UF), 242.70 m /h^3	• Physico-chemical treatment • UF System • Backwash system • Chemical injection system • Electrical equipment • Control system • Interconnection cable • Special tools • Recommended spare parts • Mechanical equipment, including lines, valves and instruments	• Physico-chemical treatment • UF System • Backwash system • Chemical injection system • Electrical equipment • Control system • Interconnection cable • Special tools • Recommended spare parts Mechanical equipment, including lines, valves and instruments
CAPEX	$ 1,355,074	$ 1,355,074
Demineralisation (33.50 m^3 /h) and potabilisation (0.63 m^3 /h)	• Cartridge filters, including feed pumps • Reverse osmosis system, including high-pressure pumps • EDI system • Backwash system • Activated carbon filters • Chemical injection system • Electrical equipment • Control system • Interconnection cable • Special tools • Recommended spare parts	• Cartridge filters, including feed pumps • Reverse osmosis system, including high-pressure pumps • Ion exchange columns • Resin regeneration system • Neutralisation system • Backwash system • Activated carbon filters • Chemical injection system • Electrical equipment • Control system • Interconnection cable • Special tools

Table 3.2.6.2.2.a
Comparison of the CAPEX of water treatment system options

Item	Option 1 - ETA OI + EDI	Option 2 - ETA OI + CB+MB
	• Mechanical equipment, including lines, valves and instruments	• Recommended spare parts • Mechanical equipment, including lines, valves and instruments
CAPEX	$ 1,526,628	$ 1,610,592
Total CAPEX	**$ 2,881,702**	**$ 2,965,666**

Note: This table is preliminary (economic values based on the database of other projects) and will be updated during the subsequent engineering phases.

Operating costs (OPEX)

Table 3.2.6.2.b presents the comparison between the operating costs (OPEX) of each of the water treatment options evaluated.

Table 3.2.6.2.b
Comparison of the OPEX of water treatment system options

Item	Option 1 - ETA OI + EDI	Option 2 - ETA OI + CB+MB
Pretreatment plant maintenance cost, including chemical consumption	$ 43,569	$ 43,569
Cost of maintenance of the demineralisation and potabilisation plant, including consumption of chemicals.	€ 49,085	$ 69,047
Total OPEX	**$ 92,654**	**$ 112,616**

Note: This table is preliminary (economic values based on the database of other projects) and will be updated during the subsequent engineering phases.

Considering the two different configurations for the demineralisation plant (Option 1: RO+EDI based demineralisation or Option 2: RO+CB+MB based demineralisation), both configurations can be used to obtain the required demineralised water quality for the electrolysers.

However, the final demineralisation option using Ion Exchange Resins involves a high consumption of chemicals and the generation of high volumes of effluent that will need to be neutralised before discharge.

Therefore, Option 1 was chosen as it is the most effective and minimises operating costs. The efficiency of the processes is very high and there are no waste flows because the low reject water generated in the EDI is recovered in the RO feed.

3.2.7
Surface and/or Groundwater Source Alternatives

3.2.7.1
Options Evaluated

As mentioned in **Section 2.6.2.1**, the source of water for the Project will be the Paraguay River (2.3 km from the Plant in a straight line). The comparative analysis mentions the main constraints and reasons why the river has been selected as the most viable alternative. However, it should be noted that the

use of well water is still under evaluation, but only as a source of water for a secondary fire fighting tank in order to comply with local legislation.

3.2.7.2
Comparative Analysis

Water from a well drilled in the ground

Due to the high conductivity of the groundwater, the necessary pre-treatment is a reverse osmosis (RO) process with an efficiency of approximately 65% (according to the simulation carried out). This implies that the total groundwater required will be 242.70 m^3 /h, which means at least 4 or 5 wells with corresponding pumps (maximum flow per borehole 50 m^3 /).

Based on the information provided by the well already drilled in the ground (drilling depth 96 m, pump suction depth 44 m and dynamic water head 22 m), the required pump power for each well has been calculated (50 m^3 /h) (**Table 3.2.7.2.2.a**):

Table 3.2.7.2.a
Power required for each well pump

	Power consumption (kW) per pump	Number of pumps required	Total energy consumed (kW)
Pump (50 m^3 /h)	7	4-5	21-28

In addition, an estimation of the energy consumption and investment cost for the corresponding pretreatment (RO) has been made. The results are included in **Table 3.2.7.2.b** below:

Table 3.2.7.2.b
Energy consumption and investment cost of pre-treatment

	Power consumption (kW)	CAPEX (€)
Pre-treatment for well water (RO)	110	2,215,000

In relation to the effluents, the rejection of the RO process considering a yield of 65% will be a flow of 6.98 m^3 /h, with an approximate conductivity of 30,000 uS/cm. This effluent would have a very high conductivity for discharge, requiring a specific study for its treatment. One option to manage its effluent would be to include an evaporation tank, the limitation of which would be the space in the plant. Another alternative is to include a storage tank/deposit to collect the effluents and have them disposed of via duly authorised waste managers.

Water from the Paraguay River

The Paraguay River is about 2 km from the plant. Considering this distance and a 3" distribution pipe from the pump discharge to the plant, the power consumed by the pump would be 23 kW.

The minimum flow of the Paraguay River is approximately 2,701 m^3 /s and the flow to be captured for the project is 242.70 m^3 /h or 0.07 m^3 /s, which corresponds to about 0.003% of the river flow, demonstrating the viability of this alternative.

Due to the turbidity and total suspended solids (TSS) of this water, the pre-treatment in this case is a physico-chemical treatment already mentioned in **Section 2.6.2.2. The** estimated pre-treated water required is 218.43 m /h.^{3}

On the other hand, the pre-treatment required for river water implies a lower investment cost than that required for well water.

Table 3.2.7.2.2.c
Energy consumption and investment cost of pre-treatment

	Power consumption (kW)	CAPEX (€)
Pre-treatment for river water	200	862,000

The volume of effluent to be discharged into the river would be 77.30 m^3 /h, with occasional peaks of 84.20 m^3 /h, the total net consumption of the plant being 165.4 m^3 /h or 158.5 m^3 /h, in each case. It should be noted that the effluents would represent only 0.008% or 0.007% of the minimum flow of the river, in each case, being considered practically negligible. These effluents will be treated at the WWTP to comply with the quality established in Resolution 222/02 and the general EHS guidelines and IFC/World Bank guidelines for the production of nitrogen fertilisers.

3.3
No Project Alternative

As mentioned in **Section 2.1**, the ATOME plant project is based on the production of CAN fertiliser from NH_3 produced with green H_2 , using renewable energy (from existing hydropower) for the electrolysis process. The objective of the project is to respond to the local and regional demand for fertilisers through the production of the first truly green fertiliser in Paraguay.

In this context, it is worth noting that Paraguay imports 100% of its fertilisers - approximately 1.2 million tons per year. Neighbouring countries such as Brazil, the world's largest importer of ammonium fertilisers (13.7% of the world's ammonium nitrate), whose main trading partner is Russia, are also strategic actors for ATOME.
More than 95% of the hydrogen produced today is made from fossil fuels, about 45% of this is dedicated to ammonia production (185 million tonnes per year) and 80% of the world's ammonia production is used to produce fertilisers.

In that sense, without the Project, the supply to meet demand would probably be made only through the traditional process of hydrogen production by burning fossil fuels, which is called grey H_2 . According to data obtained from[1] , the production of one tonne of grey H_2 releases about ten tonnes of CO_2 into the atmosphere.

The implementation of the Project would offer a substitute product with the potential to displace 525,000 t-CO_2 -eq/year of carbon emissions in the fertiliser sector. Considering the lifetime of the Project (25 years), this impact would translate into 13,125,000 t CO_2 -eq avoided.

Fertiliser production and use is responsible for the emission of 2.6 gigatonnes of carbon per year. The project installed in Paraguay, whose energy is practically 100% renewable, from hydroelectric dams such as Itaipú and Yacyretá, allows the production of a green fertiliser with the lowest levels of carbon emissions in the world and at competitive costs, being able to replace urea, reducing the loss and transport of nitrogen by leaching to aquatic ecosystems and increasing production yields.

[1] https://www.ecycle.com.br/hidrogenio-cinza/

In addition to not avoiding the impacts associated with CO_2 emissions into the atmosphere, the alternative without the Project would not have the positive impacts associated with it, such as the generation of direct and indirect jobs in the construction and operation phases, the revitalisation of the local economy through the purchase of inputs and consumer goods and the contracting of services, in addition to the collection of taxes. The Project also brings cutting-edge technologies to Paraguay.

In relation to jobs during the construction of the plant, it is estimated that around 1,020 to 1,073 workers will be hired at the peak of the works, and a large part of these positions will be filled by local residents of Villeta. In the operation phase, it is estimated that around 225 direct jobs and 874 indirect jobs will be generated. These jobs will also include local hires, with benefits associated with education and training and continuity of employment. In addition, between 40-50 people are estimated for the other components of the Project, including the LT and the water catchment and piping system.

The positive effects of the project on trade and services in the region should also be felt mainly in Villeta, which will boost the local economy and increase tax revenue, which will be applied by the municipality, resulting in benefits for the population.

The Project, in its operation phase, will also have a positive impact on the industrial GDP of Villeta, with positive reflections also on the GDP of the Central Department.

On the other hand, without the Project, several negative impacts and risks associated with it would not occur, the main ones being the loss of vegetation cover and the inconvenience to neighbouring residents as a result of the construction and operation of the Plant. Thus, without the Project, the current socio-environmental quality of the land and surroundings would be maintained.

However, the Plant design includes technologies to prevent or minimise potential impacts on acoustic quality, air quality, and potential health and safety risks. In addition, the EPC Contractor, CASALE and ATOME will apply a robust set of programmes and measures for both the works and the operation phase, consolidated in an Environmental and Social Management Plan - ESMP.

It is also important to mention that the site chosen for the implementation of the Project has an almost entirely unoccupied environment, with only one neighbouring residence. In order to avoid nuisances and risks, several measures have been foreseen, ranging from design adjustments, equipment and technology selection, emission control measures, noise abatement and mitigation proposals, if necessary. In addition, the technologies designed and adopted result in a Plant whose equipment will emit the lowest levels of noise and atmospheric emissions in order to comply with Paraguayan legislation and even international standards, and will operate in accordance with international health and safety standards.

The entire ESMP to be implemented will follow the principle of mitigation hierarchy, i.e. prevention measures will be prioritised, followed by mitigation and control alternatives, and only then, if prevention or mitigation is not possible, will the impact be compensated.

The loss of vegetation cover is an example of this application. The project provides for environmental offsets through the purchase of environmental services and compensatory plantings of native vegetation as measures for vegetation removed during project construction.

4.0 Legal Framework

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Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

SUMMARY

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4.0
Legal framework

This section identifies the environmental, social, cultural, and occupational health and safety regulations so that the company can plan, execute and operate the proposed project in compliance with them.

In addition to Paraguayan regulations, the requirements set out in the IFC Performance Standards applicable to the Project (ND 01, ND 02, ND 03, ND 04, ND 05, ND 06 and ND 08), the IFC General EHS Guidelines, ILO Conventions and other applicable international requirements will also be met.

The main aspects or thematic axes framing the project are set out below, on the basis of which the relevance and implications of the legal instruments for and in the project have been analysed. **Section 4.1** summarises the content of the IFC Performance Standards applicable to the Project and **Section 4.2** presents the applicable Paraguayan regulations separated by themes.

4.1
IFC Environmental and Social Performance Standards (PSPS)

ND1: Assessment and Management of Environmental and Social Risks and Impacts

In order to comply with IFC's PS1 for key environmental, social and health and safety requirements, a structured and comprehensive hazard and risk identification and assessment process and identification and assessment of environmental and social aspects and impacts for the Project's construction and operation activities, based on international industry best practice, must be carried out.

IR 1 sets out the following requirements for projects:

- Carry out an environmental and social assessment process;
- Establish and maintain an Environmental, Social Management System - ESMS incorporating the following elements:
  - (i) policy;
  - ii) identification of risks and impacts;
  - (iii) management programmes;
  - (iv) organisational capacity and competence;
  - (v) emergency preparedness and response;
  - (vi) stakeholder participation; and
  - (vii) monitoring and evaluation.

The process of identifying and analysing risks and impacts should be carried out for the area of influence of the project, and also consider related facilities and cumulative impacts.

The Management System must provide for the management of all Environmental and Social Programmes foreseen for the construction and operation phases of the Project, guaranteeing the proper integration between them and ensuring that the critical analysis of the results is

processed in a timely manner and results in the activation of corrective strategies at the appropriate time.

The emergency preparedness and response system should be structured to adequately respond to accidental and emergency situations associated with the project in order to prevent and mitigate any harm to people and the environment.
Such preparedness will include identification of areas where accidents and emergencies may occur, communities and individuals who may be affected, response procedures, provision of equipment and resources, allocation of responsibilities, communication, including with potentially affected communities, and regular training to ensure an effective response.

The ESMS must have *compliance assurance* procedures that effectively monitor the correct implementation of all environmental, social and health and safety requirements for the construction and operation phases of the Project, with procedures for handling non-conformities, both with respect to local standards and additional IFC requirements.

ND2: Labour and working conditions

IFC PS2 applies to all direct workers, workers for Contractors and Subcontractors and primary suppliers in the Project's supply chain.

Human Resources Policy

The Project must have a Human Resources Policy (or equivalent instrument), based on the country's legislation and consistent with the requirements of the ILO's GP2 and Fundamental Principles. It should establish labour management procedures, including clear guidelines for the recruitment and training of workers, including the principle of non-discrimination, the prohibition of child and forced labour, and a worker consultation and grievance mechanism, which should be extended to subcontracted workers and suppliers.

The Project Management System must include a procedure to verify compliance with this Policy by all companies involved.

Health and safety management

A Construction and Operational Health and Safety Programme is required to comply with ND2 and should include Contractors, subcontractors and suppliers of services and inputs. It should form part of the Management System submitted as part of ND1.

In general, ND2 requires the Project to have a safe and healthy working environment. To achieve this, a comprehensive and thorough hazard mapping and risk assessment process needs to be carried out for each of the main stages of the Project, both for the construction and operation phases, involving the Project's primary supply chain.
The framework for the assessment of these risks should be based on international good industry practice and cover the main risks that may be related to physical, chemical and biological hazards.
The Environmental, Social and Health and Safety Management System should describe the measures designed to prevent accidents, injuries and illnesses that may be related to or induced by the Project.

The hierarchy of managing risks related to workers' health and safety suggested by ND2 prioritises the elimination of the source of risk by modifying, substituting or eliminating hazardous/unacceptable working conditions or eliminating a hazardous or potentially hazardous substance to health and life. Identifying and eliminating or reducing life-threatening hazards should be a priority in the management of Worker Health and Safety.

It is essential that Health and Safety management has an assurance procedure (Monitoring, Auditing and Reporting), as mentioned above in PS1. The H&S management procedures should include routines for systematic verification of compliance with the H&S Programme and IFC requirements by all companies working on the Project, including the Contractor, subcontractors and relevant primary suppliers.

Requirements for the accommodation of workers

If the Project includes workers' accommodation, the standard used by the IFC as a reference should be followed, which is the publication "Workers' accommodation: processes and standards", produced by the IFC in collaboration with the European Bank for Reconstruction and Development (EBRD) in 2009.

Standards of accommodation facilities and recreational areas are important to ensure that workers can rest properly and maintain good hygienic conditions. In particular, overcrowding in these areas should be avoided. These aspects also have an impact on worker productivity and may even have an influence on reducing accidents at work.

If accommodation is provided, rooms and dormitories should be kept clean and in good repair. They should have good heat and sound insulation, exposure to noise and odours should be kept to a minimum, and facilities should provide as much privacy as possible. Sanitary facilities should be located within the same buildings, separate for men and women. Adequate furnishings should be provided and appropriate density should be considered to avoid overcrowding. Pest and vector control and disinfection of toilets and dormitories should be carried out.

A locker room should be provided with suitably designed facilities for storing workers' personal belongings. Benchmarks suggest that each worker should have an individual locker of at least 475 L and 1 m of shelving. Separate storage should be provided for work boots and other PPE, as well as an airy and sunny area for drying clothes.

Hygienic sanitary facilities are essential for workers to maintain a good standard of personal hygiene and also to prevent contamination and the spread of disease resulting from inadequate sanitary facilities. Sanitary facilities should be provided with toilets, urinals, washbasins and showers. Sanitary facilities should also be constructed of easily washable materials and ensure privacy. Sanitary facilities should never be shared between male and female residents. The main requirements for these facilities are set out below:

- The shower/bathroom floor should be made of washable, non-slip material.
- There should be an adequate number of hand washing facilities for workers. International reference standards range from 1 unit for every 15 persons to 1 unit for every 6 workers.

Hand washing facilities should have at least one tap connected to a washbasin and an effluent collection system, soap and paper towels for drying hands.

- International standards indicate the provision of at least 1 toilet for every 20 workers.
- Workers must be provided with an adequate number of showers. Standards vary from 1 unit for every 15 persons to 1 unit for every 6 persons.

ND3: Pollution prevention and reduction

The objective of ND3 is to minimise adverse impacts on human health and the environment by minimising pollution and emissions that contribute to climate change, as well as to promote more sustainable use of resources, including energy and water, and to reduce project-related GHG emissions.

Efficient use of natural resources

PS3 recommends taking into account the environmental conditions of the Project's life cycle during its planning, and applying the most appropriate pollution prevention and control technologies and practices (techniques) to avoid or, where feasible, minimise or reduce adverse impacts on human health and the environment, while remaining technically and financially feasible and cost-effective. The Project is also expected to include measures to improve its efficiency in the consumption of energy, water and other natural resources and inputs.

The Project footprint (including erosion control), Project emissions and receiving environment conditions (during construction and operation) must be managed in order to verify compliance with environmental performance standards, in this case the most restrictive limits taking into account the country's legislation and IFC's general and specific EHS Guidelines. Solid waste and liquid effluents and hazardous products must also be managed.

The project shall verify the need for a carbon balance of the construction and operation phases, depending on the size of the project.

ND4: Community health and safety

PS4 requires an assessment of the risks and impacts of the Project on the health and safety of affected communities and the proposal of mitigation measures commensurate with the nature and magnitude of these risks and impacts, and consideration of the possibility of minimising risks to community safety from the design phase.

The risks to the community associated with activities involving hazardous products must be assessed and include management and safety measures during construction and operation. The transport of chemicals and possibly fuels to the site or during Project operation will pose a risk to communities along the routes to be used. It is necessary to develop a risk map and a Transport Management Plan focused on minimising risks and interference in the surrounding communities.

The Project must have measures in place to prevent and control cases of water-borne and vector-borne diseases among workers in order to avoid potential exposure of the community.

Measures should be taken to publicise the risks and provide guidance to the population in the event of an emergency, both during the construction and operation phases of the Project. These measures can be disseminated as part of the Stakeholder Engagement Programme to be implemented for the Project.

ND4 also sets out rules for property security personnel. It requires that the use of force should only be for preventive and defensive purposes in proportion to the nature and extent of the threat. Therefore, prior to implementing any estate security measures, the project developer (or its contractors) should carry out a thorough risk assessment in line with international best practice, including primarily the applicable requirements of ND4 and the EBRD.

In the case of contracting a company to carry out property security with the use of firearms, ND4 requires that strict criteria be established for the selection and contracting of these service providers. Contracts with these companies should include clear and strict rules of conduct, specification of training and technical qualification requirements, rules for the use of equipment and supervision of activities, among other issues. Security personnel should be carefully selected to ensure that they have not been involved in previous crimes or abuses. Where necessary, provision should be made for the recruitment of security staff of both sexes, especially for the security of women's accommodation.

ND5: Land acquisition and involuntary resettlement

The PS5 sets out guidelines for projects involving impacts related to land acquisition, land use restrictions and involuntary resettlement involving both physical displacement (relocation) and economic displacement (loss of assets or access to assets leading to loss of sources of income or other means of livelihood).
According to LD 5, involuntary resettlement, mainly of vulnerable people, should be avoided or at least minimised whenever possible through analysis of project characteristics.

Where land acquisition or restrictions on land use result in economic displacement (loss of property or livelihoods), whether or not the affected people are physically displaced, the requirements of paragraphs 27-29 of ND5 must be met.

Adverse social and environmental impacts arising from land acquisition and restrictions on land use by affected parties should be mitigated by (i) financial compensation for the loss of assets at replacement value; (ii) in the case of business affectation, compensation to the landowner for the cost of re-establishing business activities elsewhere, for the net income lost during the transition period, and for the costs of transferring and reinstalling plant, machinery and other equipment; (iii) ensuring that resettlement activities are carried out with sufficient information disclosure, public consultation and active and well-informed participation of affected parties.

In the event that involuntary resettlement is unavoidable, a socio-economic census should be conducted and a resettlement action plan developed and implemented. In case of economic displacement, a livelihood restoration plan should be developed and implemented to compensate affected individuals or communities.

According to LD5, the living conditions of affected parties need to be improved or at least restored to pre-Project levels. In the case of resettlement, provide adequate housing with secure

tenure at resettlement sites and provide a replacement property (e.g. agricultural or commercial facilities) of equal or greater value, or monetary compensation for the full replacement value.

Economically displaced persons who do not have legally recognisable rights to land should be compensated for lost assets other than land (such as crops, irrigation infrastructure and other improvements made to the land), for the full replacement cost.

The Project's grievance mechanism should have a channel for people affected by the land acquisition and resettlement process.

ND6: Biodiversity conservation and sustainable management of living natural resources

The ND6 requires a balance between the conservation of biodiversity and the promotion of sustainable natural resource management. The requirements apply to the project in all habitats, regardless of their previous history of degradation and whether or not they are legally protected.

PS6 states that the Project must not significantly modify or degrade natural habitats unless it can demonstrate that there are no viable alternatives within the region within modified habitats. In the case of intervention in natural habitat areas, where feasible, mitigation measures will be designed to ensure that there is no loss of biodiversity.

The existence of critical habitats in the area of influence of projects should be assessed according to the 5 conditions defining critical habitats set out in paragraph 16 of PS6. Project activities should not be carried out in critical habitats unless the conditions set out in paragraph 17 are met.

In the process of identifying and assessing project impacts, potential impacts on priority ecosystem services should be identified.

ND7: Indigenous peoples

Not applicable to the Project.

ND8: Cultural heritage

Archaeological surveys were carried out as part of the baseline studies, during which no archaeological sites or cultural heritage were found in the project area.

However, in order to safeguard any archaeological or cultural property not identified during this stage, the ESMP includes an incidental finds programme to be implemented during the works.

4.2
Other International Standards

World Bank Policy for International Waterway Projects and OP 7.50 - International Waterway Projects

They apply to the following types of projects: hydroelectric, irrigation, flood control, navigation, drainage, water and sewerage, industrial and similar projects involving the use or potential pollution of international waterways.

In these cases, the government of the country where the project is located or the project developer is requested to formally notify the transboundary country of the proposed project and the respective design details.

The following exceptions to the requirement to notify the proposed project to the cross-border country are permitted:
(i) will not adversely modify the quality or quantity of water flows to the other country; and
ii) whether they will not be adversely affected by the other country's potential water use.

This is the case of the Atome Project, which will not have a significant impact in terms of water flow reduction or pollution of the Paraguay River, as the net water consumption foreseen is very small in relation to the flow of this river (flow to be captured of 242.70 m^3 /h and discharge of treated effluents of 77.30 m^3 /h, with occasional peaks of 84.20 m^3 /h, being the net consumption of the plant 158.5 m^3 /h considering the peak volume). The quality of the treated effluent will meet international standards and will not degrade the water quality of the river.

IFC General Guidelines on Environment, Health and Safety

IFC's General EHS Guidelines present environmental and health and safety performance levels and measures that are normally acceptable to IFC and are generally considered feasible in new facilities, at reasonable cost and with currently available technologies, and in line with international best practice.

In all cases where the EHS legislation and regulations of the country in which the project will be implemented differ from the standards, levels and measures specified in the IFC General EHS Guidelines, the Project is expected to comply with the more stringent of the two options.

The environmental and health and safety requirements set out in the Guidelines relate to:

- Atmospheric emissions and air quality (see emission limits and air quality standards set by the General Guidelines in **Tables 5.4.a** and **5.4.b of P.01**, **Chapter 7.0**).
- Energy conservation
- Water quality and effluents (see effluent discharge limits established by the General Guidelines in **Table 5.3.a of P.01**, **Chapter 7.0**).
- Conservation of water resources
- Management of hazardous materials and substances
- Waste management

- Noise (see noise emission limits set by the General Guidelines in **Table 5.5.a of P.01**, **Chapter 7.0**)
- Occupational health and safety (see noise emission limits for different working environments set by the General Guidelines in **Table 5.6.a of P.04**, **Chapter 7.0**).
- Community Health and Safety
- Construction and decommissioning

IFC Environmental, Health and Safety Guidelines for Nitrogen Fertiliser Production

These Guidelines set out measures for the prevention and control of emissions to air, wastewater, hazardous materials, waste and noise that must be taken into account during the design and choice of technology for nitrogen fertiliser production plants.

The guidelines set air emission limits for particulate matter (PM), NH_3 and NOx for ammonia plants; PM, NH_3 , NO_2 and NOx for nitric acid plants; urea, NH_3 and PM for urea/urea ammonium nitrate plants; and NH_3 and PM for ammonium nitrate and calcium ammonium nitrate plants. They also set levels for some parameters that effluents from nitrogen fertiliser plants must meet, including pH and Δ temperature; NH_3 , total nitrogen (Ntotal) and Total Suspended Solids (TSS) in ammonia and nitric acid plants; urea and NH_3 in urea/urea ammonium nitrate plants; and AN, NH_3 , Ntotal and TSS in ammonium nitrate and calcium ammonium nitrate plants.

In the case of the Atome Project, the specifications of these guidelines were taken into account by the design team for the ammonia production plant, the nitric acid production plant and the calcium ammonium nitrate production plant.

The Guidelines also establish guidelines for occupational health and safety, taking into account the following topics: process safety, chemical hazards, fire and explosions, and ammonia storage. It also establishes guidelines for hygiene and safety in the community.

IFC's Environmental, Health and Safety Guidelines for Electricity Transmission and Distribution

These guidelines set out recommended measures to prevent and control impacts on terrestrial habitat during construction and maintenance of easements for LTs, including, among others:

- Avoid establishing easements in critical habitats;
- Install cables above existing vegetation to avoid suppression;
- Avoid construction and maintenance activities during the breeding season;
- Replant suppressed vegetation with native species;
- Remove invasive plant species during routine maintenance, including measures for herbicide application;
- Manage construction site activities according to general guidelines.

It also sets out measures to prevent and control the risk of forest fires, recommended prevention and control measures to minimise bird and bat strikes and electrocution with LT cables and recommendations for the handling of Hazardous Materials, including oils/gas (e.g. PCBs and sulphur hexafluoride) and fuels, as well as substances or chemicals used to preserve the wood of poles and other wood construction materials.

The Guidelines also set out guidelines for occupational health and safety, taking into account the following topics: Live power lines, Working at heights, Electric and magnetic fields and Exposure to chemicals. It also establishes guidelines for Health and Safety in the community, taking into account the impacts and risks associated with electrocution, electromagnetic interference, visual impairment, noise and ozone, and air navigation safety.

The guidelines set limits for the exposure of the general public and workers to electromagnetic fields.

Fundamental Principles and Rights at Work - ILO

In 1998, the ILO adopted the Declaration on Fundamental Principles and Rights at Work and its Follow-up, which is a universal reaffirmation of the commitment of ILO member States, and the international community at large, to respect, promote and achieve a minimum standard of principles and rights at work.

The principles and rights of the ILO are governed by eight fundamental conventions covering freedom of association, the effective recognition of the right to collective bargaining, the elimination of all forms of forced or compulsory labour, the effective elimination of child labour and the elimination of discrimination in respect of employment and occupation.

ILO Convention 29 (Forced Labour)

Provides for the elimination of forced or compulsory labour in all its forms. It allows for some exceptions to compulsory labour, such as military service, duly supervised prison labour and compulsory labour in emergency situations, such as war, fire, earthquakes, among others. This Convention was ratified by Paraguay on 28 August 1967.

ILO Convention 87 (Freedom of Association and Protection of the Right to Organise)

It deals with freedom of association and the protection of the right to organise, and its essence is contained in Article 2, which guarantees workers and employers, "without distinction whatsoever", the freedom to establish and join organisations "without prior authorisation". This Convention was ratified by Paraguay on 28 June 1962.

ILO Convention 98 (Right to Organise and Collective Bargaining)

Convention concerning the Application of the Principles of the Right to Organise and to Bargain Collectively. According to Art. 1 of this Convention, all workers must be protected against discriminatory acts that infringe on freedom of association, not only with regard to trade union membership or leadership, but also with regard to participation in acts of protest or political and ideological demonstration. This Convention was ratified in Paraguay on 21 March 1966.
ILO Convention 100 (Equal Remuneration of Men and Women Workers for Equivalent Work)

Convention concerning equal remuneration for men and women workers for work of equal value, at fixed rates of pay and without discrimination on the basis of sex. This Convention was ratified by Paraguay on 24 June 1964.

ILO Convention 105 (Abolition of forced labour)

It prohibits the use of any form of forced or compulsory labour as a means of coercion or political education; punishment for expressing political or ideological opinions; disciplinary measures at work; punishment for participating in strikes; as a measure of discrimination. This Convention was ratified in Paraguay on 16 May 1968.

ILO Convention 111 (Discrimination - employment and occupation)

It requires the formulation of a national policy to eliminate any discrimination in employment, vocational training and working conditions which has the effect of nullifying or impairing equality of opportunity or treatment in respect of employment or occupation. This Convention was ratified in Paraguay on 10 July 1967.

ILO Convention 138 (Minimum Age for Admission to Employment)

It aims to abolish child labour by stipulating that each member country for which this Convention is in force undertakes to pursue a national policy to secure the effective abolition of child labour and to raise progressively the minimum age for admission to employment or work to a level appropriate to the full physical and mental development of young persons. This Convention was ratified in Paraguay on 03 March 2004.

ILO Convention 182 (Prohibition and Immediate Action for the Elimination of the Worst Forms of Child Labour)

This Convention aims to complement the provisions of Convention 138 by emphasising the need to take immediate and effective measures to ensure the prohibition and elimination of the worst forms of child labour. It also stresses the importance of free primary education, the need to promote the rehabilitation and social integration of these victims and to try to combat the main source of this problem, which is the need of their families. This Convention was ratified in Paraguay on 07 March 2001.

4.3
Paraguayan Legal Framework

4.3.1
Environmental Licensing

The main diplomas and/or regulations governing the environmental licensing procedures that will apply to the project are as follows:

- National Environmental Policy of Paraguay (PAN);
- Law N° 294/1993, on Environmental Impact Assessment, as amended by Law N° 345/1994 and regulated by Decree N° 453/2013;
- Law N° 345/1993, amending Article 5 of Law N° 294/93 on Environmental Impact Assessment;
- Law N° 716/1996, which punishes crimes against the environment;

- Law N° 1561/2000, which creates the National Environmental System (SISNAM), the National Environmental Council (CONAM) and the Environmental Secretariat (SEAM). Regulated by Decrees N° 10579/2000 and N° 17201/2002;
- Law No. 3001/2006, on the valuation and remuneration of environmental services;
- Law N° 6123/2018, which raises the SEAM to the rank of Ministry and renames it the Ministry of Environment and Sustainable Development;
- Municipal Organic Law No. 3966 of 2010 and amendments.
- Decree N° 453/2013, which regulates Law N° 294/1993 "on Environmental Impact Assessment" and its amendment, Law N° 345/1994, and repeals Decree N° 14281/1996;
- Decree No. 954/2013, amending and extending Articles 2°, 3°, 5°, 5°, 6° clause E), 9°, 10, 14 and the annex of Decree N° 453/2013; Resolution SEAM N° 1133/2004, regulating the issuance of environmental license under Law N° 294/1993;
- SEAM Resolution N° 2127/2005, which establishes deadlines for the submission of studies contemplated in the framework of Law N° 294/1993 "on Environmental Impact Assessment";
- Resolution N° 640/2014, which establishes the General Regulations for public hearings within the framework of Law N° 294/1993 on Environmental Impact Assessment, and its regulatory decree N° 453/2013 and modifying and extending N° 954/2013;
- Resolution SEAM N° 201/2015, which establishes the procedure for the evaluation of the environmental audit report on compliance with the environmental management plan for works or activities that have an environmental impact statement within the framework of Law 294/1993 on environmental impact assessment, and Decrees No. 453/2013 and No. 954/2013;
- Resolution No. 221/2015, amending Article 5 of Resolution No. 201/2015;
- Resolution No. 260/2015, repealing Resolution No. 223/2015, which regulates the functions of the person responsible for the implementation and monitoring of environmental management plans for works and activities approved under Law No. 294/1993 and its Decrees No. 453/2013 and 954/2013;
- Resolution SEAM No. 201/2015, which establishes the procedure for the evaluation of the Environmental Audit Report on compliance with the Environmental Management Plan for works or activities that have an Environmental Impact Statement, within the framework of Law 294/93 on Environmental Impact Assessment, and Decrees 453/13 and 954/13.
- Resolution SEAM N° 184/2016, whereby SEAM Control Forms N° 1, 2, 3, 4, 5 and 6 are approved, containing the list of documents required for the submission of EIA, EDE, Audit Reports (AA), consultation notes and Generic Environmental Management Plans, EMP adjustments and requests for changes of ownership, within the framework of Law No. 294/1993, its Regulatory Decree No. 453/2013 and its amendment and extension Decree No. 954/13, and repealing Resolution SEAM No. 246/2013;
- Resolution SEAM N° 248/2016, amending Art. 10 of Resolution N° 201/2015;
- Resolution SEAM N° 321/2018, amending Art. 10 of Resolution SEAM N° 201/2015;
- Resolution MADES N° 251/2018, establishing the official terms of reference for the submission of thematic maps and satellite image; the process of cartographic analysis of the Directorate of Geomatics; in the framework of Law N° 294/2013;
- Resolution MADES N° 291/2019, which broadens and combines the concepts of Resolution N° 244/13, "by which the fees to be charged are established, in the framework of Law N° 294/1993 on Environmental Impact Assessment, in view of the application of Regulatory Decree N° 453/13 to the projects submitted to the Secretariat of the Environment";

- Resolution MADES N° 182/2020, which establishes the plans and modalities of recomposition and compensation that will form part of the Environmental Management Plan (EMP) for the Environmental Impact Assessment processes within the framework of Law Nº 294/1993.
- Resolution MADES N° 207/2021, which modifies article 10 of Resolution N° 182/2020, which establishes the plans and modalities of recomposition and compensation that will be part of the Environmental Management Plan (EMP) for the Environmental Impact Assessment processes in the framework of Law N° 294/1993".

The adoption of the National Environmental Policy contemplates the three levels of political-administrative organisation: national, departmental and municipal, and orients strategies and actions towards the decentralisation of environmental management and the strengthening of local management capacity, with broad social participation.

The National Environmental Policy aims to conserve and adapt the use of Paraguay's natural and cultural heritage in order to guarantee the sustainability of development, the equitable distribution of its benefits, environmental justice and the quality of life of the present and future population. The instruments of the National Environmental Policy include Strategic Environmental Assessment, Environmental Impact Assessment, Citizen Participation and Social Control, among others. The environmental regulations establish that methodologies used by international organisations or others that comply with the objectives proposed for this purpose can be used, as long as they do not contravene national laws.

In 1993, Law Nº 294 was sanctioned, which in Art. 1º declared mandatory the Environmental Impact Assessment, which is the scientific study that allows to identify, foresee and estimate environmental impacts, in any work or activity projected or in execution (Art. 2). The minimum content of the Environmental Impact Assessment is defined in Art. 3º , which includes:

- A description of the type of work or nature of the projected activity, with mention of its owners and those responsible for it; its location; its magnitude; its installation, operation and maintenance process; types of raw materials and inputs to be used; the stages and schedule of execution; number and characterisation of the workforce to be employed;
- An estimation of the socio-economic significance of the Project, its link with governmental, municipal and departmental policies and its adequacy to a sustainable development policy, as well as to territorial, urban and technical regulations;
- The limits of the geographical area to be affected, with a detailed physical, biological, socio-economic and cultural description, both quantitatively and qualitatively, of the area of direct influence of the works or activities and an environmental inventory of the same, in such a way as to characterise its state prior to the planned transformations, with special attention to the determination of the hydrographic basins;
- The analyses necessary to determine the potential impacts and risks of works or activities during each stage of their execution and after completion; their positive and negative, direct and indirect, permanent or temporary, reversible or irreversible, continuous or discontinuous, regular or irregular, cumulative or synergetic, short, medium or long term effects;
- An Environmental Management Plan that will contain a description of the protective measures or measures to mitigate negative impacts that are foreseen in the Project; of the compensations and indemnities foreseen, of the methods and instruments of surveillance,

monitoring and control that will be used, as well as other provisions that may be added in the regulations;

- A list of the technical alternatives of the Project and those of its location, as well as an estimate of the circumstances that would arise if the Project were not carried out; and
- A report summarising the details of the environmental impact assessment and the conclusions of the document.

Art. 5, modified by Law N° 345/1994, establishes that all environmental impact assessments and their reports shall be submitted by the person or persons responsible to the Administrative Authority together with the project of the work or activity and the other requirements determined by the latter.

Art. 8 of Law Nº 294/1993 defines that the Administrative Authority must make the Environmental Impact Assessment available to the public and affected bodies at national, departmental and municipal level, and must issue, after review of the study, an Environmental Impact Statement (Art. 10), a document that grants the applicant the licence for the project, through compliance with the Environmental Management Plan (Art. 11).

Art. 1 of Decree No. 954/2013, item c), states that industrial complexes and units require an Environmental Impact Statement.

SEAM Resolution Nº 2127/2005, establishes a deadline for the submission of EIA-RIMA, Environmental Control Plans (PCA), Environmental Recovery Plans (PRA) and Wastewater Disposal Studies and for the submission of complementary studies.

The environmental licence grants the applicant permission to initiate or continue the work or activity and obliges compliance with the mitigation measures proposed for the project. In addition, the environmental licence must be renewed every two years.

Article 6 of Decree Nº 453/2013 establishes that the General Directorate for the Control of Environmental Quality and Natural Resources (DGCCARN) of the Secretariat of the Environment (SEAM) shall make the environmental impact report available to the public for a period of ten working days on its website, at its headquarters and at any other place it deems appropriate, and shall communicate this fact through publication for three consecutive days in two newspapers of wide circulation and through a national radio station. The DGCCARN shall decide whether or not to convene the public hearing within ten working days of the expiry of the deadline for submitting or, as the case may be, replying to comments, observations or objections. The public hearing shall be mandatory in the event that the proposed work or activity may directly affect indigenous communities or when it has been requested by the neighbours or by those potentially directly affected. Except in these cases, silence on the part of the DGCCARN will imply a decision not to hold the public hearing.

Art. 5º of Law Nº 716/1996 establishes that they will be punished with imprisonment from one to five years and a fine of 500 (five hundred) to 1,500 (one thousand five hundred) legal minimum wages for unspecified miscellaneous activities:

.....

d) Those who use false data or falsify true data in environmental impact studies and assessments or in official standard-setting processes; and

e) Those who evade legal obligations concerning environmental impact mitigation measures or poorly implement such measures.

Resolution N° 640/2014 establishes the General Regulations for Public Hearings, for cases of works or activities that require the submission of an EIA/RIMA.

Art. 1º of Resolution No. 201/2015 establishes, for all projects with an Environmental Impact Statement, the obligation to submit in due time and form, and as a sworn statement, the report of the Environmental Management Plan Compliance Audit as required by the DGCCARN. In addition to the Environmental Management Plan Compliance Audit, the Project or Activity Closure Audit will be carried out in case of Project Abandonment.

This Resolution establishes the procedure for the Evaluation of the Environmental Management Plan Audit Reports and their minimum content for works and activities with an Environmental Impact Statement.

MADES Resolution N° 182/2020 establishes the plans and modalities of recomposition and compensation that will be part of the EMP for environmental impact assessment processes (Art. 1º). In addition, the resolution defines the parameters to be used in establishing the types of recomposition/compensation. In cases of compensation, Art. 10 determines that this will be given for the acquisition of Environmental Services according to the ratio of 1 hectare affected by 1 hectare of Environmental Services (1:1). And that the Environmental Services must be of the natural forest type.

The Organic Law Nº 3966/2010 in its Art. 235 establishes that, in order to build, extend, reform or demolish a work, whether public or private, it is necessary to previously obtain a permit from the municipality and to be in conformity with the norms established in the laws and ordinances.

4.3.2
Pollution Control

4.3.2.1
Classification and Management of Solid Waste

- Law No. 836/1980, establishing the Sanitary Code;
- Law Nº 42/1990, which prohibits the import, deposit and use of products classified as hazardous industrial waste or toxic waste and establishes the corresponding penalties for non-compliance;
- Law Nº 1160/1997 - Penal Code of the Republic of Paraguay;
- Law No. 1262/1998, approving the amendment to the Basel Convention on the Control of Transboundary Movements of Hazardous Toxic Wastes and their Disposal;
- Resolution S.G. 750/2002, approving the regulation on the management of urban, hazardous, biological-infectious, infectious, industrial and related solid waste. It cancels Resolution S.G. No. 548/1996;
- Law No. 2333/2003, approving the Stockholm Convention on Persistent Organic Pollutants;
- Law No. 567/1995, approving the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal;

- Law N° 3956/2009, which provides for the "Integrated Management of Solid Waste in the Republic of Paraguay";
- Law N° 5.882/2017, on the integrated management of batteries and household batteries;
- Decree N° 18.969/1997, regulating Law N° 42/1990;
- Decree No. 7391/2017, regulating Law No. 3956/2009;
- Resolution N° 548/1996, establishing technical standards regulating the management of solid waste;
- Resolution SEAM N° 282/2004, establishing the criteria for the selection of areas for the final disposal of solid waste in sanitary landfills;
- Resolution N° 355/2020, approving the National Plan for Integrated Hazardous Waste Management (PNGIR) within the framework of Law No. 567/1995 and Law No. 3956/2009;
- Resolution N° 356/2020, which approves the National Plan for Integrated Management of Urban Solid Waste (PNGIRSU) in the framework of Law No. 3956/2009 and its Regulatory Decree;
- Resolution N° 460/2022, which regulates the integral management of used mineral lubricating oils and hydrocarbon residues generated in the country, of obligatory compliance for the evaluation process of projects presented within the framework of Law 294/1993 and its regulatory decrees, and creates the National Register of Individuals or Legal Entities in charge of the management of used mineral lubricating oils;
- Resolution N° 79/2023, by which an environmental contingency is declared throughout the national territory for the integral management of solid urban waste generated in the different municipalities of the Republic and for the purpose of adopting all necessary measures for environmental protection;
- Villeta Municipal Ordinance N° 46/2021, which regulates the service of collection and final disposal of solid waste and establishes the rules of public health and hygiene within the District of Villeta, in accordance with Law N° 3956/2009 and its regulatory decree.

Art. 66 of the Sanitary Code states that any action that deteriorates the natural environment, diminishing its quality and making it hazardous to health is prohibited.

The purpose of Law No. 3.956/2009 is the establishment and application of a legal regime for the responsible production and management of solid waste, whose regulatory content and practical utility should lead to the reduction of solid waste to a minimum and avoid situations of risk to human health and environmental quality. The objectives of this Law are:

- To ensure that solid waste is managed without endangering health and the environment, improving the quality of life of citizens;
- Prioritise the reduction of the amount of solid waste, as well as the avoidance of health and environmental hazards;
- Promote the implementation of planning, inspection and control instruments that favour the safety and efficiency of integrated solid waste management activities;
- Ensure citizens' access to information on public action on integrated solid waste management, promoting their participation in the development of planned actions; and
- Improving the environment and quality of life, with efficient health safety provisions.

The Act is based on five fundamental principles:

1. Principle of Co-responsibility. The generator of waste or the cause of any degrading effect on the environment, current or future, is responsible, together with the relevant authorities, for the cost of preventive or corrective recomposing actions.
2. Principle of Congruence. Any departmental or municipal regulation on this issue must be in line with the provisions of this Law. Otherwise, the provisions of this Law shall prevail over all other regulations that oppose it.
3. Principle of Prevention. The causes and sources of environmental problems shall be addressed in a prioritised and integrated manner, seeking to prevent the negative effects that may occur.
4. Principle of Sustainability. Economic and social development shall be carried out through appropriate integrated management in a way that does not compromise the possibilities of present and future generations.
5. Market Value Principle. Solid waste, a product of a society's daily activities, can be reused, forming part of the raw material required by some production systems. Therefore, they have a market value for sale and purchase.

Art. 14 establishes, in the process of solid waste management, that the following, among others, will be considered as duties of the people:

(b) comply with the technical recommendations and standards established by the competent authorities;
c) store waste and solid waste in accordance with sanitary and environmental standards, in order to avoid damage to third parties and to facilitate its collection, as established in this Law and its regulations.

The natural or legal person, public or private, who generates or possesses solid waste, is jointly responsible for its integral management. In order to prevent them from causing harmful effects on health and the environment, they must dispose of them in accordance with the provisions of this Law and its regulations.

Art. 200 of Law Nº 1160/1997, regarding the illegal processing of waste, states that "whoever treats, stores, dumps, disposes of, evacuates or otherwise disposes of waste: outside the facilities provided for this purpose; or deviates considerably from the treatments prescribed or authorised by legal or administrative provisions, shall be punished with imprisonment of up to five (5) years or with a fine".

Art. 199 establishes penalties for anyone who unduly soils or disturbs the soil by spilling substances harmful to soil conservation.

Law Nº 42/1990, prohibits the import, deposit, use of products qualified as hazardous industrial waste or toxic waste and establishes the corresponding penalties for non-compliance.

Decree Nº 18.969/1997, which regulates Law Nº 42/1990, details in its Art. 4º the industrial wastes considered hazardous or toxic. Also Annexes I and II of Law N° 567/1995 establish respectively the categories of waste to be controlled and those requiring special consideration. Regarding batteries, Art. 9 of Law Nº 5.882/2017 establishes, among the obligations of the consumer or user, the following:

b) Dispose of batteries and accumulators only at collection points made available to consumers and users.
(c) Do not dispose of used batteries and accumulators with household waste, or in watercourses, bury or burn them.

Article 8 of Decree Nº 7391/2017 provides for the classification of solid waste.

According to Art. 10 of the same Decree, large generators, which generate high volumes of solid waste, shall comply with the following requirements:

a) Implement solid waste management plans in their production processes, provision of services or in the use of containers and packaging, as well as in their manufacture or design, marketing or use that contribute to the minimisation of solid waste and promote the reduction of generation at source, their recovery or final disposal, in order to reduce the environmental impact caused.

Decree Nº 7391/2017 also addresses the obligation of prior storage of solid waste (Art. 33) and presents the characteristics that collective and temporary solid waste storage systems must have (Art. 35). It also defines the basic rules of the collection and transport service (Art. 40).

Art. 80 defines those who are obliged to formulate and implement management plans and Art. 84 includes the minimum content of solid waste management plans.

Arts. 100 and 101 state that the Solid Waste Management Plan must consider a Contingency Plan to deal with emergency situations and describe the measures to be minimally contemplated.

Law No. 2333/2003 approves the Stockholm Convention on Persistent Organic Pollutants, signed by the Republic of Paraguay in 2001. Article 3 establishes measures to reduce or eliminate releases from intentional production and use of the products listed in Annexes B and A, respectively, and Article 5 establishes measures for unintentional production and use.

Law No. 2333/2003 also establishes general prevention measures relating to best available techniques and best environmental practices to be adopted by projects. Among them, the following can be adopted in the ATOME plant project:

a) Use of low-waste technology;
b) Use of less hazardous substances;
c) Promotion of regeneration and recycling of waste and substances generated and used in the processes;
d) Substitution of raw materials that are persistent organic pollutants or where there is a direct link between materials and releases of persistent organic pollutants from the source;
e) Good operation and preventive maintenance programmes;
f) Improving waste management with a view to ending open waste incineration.

Recently, SEAM Resolutions Nº 355/2020 and Nº 356/2020 were published approving the National Hazardous Waste Management Plan and the National Integrated Urban Solid Waste Management Plan, respectively, in accordance with Law Nº 3596/2009. The publication of these

documents aims to improve waste management. In a complementary way, MADES has published in 2020 the "Guide of Good Environmental Practices and Best Available Technologies for Hazardous Waste Management", which presents some measures for the safety of activities that use or produce hazardous products. The document still defines the basic structure for emergency plans in case of accidents with hazardous products.

Art. 9 of Resolution Nº 460/2022 establishes that projects and activities related to the storage, use and/or final disposal of used lubricating oils derived from industrial processes and others must comply with the procedures established in said resolution for the presentation and approval of their Environmental Impact Studies under the Framework of Law Nº 294/2013.

Municipal Ordinance No. 46/21 of the Municipality of Villeta establishes that industrial waste includes, among others, waste from ambulatory waste, tree pruning waste, bulky or very heavy objects, waste hazardous to the health of living beings and to the environment, toxic and contagious waste, explosives and flammable materials, rubble from masonry work, painting and similar (Art. 3). According to Art. 31, industrial waste not mentioned in Art.3º can be collected by the municipality as long as it does not exceed one barrel capacity. However, the ordinance does not provide further details on the procedures that industries must take into account for the proper disposal of industrial waste generated by their production processes.

4.3.2.2
Protection of Surface and Groundwater Resources

- Law No. 836/1980, establishing the Sanitary Code;
- Law Nº 1160/1997 - Penal Code of the Republic of Paraguay;
- Law Nº 3239/2007, on Paraguay's water resources;
- Decree Nº 18831/1986, establishing environmental protection rules;
- Decree 7017/2022, regulating Law Nº 3239/2007;
- Resolution SG No. 585/1995, regulating the control of the quality of water resources related to environmental sanitation;
- Resolution SEAM Nº 222/2002, which establishes the water register in the national territory;
- SEAM Resolution Nº 2155/2005, which establishes the specifications for the construction of tubular wells for groundwater abstraction;
- Resolution SEAM Nº 50/2006, which establishes the regulations for the management of Paraguay's water resources in accordance with Article 25 of Law Nº 1561/2000, which creates the National Environmental System, the National Environmental Council and the Environmental Secretariat;
- Resolution SEAM Nº 255/2006, which establishes the classification of surface waters in the Republic of Paraguay;
- Resolution SEAM Nº 2194/2007, establishing the national water resources register, the procedures for registration in the register and for the granting of the water resources availability certificate;
- Resolution Nº 1076/2011, by which the Wetlands of the Pantanal of the Department of Ñeembucú, located in the south-western region of Paraguay, are declared of National Environmental Interest, due to their importance for the Production of Water; the conservation of Biodiversity and Environmental Quality in the Territory of Paraguay";
- Resolution SEAM Nº 376/2012, approving the Hydrographic Units of Paraguay;

- Resolution SEAM Nº 770/2014, which establishes the standards and procedures for industrial liquid effluent management and treatment systems, mandatory for industrial complexes;
- Resolution MADES Nº 521/2019, which amends Art. 3 of Resolution Nº 376/2012.

Law Nº 3239/2007, on Paraguay's water resources, aims to regulate the sustainable and integrated management of all waters in Paraguayan territory. Its Chapter V defines the Hydrographic Unit (HU) as a unit established for management and administration purposes composed of a river basin, a portion thereof or a set of these, based on physical, social, environmental and economic characteristics. Resolution SEAM Nº 376/2012, modified by Resolution MADES Nº 521/2019, establishes the hydrographic units of Paraguay. According to the map presented in the resolution, the project is located in the UH Tebicuary Cuenca Baja.

According to Art. 25 of Law Nº 3239/2007, the declaration of protected areas shall be privileged in: water sources or springs, wetland ecosystems, aquifer recharge areas and areas necessary for the regulation of the environmental flow of water.

Art. 27 establishes that SEAM, in coordination with the Ministry of Health and Social Welfare, shall determine the quality levels that surface, ground and atmospheric waters must have, according to the different classifications it makes for this purpose.

The use of water resources or watercourses requires a permit or concession (Art. 32). According to Art. 34, an application for a permit or concession must be made to the water resources authority. Permission for the use of water resources may be granted for (Art. 37):

a) Small uses of water.
b) Transitional uses.
c) Effluent discharges.

The holder of a permit acquires a precarious public right to the use of the water, but not ownership or any other property right over it (Art. 39).

According to Art. 7 of Resolution SEAM Nº 2194/2007, the certificate of availability of water resources will be a prerequisite for the granting of the Environmental Impact Statement.

Art. 66 of the Sanitary Code establishes that any action that deteriorates the natural environment, diminishing its quality and making it hazardous to health is prohibited. Art. 83, in turn, prohibits the discharge of substances into water for domestic, industrial, agricultural or recreational use, which cause pollution or contamination and which may be harmful in any way to the health of man and animals.

Decree Nº 18831/1986 also establishes, in its Art. 4º, the prohibition to "discharge into waters, directly or indirectly, all types of waste, substances, materials or solid, liquid or gaseous elements or combinations of these, which may degrade or pollute the waters or adjacent soils, causing damage or endangering human health or life, flora, fauna or compromising their use in agricultural, livestock or forestry exploitations or their exploitation for different uses".

Art. 1º of Resolution SEAM Nº 222/2002 classifies the waters of the National Territory into 4 classes: Class 1 - waters intended for domestic supplies after simplified treatment; Class 2 - waters intended for domestic supplies after conventional treatments; Class 3 - waters intended for domestic supplies, after special treatment; and Class 4 - waters intended for navigation, for landscape harmony, and for less demanding uses.
According to Art. 1º of Resolution SEAM Nº 255/2006, all waters of the Republic of Paraguay are declared Class 2 in accordance with Art. 3 of Resolution Nº 222/2002. Resolution SEAM Nº 255/2006 does not apply to water resources for better classification (Class 1), such as springs, springs or springs of watercourses that do not present serious deterioration in the ecosystem to which it belongs, or are preserved either by the National System of Protected Wildlife Areas, or by Private Nature Reserves, declared by SEAM.

Art. 7º of Resolution SEAM Nº 222/2002 establishes the conditions and criteria for discharge of effluents from any polluting source, directly and indirectly, into the receiving body. The maximum permissible values for discharge of the parameters are shown in **Table 4.3.2.2.2.a**.

Table 4.3.2.2.a
Limits for effluent discharge into receiving body

Substances, Conditions and Criteria	Limits established by SEAM Resolution Nº 222/2002
pH	5 a 9
BOD 5d 20° C	50 mg/LL
COD	150 mg/L
Temperature	< 40º C
Receiving Body Temperature Elevation	3RD C
Settleable matter (1 h test as Imhoff)	< 1 mg/L
Launch Regime	with maximum flow rate < 1.5 times the average rate of the critical period
Mineral Oils	< 20 mg/L
Vegetable Oils and Animal Fats	50 mg/L
Total Suspended Solids	-
Floating Matters	0
Ammonium (N)	5.0 mg/L
Arsenic (As)	0.5 mg/L
Barium (Ba)	5.0 mg/L
Boron (Bo)	5.0 mg/L
Cadmium (Cd)	0.2 mg/L
Cyanates (CN)	0.2 mg/L
Lead (Pb)	0.5 mg/L
Copper (Cu)	1.0 mg/L
Hexavalent Chromium (Cr)	0.5 mg/L
Trivalent Chromium (Cr)	2.0 mg/L
Tin (Sn)	4.0 mg/L
Phenol Index (C6H5OH)	0.5 mg/L
Soluble Iron (Fe)	15 mg/L
Soluble manganese (Mn)	1.0 mg/L
Total mercury (Hg)	0.01 mg/L
Nickel (Ni)	2.0 mg/L
Silver (Ag)	0.1 mg/L
Selenium (S)	0.05 mg/L

Table 4.3.2.2.a
Limits for effluent discharge into receiving body

Substances, Conditions and Criteria	Limits established by SEAM Resolution Nº 222/2002
Sulphates (Se)	0.05 mg/L
Zinc (Zn)	5.0 mg/L
Total Nitrogen (N)	40 mg/L
Total Phosphorus (P)	4 mg/L
Faecal Coliforms	4000 NMP/100 mL

According to Art. 8º of SEAM Resolution Nº 222/2002, the dilution of industrial effluents with unpolluted water is not allowed. Art. 9º , in turn, establishes that, depending on the quality standards of the receiving body, demonstrated by a self-purification study, SEAM may authorise discharge above the limits established in Art. 7, depending on the type of treatment and the appropriate conditions for the operation.

Resolution Nº 770/2014 establishes the mandatory implementation of industrial liquid treatment systems in accordance with the standards and procedures in its annex, in order to prevent, mitigate and/or minimise the environmental impacts of receiving bodies such as water and soil. Annex 1 determines that, for new industrial projects, the environmental study must have an effluent discharge permit issued by the enforcement authority based on the Effluent Disposal Study and within the parameters set out in the regulation, and approval of the industrial effluent treatment system issued by SEAM.

Art. 8º of Decree Nº 7017/2022 determines that the MADES shall adopt the necessary regulatory measures so that both the granting of permits and concessions for the use and exploitation of water resources, as well as the payment of the fee for the use permit, are carried out in full compliance with Chapter X of Law Nº 3239/2007.

Regarding the drilling of wells to capture groundwater, regardless of its destination, exploration or exploitation, Art. 1º of Resolution SEAM Nº 2155/2005 establishes that the activity must be carried out exclusively by companies registered and authorised by the General Directorate for the Planning and Conservation of Water Resources (DGPCRH).

The drilling or operation of wells with a capacity of more than 1000 L without proper authorisation will be punishable, according to Art. 2 of Resolution SEAM Nº 50/2006.

4.3.2.3
Atmospheric Emissions and Air Quality

- Law No. 836/1980, establishing the Sanitary Code;
- Law Nº 251/1993, which approves the convention on "climate change" adopted during the United Nations Conference on Environment and Development - the Earth Summit - held in the city of Rio de Janeiro, Brazil;
- Law Nº 1447/1999, which approves the Kyoto Protocol to the United Nations Framework Convention on Climate Change;
- Law Nº 1507/1999, approving amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer;

- Decree N° 3980/1999, approving the regulations for the control of ozone-depleting substances and the use of alternative technologies;
- Decree N° 14943/2001, which implements the National Climate Change Programme;
- Law No. 2889/2006, approving the amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer;
- Law No. 5211/2014 on air quality;
- Resolution SEAM No. 259/2015, establishing permissible air quality parameters;
- Law No. 5681/2016, approving the Paris Agreement on Climate Change;
- Law N° 5875/2017, National Law on Climate Change;
- Law No. 6125/2018, approving the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer;
- Decree No. 1269/2019, regulating Law N° 5211/2014; Resolution SEAM No. 78/2018, setting emission limit values for air pollutants from mobile sources and repealing Resolutions 520 B/2008 and 001/2007;
- Resolution SEAM No. 98/2018, setting emission limit values for air pollutants from mobile sources and repealing Resolutions 520 B/2008 and 001/2007;
- Resolution MADES No. 605/2021, which amends Articles 10 and 11 of Resolution N° 78/2018 and Article 2 of Resolution N° 98/2019 regarding emissions from mobile sources and provides procedures for measuring gases from them;
- Resolution MADES No. 420/2022, amending Article 4 of Resolution 609/2021;
- Resolution N° 460/2022, which regulates the integral management of used mineral lubricating oils and hydrocarbon residues generated in the country, of obligatory compliance for the evaluation process of projects presented within the framework of Law N° 294/1993 and its regulatory decrees;
- Villeta Municipal Ordinance N° 18/2018, regulating the control of air quality in the District of Villeta.

Art. 12 of Law N° 5211/2014, regulated by Decree N° 1269/2019, defines the following as polluting substances: carbon monoxide (CO), Sulphur Oxides (SOx), Nitrogen Oxides (NOx), Short-Lived Climate Pollutants, Particulate Matter, Hazardous Air Compounds (HAC), Ozone Depleting Substances, Persistent Organic Pollutants (POP), Greenhouse Gases, and Heavy Metals.

Art. 1° of SEAM Resolution No. 259/2015 establishes the following air quality parameters:

Table 4.3.2.3.a
Air quality parameters

Pollutants	Annual Average	Average in 24 h	Average in 8 h	Average in 1 h
$MP_{2,5}$	15 µg/m^3	30 µg/m^3		
MP_{10}		150 µg/m^3		
O_3			120 µg/m^3	
NO_2	40 µg/m^3			200 µg/m^3
SO_2		20 µg/m^3		
CO			10 µg/m^3	

The Municipal Ordinance N° 18/18 of Villeta also establishes air quality standards in its Art. 3º (although it indicates that these are emission limits). The values established by this ordinance are exactly the same as those of Resolution SEAM N° 259/2015, shown in **Table 4.3.2.3.3.a**.

Regarding climate change and the protection of the ozone layer, Law Nº 1507/1999 approves the amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer and Law N 251/1993 approves the Convention on Climate Change, adopted during the United Nations Conference on Environment and Development.

Regarding limits for atmospheric emissions, the Municipal Ordinance Nº 18/18 of Villeta establishes emission limits for mobile and stationary sources. For gasoline, alcohol, flex or LPG motor vehicles, the values are listed in the table in Art. 4º . For diesel vehicles, the opacity values are listed in Art. 8º , and are as follows:

Table 4.3.2.3.b
Opacity values for Diesel vehicles

Altitude	Aspirated or turbocharged with LDA	Turbo powered
Up to 350 m	1.7 m^{-1}	2.1 m^{-1}
Above 350 m	2.5 m^{-1}	2.8 m^{-1}

For stationary sources, Art. 8º sets the limit for particulate matter at 150 mg/m^3 .

SEAM Resolution No. 78/2018 and its amendments also establishes limits for vehicle emissions while, for stationary sources, national legislation does not.

Art. 11 of the Municipal Ordinance N° 18/18 of Villeta defines that in the emission levels of industrial fumes the concentration of particulate matter must be controlled so that the maximum permissible values must be in accordance with the Resolution of the Municipal Council.

Still on industrial facilities, Art. 16 establishes that those with particulate or odour emissions must have air treatment or purification systems, and/or collection or absorption devices that prevent pollutants from being dispersed in the environment. The legal regulation determines that such systems must be approved by the Municipal Board, with the prior opinion of the Directorate of Hygiene, Health and Environment of the Municipality of Villeta.

Art. 10º of Resolution 460/2022 determines that the General Air Directorate shall carry out random checks of stationary sources of emissions from the projects or activities referred to in Art. 9º .

4.3.2.4
Noise control

- Law No. 836/1980, establishing the Sanitary Code;
- Law Nº 6390/2020, which regulates noise emission, and repeals Law Nº 1100/1997, on the prevention of noise pollution;

- Villeta Municipal Ordinance No. 25/2017, amending and updating Ordinance No. 2/1994 regulating the system of advertising and noise nuisance within the District of Villeta in accordance with the provisions of Law No. 1100/1997 on the prevention of noise pollution.

According to Art. 129 of Law N° 836/1980, the Ministry of Public Health and Social Welfare shall take measures to prevent, diminish or eliminate public nuisances from noise, sounds or vibrations that may affect the health and well-being of the population, and to control them in coordination with the competent authorities. The Ministry shall identify and examine the prevalent sources and forms of noise, sounds and vibrations that affect or may affect health and shall establish standards for the tolerable limits of exposure to them (Art. 130).

Law N° 6390/2020, which repeals Law N° 1100/1997, unlike the previous law, does not establish maximum noise levels to be respected. In its Art. 4° , it defines as attributions of the municipalities, among others:

a. Determine the standards, categories and permitted emission sources, which shall be established according to the characteristics of the noise emitter and the receiving environment.
b. Establish the permitted and prohibited noise levels by regulation.

Municipal Ordinance No. 25/2017 of the municipality of Villeta, in general terms, establishes the prohibition of causing noise and annoying sounds, as well as vibrations by reason of time or intensity that affect the tranquillity, rest, health and material goods of the population. Article 10 stipulates that industrial installations located in residential areas that produce noise or noise nuisance must operate between 6am and 12pm and between 2pm and 8pm and must take measures to reduce noise. Still, the ordinance does not present the maximum levels that will be allowed for fixed or mobile sources of noise.

Thus, for the ATOME plant project, the values established in Law N° 1100/1997 will be adopted, even though it has been repealed.

4.3.3
Biodiversity Protection

- Law N° 422/1973, Forestry Law. Amended by Laws N° 96/1992 and N° 3.788/2010;
- Law N° 758/1979, which approves and ratifies the Convention for the Protection of the Flora, Fauna and Natural Scenic Beauty of the countries of the Americas;
- Law N° 96/1992, on wildlife;
- Law N° 253/1993, which approves the Convention on Biological Diversity, adopted during the United Nations Conference on Environment and Development - the Earth Summit - held in Rio de Janeiro, Brazil;
- Law N° 350/1994, approving the Convention on Wetlands of International Importance, especially as Waterfowl Habitat;
- Law N° 352/1994 on Protected Wildlife Areas (as amended by Law N° 6422/2019);
- Law N° 515/1994, which prohibits the export and trafficking of logs, logs and beams of wood;
- Law N° 536/1995, on the promotion of afforestation and reforestation;
- Law N° 542/1995, on forest resources;

- Law N° 716/1996, which punishes crimes against the environment. Amended by Law No. 2717/2005;
- Law N° 816/1996, which adopts measures for the defence of natural resources;
- Law No. 1314/1998, approving the Convention on the Conservation of Migratory Species of Wild Animals;
- Law N° 1639/2000, amending and extending Law N° 536/1995.
- Law N° 2524/2004 on the prohibition of conversion and conversion of areas under forest cover in the eastern region;
- Law N° 3139/2006, which extends the validity of Arts. 2 and 3 and extends Law N° 2524/2004;
- Law No. 3001/2006, on the valuation and remuneration of environmental services;
- Law No. 3.556/2008, on fisheries and aquaculture;
- Law No. 4241/2010, on the re-establishment of forests protecting watercourses within the national territory;
- Law No. 4928/2013 on the protection of urban trees.
- Law No. 6.256/2018, which prohibits in the Eastern Region the activities of transformation and conversion of areas with forest cover. Amends Arts. 2 and 3 of Law No. 2.524/2004 (Zero Deforestation Law);
- Law N° 6818/2021, which establishes integrated fire management; Decree N° 18.831/1986, which establishes environmental protection norms;
- Decree No. 9824/2012, regulating Law No. 4241/2010;
- Decree No. 11202/2013, which partially regulates Art. 11 of Law 3001/2006 and establishes the mechanism to advance in the regulation of Art. 8 of the same;
- Decree N° 3246/2020, which regulates the National Forest Monitoring System of Paraguay;
- Resolution SEAM No. 2242/2006, approving the list of protected wildlife species threatened with extinction;
- Resolution SEAM No. 2243/2006, updating the list of protected wildlife species in danger of extinction;
- Resolution SEAM No. 263/2007, establishing the General Classification of the Categories included within the Protected Wildlife Species;
- Resolution SEAM N° 614/2013, establishing the ecoregions for the eastern and western regions of Paraguay;
- Resolution SEAM N° 1093/2013, establishing the nominal value of the environmental services certificates of the ecoregions of the eastern and western region of Paraguay;
- Resolution SEAM N° 199/2013, establishing the conditions and requirements to be able to certify the environmental services produced by forests, as well as the conditions and requirements for acquirers of forest environmental services certificates to use them to compensate for the deficit of the legal reserve of natural forests, in accordance with Laws N°422/1973 and N°3001/2006;
- Resolution SEAM N° 352/2013, establishing the fees to be levied, within the framework of Law N° 3001/2006, in view of the application of Resolution 199/2013 to the projects submitted to SEAM;
- Resolution SEAM N° 289/2013, approving the technical methodology for the identification of conservation indices for natural grasslands in compliance with Law N°3001/2006;
- Resolution SEAM N° 756/2016, establishing the procedure for monitoring and auditing environmental services under Law No. 3001/2006;

- Resolution N° 07/2017, which establishes the conditions and requirements to be able to certify the environmental services of scenic beauty produced by protected wild areas, whether state or private, duly declared as such; within the framework of Law N° 3001/2006;
- Resolution SEAM No. 611/2017, establishing the requirements and conditions for joining the Environmental Services Regime;
- Resolution SEAM No. 632/2017, updating the list of protected wildlife species of the class mammalia (mammals);
- Resolution SEAM No. 344/2018, which updates the mechanism for acquiring certificates for compensation for high impact works projects or activities, the register of environmental services certificates, forms No. 1, 2 and 3, monitoring guidelines and establishes the process for extending environmental services certificates in the framework of Law No. 3001/2006;
- Resolution No. 81/2019, which regulates Article 8 of Decree 11202/2013 partially regulating Article 11 of Law 3001/2006 "on valuation and remuneration of environmental services and establishing the mechanism to advance in the regulation of Article 8 of the same;
- Resolution SEAM No. 254/2019, updating the list of protected wildlife species of the bird class;
- Resolution No. 293/2019, approving the National Forest Strategy for Sustainable Growth;
- Resolution N° 470/2019, updating the list of protected species of the native wild flora of Paraguay;
- Resolution SEAM No. 433/2019, updating the list of protected wildlife species of the class Amphibia;
- Resolution SEAM No. 206/2020, updating the list of protected wildlife species of the reptilian class;
- Villeta Municipal Ordinance No. 18/2005, creating the Programme for the Identification of Plant Species in the City of Villeta;
- Villeta Municipal Ordinance N° 07/2022, regulating the pruning or felling of trees and afforestation in the city of Villeta.

Law N° 422/1973, Forestry, creates the National Forestry Service, with the aim of administering, promoting and developing the country's forest resources, in terms of their defence, improvement, expansion and rational use. According to Art. 21, all forests and forest lands in the country's territory are subject to the regime of Law N° 422/1973. Art. 23 of Law N° 342/1995, in turn, defines certain characteristics and uses of forests and lands susceptible of expropriation for public utility.

According to Art. 47 of Law No.° 342/1995, any logging activity may only be initiated after prior authorisation by the National Forestry Service. The transport and marketing of timber and other forest products require permits issued by the National Forest Service, specifying the quantity, species, weight or volume, origin and destination of the transported product (Art. 27 of Law N° 342/1995). The harvesting, industrialisation, trade of forest products and reforestation for production purposes require registration with the National Forest Service (Art. 29).

Art. 45 of Law N° 342/1995 establishes that all rural properties, regardless of their extension, must maintain 25% (twenty-five percent) of their area in natural forest. In case of not having this minimum percentage, the owner must forest up to 5% (five per cent) for properties up to 100 (one hundred) hectares and up to 10% (ten per cent) for properties of more than 100 (one hundred) hectares of the surface of the property and in accordance with the regulations in force.

It should be noted that, due to its industrial nature and location, the Project is not among the activities disqualified by the Zero Deforestation Law in the Eastern Region, which prohibits activities of transformation or conversion of areas with forest cover to areas destined for human settlements, production, transport and commercialisation of timber, firewood, charcoal and any forest by-product originating from unpermitted clearing, excluding all industrial activities from maintaining the 25% and zero deforestation.

According to Art. 11 of Law No. 3001/2006, the projects of works and activities defined as having a high environmental impact, such as construction and maintenance of roads, hydraulic works, power plants, electric transmission lines, pipelines, port works, industries with high levels of gas emissions, discharge of urban and industrial effluents or others, according to the list determined by the Executive Power, must include within their investment scheme the compensation for environmental services through the acquisition of Environmental Services Certificates, without prejudice to the other mitigation and conservation measures to which they are obliged. Investments in environmental services of these projects of works or activities may not be less than 1% (one per cent) of the cost of the work or of the annual operating budget of the activity.

Art. 12 of the same Law No. 3001/2006 establishes that those who have not complied with the requirement of legal reserve of natural forests as defined in Law No. 422/1973 must acquire Environmental Services Certificates until the deficit of such legal reserve is compensated. The SEAM will determine by resolution the conditions under which those persons, natural or legal, whose properties do not comply with the requirement of legal reserve of natural forests established in Law No. 422/1973, must acquire Environmental Services Certificates.

The Environmental Services Certificate is a security freely negotiable by those who are not obliged by virtue of this Law or by judicial sentence to invest in environmental services, and may be traded on the international market for the payment of environmental compensations made by natural or legal persons obliged to do so for the activities or exploitations they carry out and which are considered harmful to the environment. They may also be used to offset local or national taxes such as IMAGRO, Real Estate Tax and Personal Income Tax (Art. 8).

Art. 2 of SEAM Resolution No. 199/2013 establishes forest areas, in addition to forest areas maintained as legal reserves established by Law No. 422/1973 and areas established as watercourse protection strips under Law No. 4241/2010, which can be used as environmental services. This resolution also presents the conditions and technical requirements for certification of natural forests.

SEAM Resolution No. 289/2013, in turn, establishes conditions and requirements for certification of natural grasslands under the environmental services regime. There is also how to certify the environmental services of scenic beauty produced by Wildlife Protected Areas. Resolution SEAM N° 17/2017 establishes conditions and requirements for certification of these areas.

SEAM Resolution No. 611/2017 establishes the general requirements and conditions for joining the environmental services regime.

Resolution SEAM N° 1093/2013 establishes the nominal values for the calculation of environmental services for each ecoregion of Paraguay. According to the map of ecoregions

established in Resolution SEAM N° 614/2013, the area of the ATOME Plant is in the ecoregion Litoral Central and/or Ñeembucú. For these ecoregions, the nominal values for the calculation of environmental services, according to Art. 1 of Resolution SEAM N° 1093/2013 are:

Table 4.3.3.a
nominal values for the calculation of environmental services, by ecoregion

Ecoregions	Guaraníes/hectare/year
Central Coast	5.152.526
Ñeembucu	3.554.037
Humid Chaco	2.517.405

Resolution Nº 81/209 establishes the typology of high impact works or activities as those originating from physical and human actions of significant effect both in the area of influence, as well as in the severity of the action considered practically irreversible. Among the works and activities listed in Annexes I and II of the Resolution are the construction of industrial establishments with investments equal to or greater than US$ 50,000,000 and the operation of chemical industries.

In accordance with Art. 6º of Decree No. 18.831/1986, which establishes environmental protection regulations, it is forbidden to clear land in areas larger than 100 (one hundred) hectares, and forest strips of at least 100 (one hundred) metres wide must be left between plots.

Art. 7º establishes that in plots of land that have been cleared in excess of those established in this Decree, reforestation must be carried out immediately in order to achieve the conditions established in Article 6 in the medium and long term.

Law Nº 96/1992, creates the Wildlife Protection and Conservation System and regulates the protection, management and conservation of the country's wildlife. According to Art. 25, wild flora located in those environments that are valuable for their ecological importance or rarity shall be considered susceptible to permanent protection and conservation.

Art. 26, in turn, establishes that wild flora species used in folk medicine or in other uses with relevant social values, shall be subject to specific regulations by the Authority of Application.

According to its Article 33, the Authority of Application shall grant authorisations for the collection, exploitation, commercialisation, transit, import, export and re-export of elements of wild flora, whether on a permanent or occasional basis, based on scientific studies and in accordance with the provisions of international conventions in force, provided that such activities are carried out:

a) Do not directly or indirectly affect endangered, rare or endemic species;
b) They are positively related, in their frequency or intensity, to the biology of each species;
c) Allow for the normal and balanced reproduction of both the harvested species and the other organisms that depend on them;
d) Do not pose a danger to the survival or normal development of other organisms, or to human health;
e) Do not infringe on the rights, interests and customs of indigenous or other protected minority groups; and
f) Are not prohibited or restricted by other legislation.

Law N° 6.256/2018 establishes, in its Art. 2° , that it is prohibited in the Eastern Region, to carry out activities of transformation or conversion of surfaces with forest cover, to surfaces destined for agricultural use in any of its modalities; or surfaces destined for human settlements; as well as the production, transport and commercialisation of wood, firewood, charcoal and any forest by-product originating from non-permitted clearing. Article 3 also prohibits the issuing of permits, licences, authorisations and any other type of legally valid document that covers the transformation or conversion of areas with native forest cover. The forests will be registered in a special register at the National Forestry Institute (INFONA) and will not be subject to agrarian reform and will be declared non-expropriable.

In compliance with Art. 3° of Law N° 6256/2018, Decree N° 3246/2020 was approved, which regulates the National Forest Monitoring System (SNMF), whose purpose is to provide official national information on the national forest cover in a periodic, measurable, verifiable and comparable way with other geographic information systems, as well as to provide parameters and information that allow to dimension the magnitude of the carbon content stored in the national forest mass and the qualitative and quantitative typification of forest species that integrate the national forest mass.

Regarding fire prevention and control, the new Law N° 6818/21 transfers to the municipalities to grant the burning permit according to the weather conditions and the preventive measures to be taken by the affected person (Art. 6).°

The list of native flora species threatened with extinction in Paraguay is presented in Resolution SEAM N° 2242/2006, updated by Resolutions SEAM N° 2243/2006 and N° 470/2019.

Law No. 4241/2010, in Art. 2° , declares natural areas bordering watercourses as protective zones. It also states in Art. 9° that protective forests shall be maintained or re-established in direct proportion to the width of the watercourse and the particularities of the natural regions of the country. In accordance with this article, the National Forestry Institute - INFONA (created by Law No. 3464/2008) will establish the minimum and maximum parameters required for compliance, as well as the species to be planted, in accordance with Article 23, Inc. b) of Law No.° 3239/2007 .

In the specific case of the district of Villeta, Ordinance N° 7/2022 regulates the Law for the Protection of Urban Trees in the municipality and establishes provisions for pruning, transplanting, felling, as well as the promotion of planting, management and repopulation of any tree species in both public and private spaces. In this sense, the ordinance applies to urban areas of the district of Villeta, disaffecting the ATOME property due to its location. Art. 6° line "e" establishes that plans relating to civil works buildings located on land that exceeds 1000 m2 must present a tree planting project for the land, containing the botanical and common names of the trees to be planted, in order for the project to be approved by the Municipal Council. For urban areas, all pruning and felling of trees of any species requires prior authorisation by the Municipal Intendancy via Resolution (Arts. 16 and 17) and establishes a compensation of 10 small trees or native tree seedlings of 1 metre high, with their respective protectors, for each tree felled, to be delivered to the Environmental Directorate of the Municipality of Villeta (Art. 12).

Regarding fauna, Law N° 96/1992, in its Art. 27, establishes that those species of fauna that develop in restricted environments or habitats highly altered by man will be protected and conserved with specific regulations. Furthermore, all measures shall be taken to preserve species in danger of extinction or in the process of population decline (Art. 34). Art. 37 prohibits the hunting of wild animals.
Art. 5° of Law N° 716/1996 establishes that the following shall be punished with imprisonment from one to five years and a fine of 500 (five hundred) to 1,500 (one thousand five hundred) legal minimum wages for various unspecified activities: *a) Those who destroy endangered species of wild animals and those who illegally traffic or trade in them, their parts or products.*

According to Art. 6° of Law No. 2717/2005, whoever violates the rules and regulations governing the hunting, collection or preservation of the habitat of species declared endemic or endangered shall be punished with imprisonment of one to five years or with a fine of five hundred to one thousand legal minimum wages for unspecified miscellaneous activities. In both cases, the confiscation of the elements used for this purpose shall also be applied.

SEAM Resolution N° 263/2007 categorises Protected Species as: a) endemic b) threatened with extinction c) rare d) endangered. This resolution further stipulates that Protected Species may not be susceptible to commercial use, with the exception of those species originating from nurseries, cultivation and/or breeding.

Specifically for mammals, the list of species threatened with extinction was published by Resolution SEAM N° 632/2017. For birds, the list of native species in danger of extinction in Paraguay is presented in Annex I of Resolution N° 254/2019. In the case of reptiles, Resolution SEAM N° 206/2020 also updated the list of protected species.

Law No. 1314/1998 approves the Convention on the Conservation of Migratory Species of Wild Animals and lists endangered migratory species (Appendix I) and migratory species to be the subject of agreements (Appendix II).

4.3.3.1
Protected areas

- Law N° 352/1994, on Protected Wildlife Areas. Amended by Law N° 6422/2022;
- Law N° 350/1994, approving the Convention on Wetlands of International Importance, especially as Waterfowl Habitat;
- Law N° 3239/2007, on Paraguay's water resources;
- Decree N° 18.831/1986, establishing environmental protection regulations;
- Resolution DPNVS N° 79/2000, which establishes the procedures for the legal creation of protected wildlife areas under the private domain of Paraguay;
- Resolution SEAM N° 200/2001, by which management categories, zoning, uses and activities are assigned and regulated;
- Resolution SEAM N° 781/2005, establishing the regulations for the use of protected wilderness areas under public domain.

Law N° 352/1994 regulates the management and administration of the National System of Wildlife Protected Areas - SINASIP of the country, which corresponds to the set of Wildlife Protected Areas of ecological and social relevance, under an orderly and directed management

that allows compliance with the objectives and conservation policies established by the Nation. Art. 2º declares SINASIP to be of social interest and of public utility.
In Art. 6º and 7º the terms of the Management category are defined, which differentiates the areas according to the type of management or administration, and Buffer Zone, which corresponds to the region adjacent to the perimeter of the protected area, whose responsibility is shared between the administration of the area and the communities, and where sustainable development is aimed at through socio-environmental education.

Art. 9º defines the Management Plan as the document prepared by a multidisciplinary team and with the participation of community representatives, which defines the objectives, management category and boundaries of the protected area, and establishes the programmes and actions necessary for the administration and management of the resources. The document also defines the Buffer Zone.

According to Art. 12, any project affecting a Protected Wildlife Area or its buffer zone must have an Environmental Impact Assessment Study.

The management categories of protected areas are established in Resolution SEAM N° 200/2001, and according to its Art. 2º , they may be of strict protection, flexible use and special use. Areas considered as strictly protected management category include Scientific Reserves, National Parks and Natural Monuments (Art. 3º). Flexible Use Management includes Wildlife Refuges, Protected Landscapes, Managed Resource Reserves and Biosphere Reserves (Art. 5º). Special management is restricted to Ecological Reserves and Nature Reserves (Art. 7).º

Art. 2º of SEAM Resolution Nº 781/2005 establishes regulations for public use of Wildlife Protected Areas under public domain. It defines prohibited activities, including killing, harming or scaring wild animals; destroying, uprooting or removing plants from the site, prospecting without a permit, discharging polluting substances.

With regard to wetlands, Art. 1º of Law N° 350/1994 approves the convention on wetlands of international importance, especially as habitat for waterfowl. Paraguay acceded to the Ramsar Convention on 7 October 1995.

Art. 29 of Law Nº 3239/2007, on water resources of Paraguay, establishes that the State shall recognise wetlands as ecosystems of great importance for society, and their conservation and sustainable management shall make possible the adequate functioning of water resources in general.

Article 23, Inc. b) of Law Nº 3239/2007, in turn, establishes a 100-metre wide protection zone for water sources on both banks, in which the use of the land and the activities carried out there will be conditioned, in accordance with the provisions of the environmental legal regulations. This 100 m protection zone was already foreseen in Art. 3º of Decree Nº 18.831/1986.

Art. 25 also declares as protected areas the areas of water sources or springs, wetland ecosystems, aquifer recharge areas and areas necessary for the regulation of the environmental flow of water.

The ATOME plant project will not affect protected areas.

4.3.4
Historical, Cultural and Archaeological Heritage

- Law No. 1231/1986, approving and ratifying the Convention concerning the Protection of the World Cultural and Natural Heritage;
- Law No. 3051/2006, National Law on Culture;
- Law N° 5621/2016, on the protection of cultural heritage;
- Decree No. 20132/2003, approving the manual establishing rules and procedures for the administration, control, custody, classification, accounting and regime of state assets and repealing Decree No. 39759/1983;
- Decree No. 7837/2017, which regulates the procedures for preventive measures and preliminary investigations, as well as the instruction of administrative inquiries for the application of the sanctions provided for in Art. 42 of Law No. 5621/2016;
- Decree No. 5430/2021, regulating Chapter III of the National Heritage System, of Law Nº 5621/2016;
- Resolution SNC Nº 014/2007, approving the Regulations for palaeontological, archaeological and anthropological prospecting in the national territory;
- Resolution SNC Nº 1104/2019, which approves the National Protocol of Preventive Interventions for Archaeological and Palaeontological Heritage;
- Resolution SNC N° 416/2021, which establishes the National Protocol for Action and Interventions in the Underwater Cultural Heritage of Paraguay;
- SNC Resolution No. 462/2020, regulating Article 6 of Law No.º 5621/2016;
- SNC Resolution No. 687/2021, which regulates the submission of the inventory of private property in accordance with Article 32 of the Law on the Protection of Cultural Heritage;
- SNC Resolution No. 549/2021, which approves the forms relating to the formalities and procedures before the General Directorate of Cultural Heritage of the SNC.

In Paraguay, all archaeological materials and sites are subject to Law N° 5621/2016, which repealed Law N° 946/1982.

Art. 7º of Law No. 5621/2016, in accordance with the provisions of Law No. 3051/2006, defines the National Secretariat of Culture (SNC) as the highest instance at national level in the area of culture, acting as the governing body responsible for the implementation of policies, programmes and projects that ensure compliance with this Law.

Art. 18 establishes that the properties that make up the cultural heritage shall be subject to the present general regime of protection, which shall be exercised on all of them, without exception.

Article 21 establishes the prohibition of demolition, destruction or transformation of cultural property covered by this Law, without the due authorisation of the National Secretariat of Culture. The works to be carried out on a cultural property require for their commencement the due authorisation of the National Secretariat of Culture, in accordance with that issued by the local authorities; which will be regulated by the former (Art. 22).

The National Secretariat of Culture (SNC) may order, prior notification to the owner, the carrying out of excavations in privately owned properties where the existence of cultural property is reasonably presumed (Art. 23) and also proceed to the occupation or securing of cultural

property, when the causes established in Article 21 and concordant articles of the present Law or in its regulations are present (Art. 24).

According to Art. 28, any person who knows of the existence of national cultural heritage property is obliged to notify the SNC.

Art. 41 foresees criminal sanctions for damage caused to cultural heritage property in all its categories or classifications, such as destruction, damage, theft, robbery, partial or total demolition; as well as: illicit trafficking, transformation, restoration or undue intervention of the same. Art. 42 foresees administrative sanctions for damage, lack of safekeeping, failure to formalise, and failure to notify the CNS in relation to cultural property.

Decree N° 5430/2021 establishes that, through the National Heritage System, the SNC will undertake the decentralisation of the management of Paraguay's cultural heritage, acting as the controlling entity responsible for guaranteeing compliance with the obligations of the system's member institutions (Art. 4). °

SNC Resolution N° 014/2007 approves the Regulations for palaeontological, archaeological and anthropological surveys in the national territory.

In 2019, the SNC published Resolution N° 1104/2019, which approves the National Protocol for Preventive Interventions for Archaeological and Palaeontological Heritage. According to this regulation, private projects that are carried out on land where there is no previous infrastructure need to require a prior assessment under the SNC to determine the need or not for a preventive diagnosis on the land.

4.3.5 Land Acquisition, Expropriation and Resettlement Processes

- National Constitution of Paraguay;
- Law No. 1183/1985, Civil Code and amendments.

Art. 39 of the National Constitution of Paraguay provides that every person has the right to be fairly and adequately compensated for damages or losses suffered by the State.

According to Art. 109 of the Constitution, private property is inviolable. No one may be deprived of his property except by virtue of a court ruling, but expropriation is permitted for reasons of public utility or social interest, to be determined in each case by law. Such expropriation shall guarantee the prior payment of fair compensation, established by agreement or by judicial sentence, except for unproductive large estates intended for agrarian reform, in accordance with the procedure for expropriation to be established by law.

Article 128, in turn, states that in no case shall the interests of private persons take precedence over the general interest.

Also Art. 1964 of the Civil Code (Law N° 1183/1985) establishes that no one can be deprived of the domain or of any of its faculties, except for reasons of public utility or social interest, defined by law, nor be dispossessed of his property without fair compensation. In Art. 1965, it provides

that, if the expropriated thing is not used for the purpose for which it was expropriated within a reasonable period of time, the previous owner may demand its recovery in the state in which it was sold, consigning the price or the compensation paid. In addition, Art. 1967 establishes expropriation as one of the causes for the loss of ownership of real estate (paragraph d).

Art. 738 defines that the rules of purchase and sale shall apply subsidiarily to expropriation for reasons of public utility or social interest.

Art. 2000 of the Civil Code, which deals with the harmful use of property, stipulates that the owner is obliged, in the exercise of his right, especially in industrial exploitation works, to refrain from any excess to the detriment of the property of the neighbours. In particular, smoke or soot emissions, noxious and annoying fumes, noise, tremors which have a detrimental effect and which exceed the limits of tolerance owed by neighbours in consideration of the local use, location and nature of the property are prohibited. The owner, tenant or usufructuary of a property has the right to prevent the misuse of the neighbouring property from impairing the safety, peace and health of the inhabitants. Depending on the circumstances of the case, the judge may order the cessation of such nuisance and compensation for damages, even if there is administrative authorisation.

4.3.6
Occupational Health and Safety at Work and Community Safety

- Law No. 836/1980, Sanitary Code;
- Law No. 213/1993, establishing the Labour Code. Amended by Law No. 496/1995;
- Law N° 1160/1997, Penal Code of the Republic of Paraguay;
- Law N° 5508/2015, which establishes the promotion, protection of maternity and support for breastfeeding;
- Law N° 5804/2017, which establishes the national system for the prevention of occupational risks;
- Decree N° 7550/2017, which regulates Law N° 5508/2015 on the promotion, protection of maternity and support for breastfeeding;
- Decree N° 14390/1992, approving the general technical regulations on safety, hygiene and medicine at work;
- Decree N° 5078/2021, repealing Articles 260, 262, 263, 264, 265, 266 and 270 of the general technical regulations on safety, hygiene and medicine at work, approved by Decree N° 14.390/1992;
- MTESS Labour Resolution N° 785/2020, which provides for the implementation of Articles 1, 2, 3, 3, 4, 5, 6, 7, 8, 13, 14, 17, 18, 19, 23, 24, 25, and 41, 42, 43, 44, 45 and 46 of Law No. 5804/2017, which establishes the national system for the prevention of occupational risks;
- MTESS Labour Resolution N° 03/2022, which regulates the content and frequency of compulsory medical examinations for admission and periodic examinations of workers and other aspects related to occupational health and safety, in accordance with Decree No. 5078/2021, which repeals Articles 260, 262, 263, 264, 265, 266 and 270 of the general technical regulations on safety, hygiene and medicine at work, approved by Decree No.° 14.390/1992;
- Municipal Ordinance of Villeta N° 2/2003, by which it is declared of municipal interest to carry out sanitary controls in commercial and industrial premises, warehouses, private

homes and public transport vehicles in general, in order to guarantee the health of the population;

- Villeta Municipal Ordinance N° 12/2010, on fire safety and prevention;
- Villeta Municipal Ordinance N° 14/2011, amending and extending Ordinance N° 02/2003, which declares of municipal interest the obligation to carry out sanitary controls in commercial and industrial premises, warehouses, private homes and public transport vehicles in general in order to guarantee the health of the population.

According to Art. 87 of Law N° 836/1980, the Ministry of Public Health and Social Welfare shall dictate technical norms and exercise control over the sanitary conditions of commercial, industrial and health establishments, considering the necessary protection of workers and the population in general.

Prior authorisation from the Ministry shall be required for the granting of a patent or permit for the operation of industrial establishments and other workplaces, as well as for the extension or modification of existing facilities (Art. 88), and the Ministry may cancel the authorisation granted if its operation represents a risk to health (Art. 89).

Law No. 213/1993 establishes the Labour Code, and provides for Safety, Hygiene and Comfort at Work in Articles 272 to 282:
"The worker, in the provision of his professional services, shall have the right to effective protection in the field of health, safety and hygiene at work (Art. 272).

The employer shall ensure the hygiene, safety and health of workers in the performance of their work. For this purpose, he shall take all necessary measures, including information, training, risk prevention activities and the establishment of the necessary organisation or means. Occupational health and safety measures shall not entail any financial burden for workers (Art. 274).

The employer shall, as a minimum (Art. 275):

a) Arrange for the admission and periodic medical examination of each worker, at their own expense.
b) Assessing, preventing and combating risks at source;
c) Establish the working and production conditions and methods which have the least adverse effect on the hygiene, safety and health of workers;
d) Plan prevention and determine the measures to be used, both collective and individual, as well as the protective equipment to be used against the risks inherent to the activity carried out;
e) Inform the competent authorities of occupational accidents and diseases suffered by workers.

The employee is obliged to observe the legal and regulatory measures for health, safety and occupational medicine at work.
The employer shall provide practical and adequate training and information on health, safety and hygiene to the workers he employs, or when they change their job or have to apply a new technique that may cause risks. The worker is obliged to follow such training and to carry out the corresponding practices (Art. 276).

The introduction, sale and consumption of alcoholic beverages on work premises, as well as their production in enterprises that do not have this special purpose, is prohibited (Art. 277).

Workers shall not be allowed to sleep on the working premises, except for the peculiarities of certain undertakings, in which case the employer shall provide appropriate accommodation. Where workers are permitted to eat on the premises, a suitable and adequately equipped place shall be provided for that purpose, which shall be separate from the place of work. Canteens, changing rooms and sanitary facilities shall be maintained in good condition (Art. 280).

The Labour Administration Authority shall take measures to promote education in safety and health and in the prevention of hazards by all appropriate means in order to arouse and maintain the interest of employers and workers (Art. 282)".

Art. 205 of the Penal Code (Law No. 1160/1997), on exposure of persons to hazardous workplaces, states:

"1° The owner of an establishment or company and the person responsible for the prevention of accidents at work who: causes or fails to prevent workplaces or means of work from violating the legal provisions on safety and accident prevention at workplaces; or clearly fails to comply with the requirements of technical care, and thereby endangers the life or limb of others, shall be punished by imprisonment for up to five (5) years or a fine.

2° Those responsible, in accordance with Sub-Clause 1, who fail to inform employees in an appropriate manner of the dangers to life and limb associated with the work and of the measures for prevention, shall be liable to imprisonment for up to three (3) years or a fine".

Decree N° 14390/1992, in its Title I, establishes the general conditions for establishments or workplaces and the mechanisms for protective measures.

In Chapter I, Buildings and Premises, it establishes the conditions for working environments, and in Section II, specifically on Auxiliary Installations. The conditions required for living quarters (Art. 30), sleeping rooms (Art. 31), dining rooms (Art. 32) and kitchens (Art. 33) are presented. The conditions for toilet facilities are dealt with in Section III and for first-aid facilities in Section IV.

Section V deals with the conditions for temporary premises, i.e. in open-air work where 20 or more workers are employed for 15 days.

Decree N° 14390/1992 also includes specifications for the following topics:

- Chapter II - Fire prevention and suppression
- Chapter III - Explosion Hazardous Premises
- Chapter IV - Signalling
- Chapter V - Electrical energy
- Chapter VI - Pressure vessels and appliances generating heat and cold
- Chapter VII - Apparatus, machines and tools
- Chapter VIII - Lifting and carrying appliances

- Chapter IX - Motor transport
- Chapter X - Work with special risks (work at heights, excavations and foundations; demolition, explosives)
- Chapter XI - working environment
- Chapter XII - Personal Protection
- Chapter XIII - On the organisation of occupational health in the workplace
- Chapter XIV - Internal accident prevention commissions (CIPA)

It is important to mention that Decree No. 5078/2021 repealed articles 260, 262, 263, 264, 265, 266 and 270 of the general technical regulation on safety, hygiene and medicine at work, approved by Decree No. 14.390/1992, which deal with admission and periodical medical examinations, as well as with occupational accident issues. These aspects will be regulated by MTESS Labour Resolution N° 03/2022.

MTESS Resolution N° 785/2020 in its Art. 3º establishes the elaboration of the Occupational Safety Information Register with the aim of having reliable information about employers obliged by Law N° 5.804/2017, in order to compose the statistical register of occupational accidents.

Ordinance No. 12/10 states that any new construction, extension or alteration of buildings whose activities produce or use chemical products capable of causing explosion, combustion or are carriers of fumes, emanation of dangerous gases, radioactive or hazardous effects must observe the safety and fire prevention standards and requirements set out in the ordinance.

Finally, Ordinance N° 14/11 makes it compulsory to disinfect, disinsect and disinfect buildings intended for industrial use every six months, with certificates issued by legally authorised private companies or by the municipality.

4.3.6.1
Noise at Work

- Law N° 1100/1997 on the prevention of noise pollution. Repealed by Law N° 6390/2020.

Art. 10 of Law N° 1100/1997 established the maximum permissible daily exposure for noise and noise nuisance caused inside premises with occupational, industrial, commercial or social activities according to **Table 4.3.6.1.a** below:

Table 4.3.6.1.a
Exposure limits for noise and nuisance sounds

Duration in hours and days	Decibels DB SFL
8 hours	90
6 hours	92
4 hours	95
3 hours	97
2 hours	100
1 ½ hours	110
1 hour	115

As already mentioned in **Section 4.3.2.4**, this Act was repealed by Act N° 6390/2020, but the latter does not set limits for occupational noise exposure. It leaves it up to the municipality to set these limits. Villeta Municipal Ordinance No. 25/2017, which deals with noise, does not set emission limits. Therefore, the ATOME Plant Project will adopt the values established in Law N° 1100/1997, even though it has been repealed.

4.3.6.2
Control of Water Potability

- Norma Paraguaya NP N° 24 001 80/1997, do Instituto Nacional de Tecnología y Normalización, que especifica los parámetros para el agua potable.

The values of maximum allowable concentrations for toxic substances, chemicals, organic compounds and radionuclide compounds, presented in **Tables 4.3.6.2.a** to **4.3.6.2.e** below, were extracted from NP No. 24 001 80. Also included in the Tables are the World Health Organization (WHO) standards - Global Drinking Water Quality Guideline, 2017 update.

Table 4.3.6.2.a
Maximum Permissible Concentrations of Toxic Substances

Toxic Substances	Maximum Allowable Concentrations (in mg/L) - NP N° 24 001 80	WHO (in mg/L)
Arsenic (As)	0.05	0.01
Chromium (Cr+6)	0.05	0.05
Lead (Pb)	0.05	0.01
Selenium (Se)	0.01	0.01
Mercury (Hg)	0.001	0.001
Cadmium (Cd)	0.005	0.003
Nickel (Ni)	0.005	0.02
Cyanide (Cn)	0.1	0.07

Table 4.3.6.2.b
Maximum Allowable Concentrations of Chemical Substances

Chemicals	Maximum Allowable Concentrations (in mg/L) - NP N° 24 001 80	WHO (in mg/L)
Fluorides (F-)	1.5	1.5
Nitrates (NO^3)	45	50

Table 4.3.6.2.b
Maximum Allowable Concentrations of Chemical Substances

Chemicals	Maximum Allowable Concentrations (in mg/L) - NP N° 24 001 80	WHO (in mg/L)
Ammoniacal nitrogen, as NH4-	0.5	0.,2
Nitrous nitrogen, in NO^2	0	-
Phosphate (PO4-)	2	-
pH	6 - 9	6.5 - 9.5
Alkalinity (P) expressed in $CaCO^3$	120	-
Alkalinity (M) in $CaCO^3$	250	-
Total hardness expressed as $CaCO^3$	250	200 - 500
Total dissolved solids at 105 °C	1000	1000
Oxidability expressed as O2	3	3
Chloride expressed as Cl-	250	250
Sulphate expressed as SO4- bonding	250	250
Iron expressed as soluble Fe	0.3	0.3
Manganese expressed as Mn	0.1	0.4
Zinc expressed as Zn	0.2	3
Residual chlorine expressed as Cl-	1	0.6 - 1
Copper Cu	1	2

Table 4.3.6.2.c
Maximum Allowable Concentrations of Organic Compounds

Organic components	Maximum Permissible Concentrations (in µg/L) - NP N° 24 001 80	WHO (in µg/L)
Endrin	0.2	0.6
Aldrin	0.03	0.03
Dieldrin	1	0.03
Lindane	3	2
Toxaphene	5	0
Heptachlor	0.1	0.1
Heptachlor epoxide	0.1	0.1
DDT isomers metabolites	1	1
Chlordane total isomers	0.3	0.2
Methoxychlor	30	20
Total organophosphates and carbonates	10	10
Herbicides	Maximum combination limit 100 µg/L	Maximum combination limit 100 µg/L
2,4,5 - TP 2,4,5 - T 2,4,5 D (e)		
Phenolic compounds	2	2
Detergents surfactants	200	-
Oil and fats	Absent	Absent
Organic nitrogen	Absent	-

Table 4.3.6.2.c
Maximum Allowable Concentrations of Organic Compounds

Organic components	Maximum Permissible Concentrations (in µg/L) - NP N° 24 001 80	WHO (in µg/L)
Polycyclic aromatic hydrocarbons (benzo to pentane)	0.01	0.01
Benzene	10	10
Chloroform	30	30
Carbon tetrachloride	3	4
1,2 dichloroethane	10	30
1,1 dichloroethane	0,3	-
Tetrachloroethyl	10	40
2,4,6 trichlorophenol	10 (+)	2
Formaldehyde	500	900
Ethyl mercury chloride	0.1	-
Pentachlorophenol	10	9
Diethyl mercury	0.1	-

Table 4.3.6.2.d
Maximum Permissible Concentrations of Radionuclide Compounds

Radionuclide compounds	Form Soluble Concentration Maxi. concentration (µ Ci/L)	Insoluble Form Max. Concentration (µ Ci/L)	(WHO) (in µ Ci /L)
3 H tritium	3	-	2.7
Carbon 14 + CO2	0.8	-	0.027
Sodium - 22	0.04	0.03	0.027
Phosphorus - 32	0.02	0.02	0.027
Sulphur - 35	0.06	0.3	0.027
Potassium - 42	0.3	0.02	-
Calcium - 45	0.009	0.2	0.027
Iron - 59	0.06	0.05	0.027
Copper - 64	0.3	0.2	-
Zinc - 65	0.1	0.2	0.027
Cadmium - 109	0.9	0.2	0.027
Iodine - 139	0.002	0.06	0.0027

Note: For professionals who are exposed to radiation, the values should be multiplied by a factor of ten.

According to NP No. 24 001 80, the drinking water shall be of such quality that it does not represent a risk to the health of the consumer (absence of pathogenic micro-organisms) and shall comply with the microbiological requirements presented in **Tables 4.3.6.2.e** and **4.3.6.2.f.**

Table 4.3.6.2.e
Maximum Allowable Concentrations of Organisms in Drinking Water

Organisations	Maximum Limits			
	Treated Water	Untreated Water	Membrane Filtration Technology	
			Treated Water	Untreated Water
Total mesophilic aerobes 48 hours	< 25 CFU / ml	< 100 CFU / ml	< 25 CFU / ml	< 100 CFU / ml
Total coliforms	< 1 MPN / 100 ml	< 2 MPN / 100 ml	0 CFU / ml	0 CFU / ml
Faecal Coliforms	Absence	Absence	0 CFU / ml	0 CFU / ml
Escherichia coli	Absence	Absence	0 CFU / ml	0 CFU / ml

Table 4.3.6.2.f
Maximum Allowable Organism Concentrations for Water in the Distribution System

Organisations	Unit	Guide value	Remarks
Faecal Coliforms	MPN / 100 ml	0	-
Total coliforms	MPN / 100 ml	0	In 95% of the samples tested during the year, when large supply systems are involved and sufficient samples are examined
Total coliforms	MPN / 100 ml	3	Occasionally in some samples, but not in consecutive samples

4.3.7
Labour legislation

- Law No. 884/1981, which regulates working conditions in land motor transport;
- Law No.º 213/1993, establishing the Labour Code. Amended by Law No. 496/1994 and Law No. 1416/1999;
- Law Nº 1542/2000, which establishes the procedure for the qualification of a strike;
- Law No. 1657/2001, approving Convention 182 and the Recommendation concerning the Prohibition and Immediate Action for the Elimination of the Worst Forms of Child Labour;
- Law No. 1680/2001, Childhood and Adolescence Code of Paraguay;
- Law Nº 1.925/2002, which approves the Inter-American Convention for the Elimination of all Forms of Discrimination against Persons with Disabilities;
- Law No. 2128/2003, approving the International Convention on the Elimination of All Forms of Racial Discrimination;
- Law No. 3338/2007, approving Convention 156 on Equal Opportunities and Equal Treatment for Men and Women Workers: Workers with Family Responsibilities;
- Law No. 3540/2008, approving the Convention on the Rights of Persons with Disabilities and the Optional Protocol to the Convention on the Rights of Persons with Disabilities.
- Law No. 4934/2013, approving the right of accessibility to the physical environment for persons with disabilities.
- Law N° 5508/2015, which establishes the promotion, protection of maternity and support for breastfeeding;

- Decree N° 4951/2005, which regulates Law N° 1657/2001 and approves the list of hazardous child labour.

The Labour Code (Law No. 213/1993) consists of 413 articles and its main provisions are as follows.

Art. 65 defines the obligations of workers, among them:

"...
(c) Comply with the provisions of the working regulations and carry out the orders and instructions given by the employer or his representatives in accordance with the established organisation;
(d) To observe exemplary conduct and good morals while on duty;
(e) Refrain from any act that may endanger their own safety, that of their colleagues or third persons, as well as that of the establishments, workshops or places where the work is carried out;

...
(l) comply with preventive and hygiene measures imposed by the competent authorities or directed by the employer or his representatives for the safety and protection of the personnel;
(m) Give notice to the employer or his representatives of causes for absence from work; and,
(n) Fulfil other obligations established by labour laws and regulations".

Among the prohibitions stipulated in Art. 66, the following can be mentioned:

".....
(c) Using tools, materials and implements supplied by the employer for purposes other than those specified by the employer or for the benefit of strangers;
(d) Reporting for work while intoxicated or under the influence of intoxicating drugs or in any other abnormal condition;
(e) Carrying weapons of any kind, unless required by the nature of the service;
...".

Other important provisions of the Labour Code (Act No. 213/1993) are described below.

The ordinary working day may not exceed, except in special cases provided for in this Code, eight hours per day or forty-eight hours per week when the work is performed during the day (between 6 a.m. and 8 p.m.), or seven hours per day or forty-two hours per week when the work is performed at night (between 8 p.m. and 6 a.m.) (Art. 194).

The wage shall be freely stipulated, but may not be less than the minimum wage established in accordance with the requirements of the law (Art. 228).

Pay rates may not establish inequality on grounds of sex, nationality, religion, social status, political or trade union preferences. For work of equal value, whether or not of the same nature, duration and efficiency, equal remuneration shall be paid, except for higher wages based on seniority and merit (Art. 229).

A probationary period of a maximum of 30 days for unskilled workers and 60 days for skilled workers or apprentices is established (Art. 58).

The Code provides for a family allowance of 5% of salary, as family allowance, for each child under 17 years of age (without limit for disabled children).

In case of dismissal of the worker, the employer must pay the worker an indemnity equivalent to fifteen daily wages for each year of service rendered (Art. 91). Notice is only compulsory for permanent contracts (the obligation is for both parties) and ranges from a minimum of 30 days per year worked, up to 90 days for workers with more than ten years of employment (Art. 87).

Between one and five years of employment, you are entitled to twelve calendar days of paid leave. From five to ten years; eighteen days. More than ten years; thirty days (Art. 218). For the purposes of holidays, the days that the worker has missed work due to illness cannot be deducted.

Art. 358 of the Labour Code recognises the right to strike.

The Labour Code recognises the right to join or leave any trade union organisation on the part of both the employer and the worker (Art. 284), while acts of interference aimed at creating employer-dominated workers' organisations are prohibited (Art. 286).

The Chapter II of Law No. 213/1993 provides for the work of minors and women. Art. 119 prohibits the work of minors under 15 years of age in industrial, public or private enterprises or on their premises, with the exception of those in which only members of the employer's family are employed, provided that the nature of the work or the conditions under which it is carried out are not dangerous for the life, health or morality of the minors. Art. 121 and 122 establish the requirements and prohibitions for the work of minors between the ages of fifteen and eighteen.

Regarding gender equality, Art. 128 states that women enjoy the same labour rights and have the same obligations as men. The other articles in the section on women's work have as their main purpose the protection of maternity.

Art. 5 of Law No. 2128/2003, in turn, establishes, among several civil rights for persons of all races, colours or national or ethnic origin, the following:

The right to freedom of opinion and expression;
The right to freedom of peaceful assembly and association;
Economic, social and cultural rights, in particular:
The right to work, to free choice of employment, to just and favourable conditions of work, to protection against unemployment, to equal pay for equal work and to just and favourable remuneration;
The right to form and join trade unions;
The right to housing;
The right to public health, medical care, social security and social services;
The right to education and vocational training;
The right to equal participation in cultural activities;

The right of access to all places and services intended for public use, such as means of transport, hotels, restaurants, cafés, shows and parks.

Article 2 of Decree No.º 4951/2005, which regulates Law No. 1657/2001, approves the list of activities that are considered hazardous child labour, including several activities carried out on construction sites.

Law No. 3.338/2007 recognises equal opportunities and equal treatment for male and female workers who have family responsibilities, i.e. responsibilities for other members of their immediate family who clearly need their care or support. These persons have the right to carry out their employment and occupation without discrimination and, as far as possible, without conflict between their family and professional responsibilities.

Law No. 1.925/2002 approves the Inter-American Convention on the Elimination of all Forms of Discrimination against Persons with Disabilities, and aims to prevent and eliminate all forms of discrimination against persons with disabilities and to promote their full integration into society, including recruitment for job offers. In a complementary manner, Law 4934/2013, establishes means to promote equal opportunities for persons with disabilities through the promotion of accessibility to the physical environment.

Law No. 3540/2008 guarantees equal opportunities for persons with disabilities. According to its Art. 27, it recognises the "right of persons with disabilities to work, on an equal basis with others; this includes the right to the opportunity to gain a living by work freely chosen or accepted in a labour market and work environment that is open, inclusive and accessible to persons with disabilities. States Parties shall safeguard and promote the realization of the right to work, including for persons who acquire a disability through employment.

Finally, Law Nº 5508/2015, establishes that women shall have the right to maternity and breastfeeding up to 6 months of age and breastfeeding complemented up to 24 months of age, ensuring the attention and care of the feeding of children, and of the mother in the period of gestation and breastfeeding. In addition, it confers that women shall not be subject to discrimination or violation of their rights because of their condition. In a complementary manner, Decree Nº 7550/2017, determines that all working women shall have the right to maternity leave and to enjoy maternity leave within the period established by the Law, with all the benefits established therein (Art. 6°).

Article 54 of Law No. 1680/2001 prohibits adolescents from working, without prejudice to the provisions of the Labour Code, a) in any underground or underwater place; and b) in other activities that are dangerous or harmful to their physical, mental or moral health.

Article 58 deals with the length of the working day. According to it, the adolescent worker who has reached the age of 14 and up to the age of 16 may not work more than 4 hours a day and 24 hours a week. Working adolescents from the age of 16 to the age of 18 may not work more than 6 hours a day and 36 hours a week. For workers still attending educational institutions, the daily working hours shall be reduced to four hours. Adolescent workers who have reached the age of 14 until they reach the age of 18 shall not be employed during the night in a 10-hour interval, which shall be between 8 p.m. and 6 a.m.

4.3.8
Natural Disaster Management and Emergency Response

- Constitution of the Republic of Paraguay, 1992;
- Law Nº 251/1993, which approves the convention on "climate change" adopted during the United Nations Conference on Environment and Development - the Earth Summit - held in the city of Rio de Janeiro, Brazil;
- Law Nº 426/1994, which establishes the organic charter of the departmental government;
- Law N° 1.431/1999 regulating the organisation of the voluntary fire brigades of Paraguay. Amended by Law N° 5375/2014;
- Law Nº 2.615/2005, which creates the National Emergency Secretariat (S.E.N.), regulated by Decree Nº 11632/2013;
- Law Nº 3966/2010, Ley Orgánica Municipal;
- Law Nº 4739/2011, which creates the 911 system of attention, dispatch and monitoring of emergency communications;
- Law Nº 5681/2016, which approves the Paris Convention on Climate Change;
- Decree Nº 1402/2014, approving the National Risk Management and Reduction Policy Document (PNGR). Amended and extended by Decree Nº 3713/2015.

According to Art. 202 of the Paraguayan Constitution, among the duties and powers of Congress is 13) to issue emergency laws in cases of disaster or public calamity.
At the level of regional governments, Law No. 426/1994 establishes as a duty and attribution of the governors to develop prevention and protection programmes conducive to resolving emergency or disaster situations. On the other hand, Law N° 3996/2010 defines the prevention and response to emergencies and disasters as a function of the Municipalities.

Law Nº 2.615/2005 creates the National Emergency Secretariat (S.E.N.) with the aim of preventing and counteracting the effects of emergencies and disasters caused by natural agents or any other origin, as well as promoting, coordinating and guiding the activities of public, departmental, municipal and private institutions for the prevention, mitigation, response, rehabilitation and reconstruction of communities affected by emergencies or disasters. Article 6 creates the National Emergency Fund, 50% to finance disaster prevention and/or mitigation projects and 50% for preparedness and response measures.

Art. 6º of Law Nº 4739/2011 defines that the 911 System will be integrated by the following institutions: 1. Ministry of the Interior; 2. National Police; 3. Ministry of Public Health and Social Welfare; 4.

Art. 2º of Law No. 1.431/1999, amended by Law No. 5375/2014, establishes that the main purpose of the Volunteer Fire Brigades is to assist in situations of natural disasters or accidents, to prevent, extinguish and investigate fires and to provide advice for the protection of the lives and property of citizens who, due to natural, accidental or intentional disasters, require their intervention.

Law Nº 5681/2016, in its Art. 7º , paragraph 7, states that the parties should be committed to (c) Strengthening climate science, including research, systematic observation of the climate system and early warning systems, in a way that informs climate services and supports decision-making.

4.3.9
Expropriation Processes

- National Constitution of Paraguay;
- Law N° 966/1964, which creates the National Electricity Administration (ANDE) as an autarkic entity and establishes its Organic Charter;
- Law No. 976/1982, extending Law No. 966/1964;
- Law No. 1183/1985, Civil Code;
- Law No. 1863/2002, which establishes the agrarian statute;
- Law No. 2002/2002, amending several articles of Law No. 1863/2002;
- Law No. 6681/2020, amending Article 1 of Law No. 976/1982.

According to Art. 109 of the Constitution, private property is inviolable. No one may be deprived of his property except by virtue of a court ruling, but expropriation is permitted for reasons of public utility or social interest, to be determined in each case by law. This shall guarantee the prior payment of fair compensation, established by agreement or by judicial sentence, except for unproductive large estates intended for agrarian reform, in accordance with the procedure for expropriation to be established by law.

Article 128, in turn, states that in no case shall the interests of private persons take precedence over the general interest.

Also, Art. 1964 of the Civil Code establishes that no one can be deprived of the domain or of any of its faculties, except for reasons of public utility or social interest, defined by law, nor be dispossessed of his property without just compensation. Art. 1965, provides that, if the expropriated thing is not used for the purpose for which it was expropriated within a reasonable period of time, the previous owner may demand its recovery in the state in which it was alienated, consigning the price or compensation paid. In addition, Art. 1967 establishes expropriation as one of the causes for the loss of ownership of real estate (paragraph d).

Easements as a right in rem are regulated in the Civil Code, with the following types: easements in general (Art. 2188 to 2207, easement of transit: Art. 2208 to 2214; and easement of aqueduct: Art. 2215 to 2229).

Art. 2188 provides that, by virtue of the right in rem of servitude, it is possible to exercise certain acts of disposition or use over another's property, or to prevent the owner from exercising some of the powers inherent to the domain. The owner of the dominant estate must exercise the easement in the manner least detrimental to the servient estate. He may not make unnecessary changes to the servient estate and is obliged, if he has a construction on it for the exercise of the servitude, to maintain it as required by the interest of the owner of the encumbered property (Art.2197).

Regarding the aqueduct easement, Art. 2216 establishes that it can be constituted, among others, c) of those which are gathered in dams or canals belonging to private individuals, provided that the latter have granted the disposition of them.

In Art.2219 it is established that the aqueduct easement obliges the holder of the easement to pay:

(a) the value of the use of the land to be occupied;
b) the value of the use of a strip of land on each side, not less than one metre wide along the entire course, which may be extended by agreement of the parties or by order of the judge;
c) a further ten percent of the sum resulting from the two previous paragraphs; and
d) any damage caused by the construction of the aqueduct, and that resulting from seepage or spillage caused by defects in the aqueduct.

The owner of the servient estate retains ownership of the land on which the aqueduct exists, and all rights compatible with the exercise of the servitude (Art.2226).

Law No. 2002/02 redrafted Art. 56 of Law No. 1863/02, establishing, with regard to the titling of land in INDERT settlements, that "the implementing agency is obliged to grant title to the successful bidders who pay the full amount of the lot. The successful bidder who has paid no less than 25% (twenty-five percent) of the price and has signed the corresponding promissory notes for the balance, shall be entitled to be granted the corresponding title deed".

According to Art. 76 of Law No. 966/1964, in the case of easements on private property, ANDE may establish an electroduct easement consisting of the right to cross the property of third parties. The owner or occupier of the servient estate is obliged to allow access to his property by personnel authorised by ANDE with their equipment and work equipment to carry out construction and maintenance work. In case of refusal by the owner or occupier, ANDE will seek the corresponding authorisation from the Judiciary (Art. 77).

According to Art. 78, the owner of the servient estate may not build works, plantings and/or fences that disturb or impede the free exercise of the easement established by ANDE in accordance with the Law, unless expressly authorised by ANDE. The owner of the servient estate who feels injured by the form and characteristics of the easement may appeal to the Judiciary so that the Judge may decide on the compensation that corresponds to the owner, as well as on the specific conditions for the exercise of the easement. Claims by private parties in connection with easements established for the benefit of ANDE shall be resolved in court (Art. 79).

ANDE may agree directly with the owners the purchase of those properties that were necessary to carry out works or install services related to the fulfilment of its purposes. The real estate ANDE needs for the expansion and improvement of the electric power service and subject to expropriation in accordance with the National Constitution and relevant laws (Art. 74).

Article 1 of Law No. 6681/2020 determines, as a safety and service zone for 220,000 volt transmission lines, a distance of 50 m, 25 m measured on each side of the axis.

ANDE will proceed, without any compensation whatsoever, to demolish any work or construction carried out in the aforementioned area with an already established easement and to remove the materials, as well as to adopt all the necessary measures to ensure the permanent and effective operation of the service (Art. 2).

5.0 Diagnostics (Baseline)

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Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

SUMMARY

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5.0
Diagnosis (Baseline)

5.1
Defining Areas of Influence

The delimitation of the areas of influence is a basic and strategic aspect in carrying out Environmental and Social Impact Assessments. In practice, this procedure constitutes the definition of the spatial units of analysis adopted in the studies, guiding not only the elaboration of the socio-environmental diagnosis (i.e. the delimitation of the study areas), but also reflecting the scope of the environmental and social impacts potentially resulting from the construction and operation of the project (i.e. the areas subject to changes attributable to the project).

The delimitation of the areas of influence also determines the methodological aspects to be applied during the development of the work, since, for each spatial scale identified, both the nature of the information to be collected and the tools to be used must be defined.

In practical terms, the areas of influence are the areas that may be affected directly or indirectly, positively or negatively, by the project in its various phases, i.e. from planning to operation of the project.

Three units of analysis were defined in this study:

- Area of Indirect Influence (AII or IIA), which is a broad area where the indirect impacts of the project have reach;
- Area of Direct Influence (AID or DAI);
- Directly Affected Area (DAA or ADA).

The AII information is based on secondary data, allowing an understanding of the project's interactions with the environment. This data was supplemented with primary data collected in field surveys.

All basic environmental information was obtained from recognised sources, such as official agencies, universities, national institutions, complemented by field work, as mentioned above.

At the same time, geo-coded databases were developed and geographic information was used for the acquisition, processing, analysis, geo-referencing and presentation of spatial data. This tool was key in the integrated assessment of physical, biotic and socio-economic issues.

The methodological procedures applied to the production of cartographic products were common to all the topics covered in the study and follow Paraguayan regulations (MADES Resolutions Nº 251/2018 and Nº 135/2022). Secondary data and information provided by official government agencies and research institutions, as well as primary information collected directly in the field, were also used for the maps.

The satellite images used were those available in Google Earth Pro.

The Area of Indirect Influence (AII) is a broad area potentially susceptible to indirect impacts resulting from project planning, construction and operation. Impacts in the AII tend to occur in a more diffuse geographic and temporal manner, which implies indirect effects on the characteristics of the environment.

For the ATOME Plant, the AII was defined with two different cut-offs, one for the Physical and Biotic Environment, and the other for the Socio-economic Environment.

For the Physical and Biotic Environments, the boundaries of the drainage areas of the hydrographic sub-basins of Hydrographic Units recognised by the MADES were considered as AIIs. The choice of delimiting the AII through this geographical factor, which also forms part of the water management unit, is due to the fact that the basin is a unit of integration of processes acting on the surface, whose physiographic characteristics reflect the process conditions intrinsic to its dynamics.

The Hydrographic Units of Paraguay recognised in accordance with Resolution SEAM N° 376/12, are presented based on the study called Technical Criteria for the Delimitation and Codification of Basins in Paraguay (ANTÚNEZ, 2012), developed within the framework of the Modernisation of the Water and Sanitation Sector Project, which has delimited and codified all the basins of the national territory using the Pfafstetter method (Ottocodification). These Hydrographic Units are recognised by MADES, the Authority for the Application of Law No. 3239/07 "On Paraguay's Water Resources", as the space for the creation of basin management and water resources planning bodies.

From a theoretical point of view, it should be noted that the watershed has been widely used as a category of spatial analysis, including for urban and environmental planning purposes. In this respect, Horton's (1945) studies on the organisational parameters of drainage networks (hierarchisation); Tricart's Ecodynamic Theory (1977), which recognises the watershed as the physical basis of the environment; in addition to the systemic conceptions and approaches to the watershed recognised in the studies of Bertrand (1972), Strahler (1964), Sotchava (1978) and Christofoletti (1980). The watershed-based delineation also complies with the recommendations of Article 3 of Law N° 294/93, on Environmental Impact Assessment, which states that all Environmental Impact Assessments must contain, as a minimum:
...
c) The limits of the geographical area to be affected, with a detailed physical, biological, socio-economic and cultural description, both quantitatively and qualitatively, of the area of direct influence of the works or activities and an environmental inventory of the same, in such a way as to characterise its state prior to the planned transformations, with special attention to the determination of the hydrographic basins;

In view of the above, the Surubi'y Stream Basin, part of the Lower Tebicuary Hydrographic Unit (SEAM Resolution N° 376/12), is considered as the boundary of the AII for the Physical and Biotic Environments. This basin is located in the northern part of the Lower Tebicuary Hydrographic Unit, bordered to the northeast by the Arroyo Pikyrysy Basin, to the east and south-southwest by the Arroyo Paray Basin and to the west-northwest by the Paraguay River. The Surubi'y Stream Basin has an approximate surface area of 361 km^2 and covers areas of the Districts of Villeta and Nueva Italia, belonging to the Central Department. The main access route is the Villeta-Alberdi road, as well as the Paraguay-Paraná waterway.

For the Socio-economic Environment, the administrative boundary of the Municipality of Villeta was considered as the study area for the baseline. However, the indirect social impacts of this project may be more diffuse in scope and go beyond this area of influence.

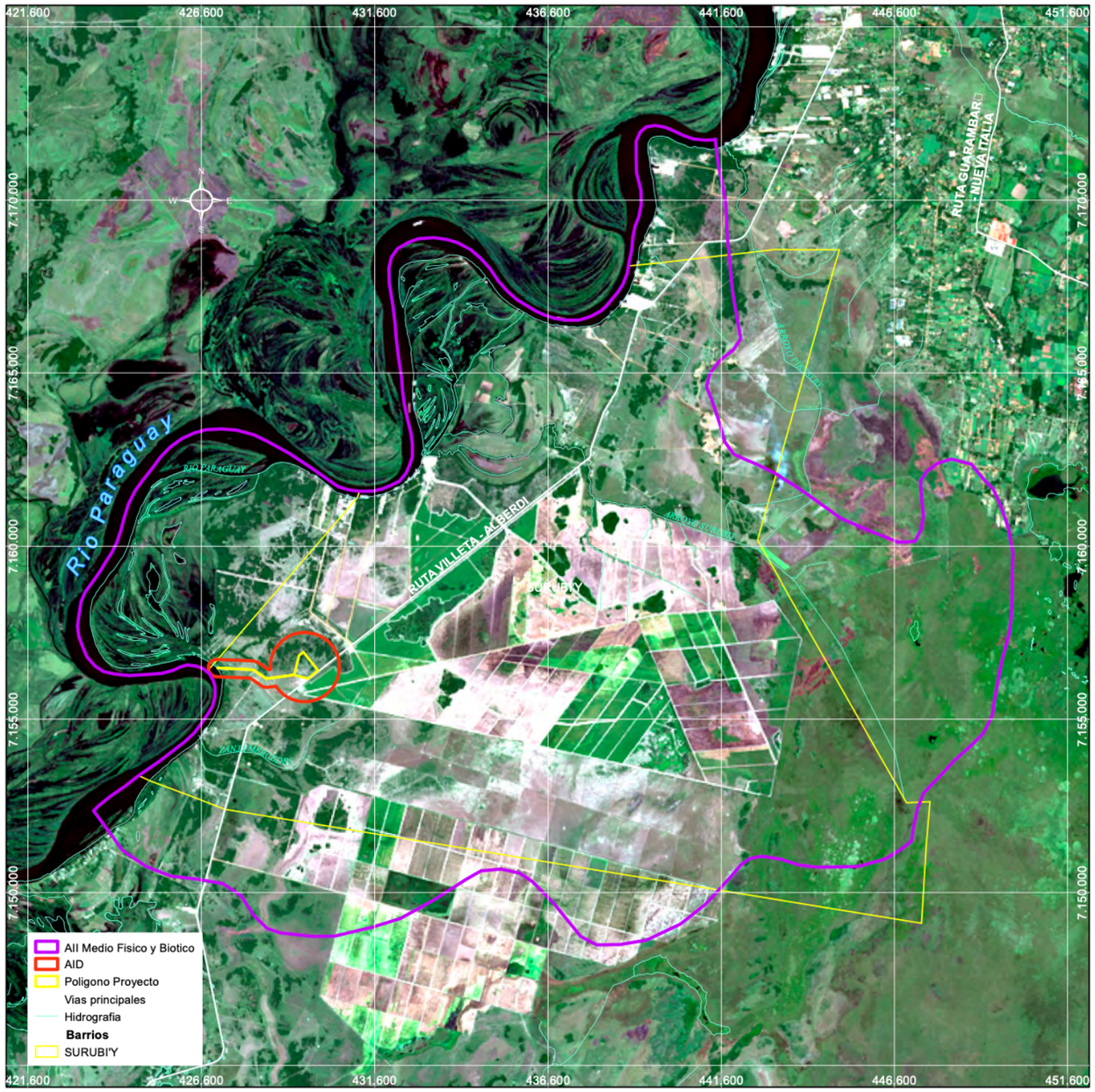
The Area of Direct Influence (AID) for all media was defined as a 1 km radius buffer around the Plant area, which includes the Buey Rodeo Substation and the transmission line that will supply power to the project. Also considered is the 1 km strip (500 m for each side of the axis) around the water and effluent pipelines, the access between the plant and the export port and other accesses that will be used during construction and operation.

The Directly Affected Area (DAA) is the 30 ha of the plant site, the water intake and easement strips of the TL (3.30 ha or 33,000 m^2) and pipelines (1.15 ha or 11,500 m^2).

The areas of influence are shown in **Map 5.1.a** below.

Map 5.1.a - Map of Areas of Influence

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	5.1.a - MAPA DE ÁREAS DE INFLUENCIA





Carátula Juridica Legal

Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	27/10/2023

Fuente Cartográfica

Proponente, DGEEC 2012
2023

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:125.000

5.2
Physical Environment

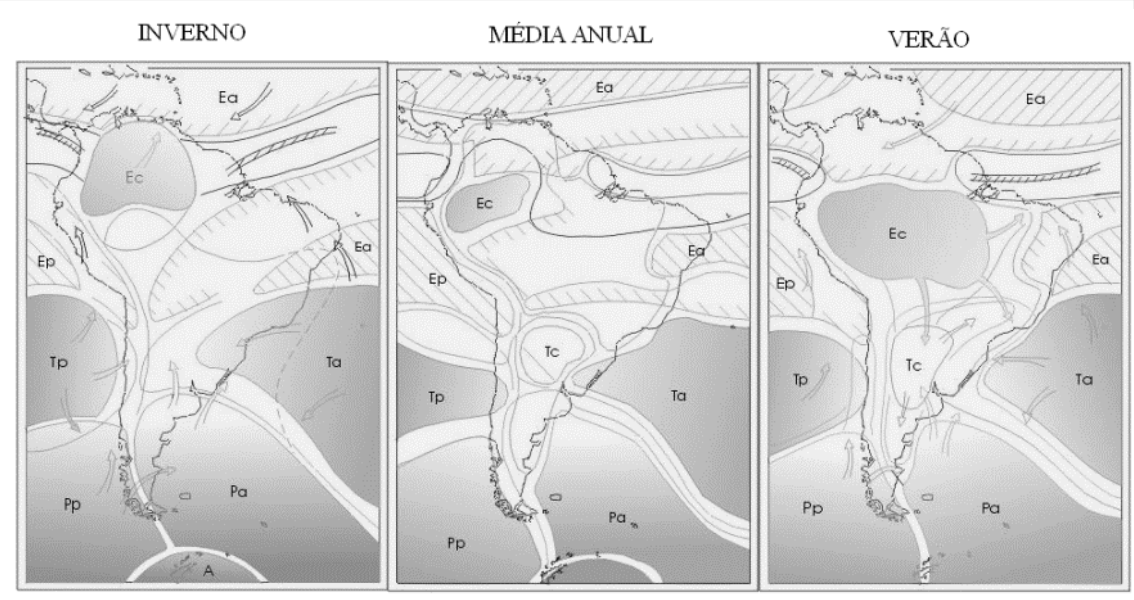
5.2.1
Climate

5.2.1.1
Atmospheric Circulation

South American Climatology

South American climatology is characterised by the shape, position and size of the continent. Its territorial extension in a north-south direction, from low to high latitudes, as well as its position between the Pacific and South Atlantic Oceans, make its climatic definition very complex, being affected by several air masses, as exemplified in **Figure 5.2.1.1.a**, below.

Figure 5.2.1.1.a General scheme of air masses operating in South America



Ea: Equatorial Atlantic; Ec: Equatorial Continental; Ta: Tropical Atlantic; Tc: Tropical Continental; Pa: Polar Atlantic; Ep: Equatorial Pacific; Tp: Tropical Pacific; Pp: Polar Pacific.
Source: Sant'Ana Neto (2005).

It is characterised by the presence of the Andes, which extends south-north from Venezuela to Cape Horn, as well as by two almost stationary anticyclones, one in the South Atlantic (ASAS) and one in the South Pacific (ASPS), on which the penetration of air masses into the continent depends, defining the local climatological characteristics, allied to meso- and micro-scale factors.

The Andes mountain range prevents tropical air masses from the Pacific Ocean from entering the continent. The exception is when polar air masses reach the interior of the continent through Argentina, where the mountain range has lower altitudes. These air masses arrive

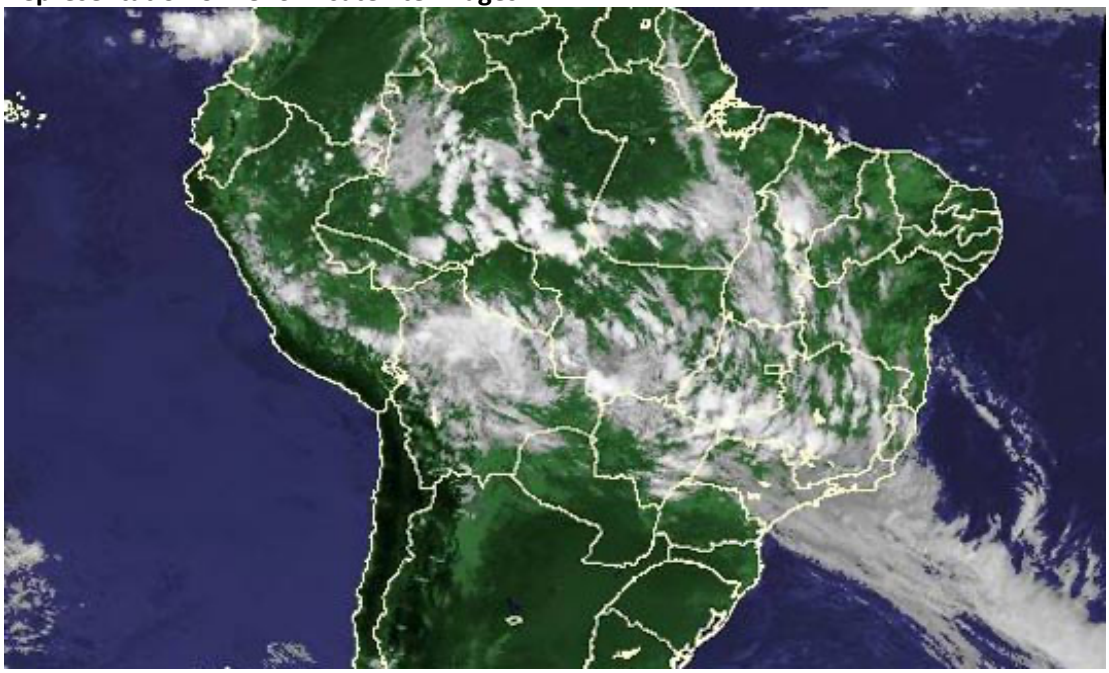
relatively dry as a result of moisture loss due to adiabatic cooling, when they are forced up the mountain range to windward in Chile, then crossing Patagonia.

The South Atlantic Subtropical Anticyclone (ASAS) is a semi-stationary system that remains in place throughout the year, with variations in its position and spatial extent. In January, it mainly influences the eastern region of the continent. Its circulation generates, with the exception of western Amazonia, regional winds predominantly in the E-NE direction. It presents a high humidity index due to oceanic evaporation, making it humid and hot, also due to the high incidence of solar radiation.

The South Pacific Subtropical Anticyclone (ASPS) does not act directly over the continent due to the blockage caused by the Andes Mountains. Its atmospheric circulation is induced by the direction of the Cordillera, causing cold air to follow also in a south-north direction which, allied to the circulation of the cold Humboldt marine current, establishes a high degree of stability and absence of precipitation on the east coast of the continent.

The South Atlantic Convergence Zone (SACZ) (**Figure 5.2.1.1.b**) is a typical summer system in the Southern Hemisphere, characterised by a band of cloudiness oriented in a NW-SE direction, acting in the central-southern region of Amazonia, central-western and southeastern Brazil.

Figure 5.2.1.1.b
Representation of ZCAS in satellite images



Source: Google. Note: The ZCAS is represented by the nebulosity line oriented in the NW-SE direction.

Positive sea surface temperature (SST) anomalies in the South Atlantic tend to intensify the ZCAS, while negative anomalies diminish its influence. However, when the ZCAS is enhanced, the SST undergoes a negative anomaly due to increased cloudiness, which weakens the ZCAS, thus establishing a pattern of positive and negative *feedbacks*, which naturally tends to equilibrium.

The Chaco Low is located over the Paraguayan-Bolivian Chaco region and is formed due to continental warming during the summer. It is a low pressure system formed by the seasonal updraft that presents convergence of air in the surrounding regions at low levels.

The Polar Anticyclone is a cold air mass that originates in the Antarctic continent, with counterclockwise circulation and divergent surface winds, originating in these regions the so-called polar air mass. At its origin, it has characteristics of stability, as it is cold and dry. However, after crossing territories of lower latitudes, absorbing heat and humidity, it begins to present unstable characteristics.

This mass is also known as the Polar Migratory Anticyclone (MPA), which invades the continent with some frequency and a predominantly SW-NE path, but is influenced by both the ASAS and ASPS, depending on the season in the southern hemisphere.

One of the possible trajectories of the APM is through the interior of the continent, between the Andes Mountains and the Brazilian Massif, driving the cold air mass through Paraguay, Mato Grosso/BR towards the Upper Amazon, causing sharp temperature drops.

There are also two types of phenomena among the Mesoscale Convective Systems: the Instability Lines (IT) and the Mesoscale Convective Complexes (MCC). ITs are barometric depressions in the form of elongated lines, formed over the states of Pará and Amazonas as a result of the diurnal heating cycle. As they tend to mature, they move towards the south and southeast regions, and depending on the strength of IT formation, they can cause heavy rainfall and short-lived thunderstorms, accompanied by wind gusts that can reach up to 90 km/h.

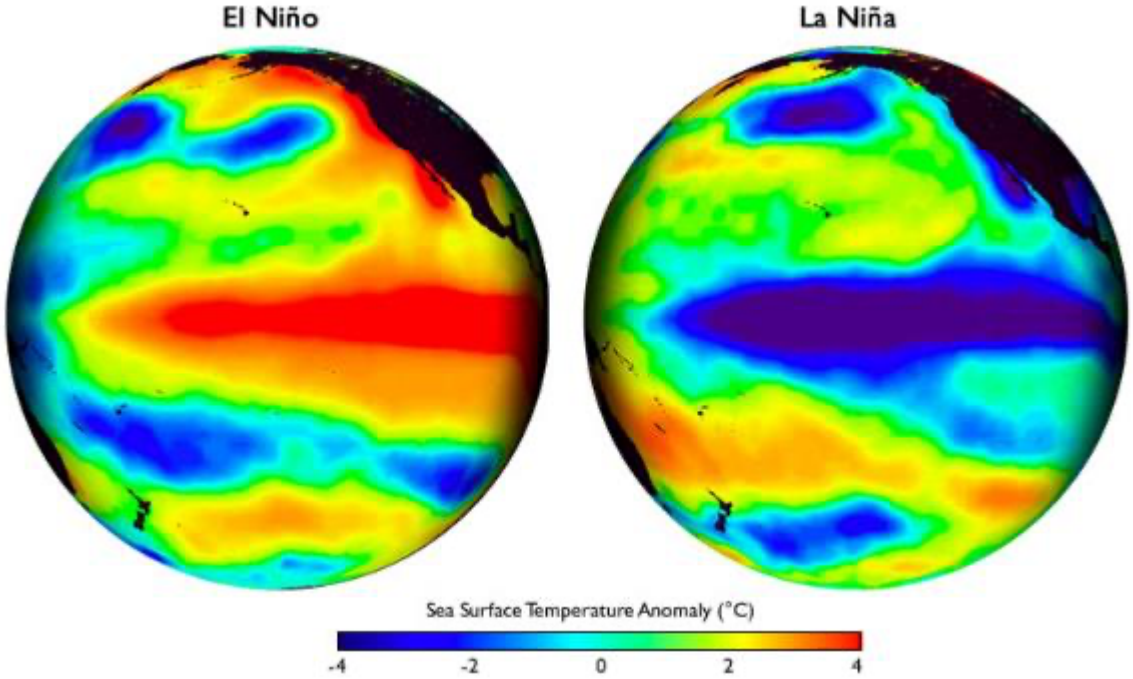
Finally, it is important to note that the rainfall regime of the continent is strongly influenced by the occurrence of the "*El Niño*" phenomenon (**Figure 5.2.1.1.c**) which is associated with the negative phase of the Southern Oscillation (ENSO). *El Niño* represents a positive thermal anomaly in the Pacific Ocean SST during the southern hemisphere summer, while the Southern Oscillation is characterised by a fluctuation in sea level pressure, observed between the Indonesian and eastern Pacific Ocean regions. This phenomenon has an average duration, from warming to cooling, of 12 to 18 months, generally starting at the beginning of the year and peaking around December. Its recurrence occurs in periods of two to seven years, but without a defined pattern.

During the occurrence of *El Niño,* precipitation rates in Paraguay are strongly altered, especially during spring and autumn, where precipitation rates can double. During the occurrence of *La Niña, the* impact is reversed and precipitation rates are strongly altered downwards, generating either floods or severe droughts. According to information from the Development Bank of Latin America (CAF), *El Niño* significantly increases rainfall in Paraguay, for example, by doubling the volume of the Paraná River.

The Paraguayan Directorate of Meteorology and Hydrology (DHM) has evaluated several studies on the relationship between *El Niño* and precipitation in the country, which showed a strong relationship, resulting in the rainy season being affected, especially in the eastern region where the proposed project is located, especially between October and March, with the opposite being true, with a strong decrease in precipitation during *La Niña* events. Studies also

show that during strong *El Niño* events, such as 1982-1983 and 1997-1998, the increase in rainfall ranged from 400 mm to 800 mm, reaching a surplus of more than 1,000 mm.

Figure 5.2.1.1.c
Depiction of sea temperatures during *El Niño* and *La* Niña



Source: Adapted from NOAA *Education Resources*. Subtitle text: Sea surface temperature anomaly (free translation).

Table 5.2.1.1.a presents a history of the occurrence of the phenomenon, as well as its inverse, known as *La Niña*.

Table 5.2.1.1.a
History of *El Niño* and *La Niña* occurrences and respective intensities

El Niño	La Niña
1895-1896	1892-1893
1896-1897	1893-1894
1899-1900	1903-1904
1902-1903	1906-1907
1904-1905	1908-1909
1905-1906	1909-1910
1911-1912	1910-1911
1913-1914	1916-1917
1914-1915	1917-1918
1918-1919	1924-1925
1919-1920	1933-1934
1925-1926	1937-1938
1930-1931	1938-1939
1939-1940	1942-1943
1940-1941	1949-1950
1941-1942	1954-1955

Table 5.2.1.1.a
History of *El Niño* and *La Niña* occurrences and respective intensities

El Niño	La Niña
1951-1952	1955-1956
1952-1953	1967-1968
1957-1958	1970-1971
1963-1964	1973-1974
1965-1966	1975-1976
1968-1969	1988-1989
1969-1970	1998-1999
1972-1973	1999-2000
1976-1977	2007-2008
1979-1980	2010-2011
1982-1983	201-2018
1986-1987	-
1987-1988	-
1991-1992	-
1992-1993	-
1997-1998	-
2002-2003	-
2006-2007	-
2009-2010	-
2015 - 2016	-

Source: CPTEC / INPE.
Weak/ Moderate/ **Strong**

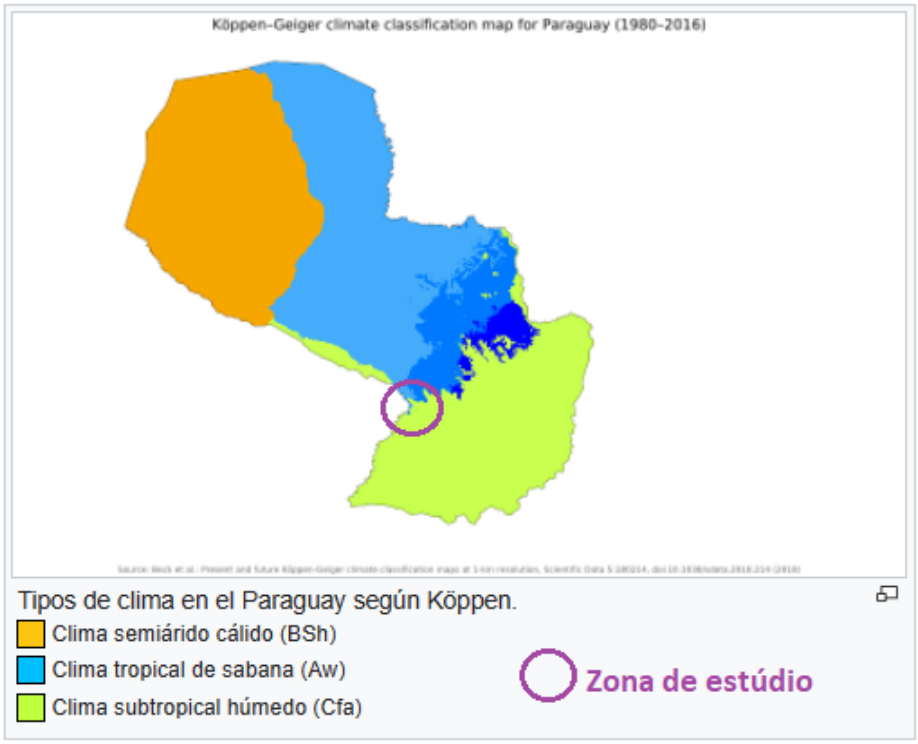
5.2.1.2
Climate Classification

The climate classification of the area of influence was based on the Koppen-Geiger methodology, which is one of the most widely used climate classification systems in use today. It was proposed in 1900 by Wladimir Koppen and updated by Rudolph Geiger, based on the assumption that the natural vegetation of each region of the Earth is the expression of the climate prevailing there.

This system divides the climate into five main groups, representing five of the most relevant plant associations and covering 11 most important climate types, as well as types and subtypes. Each climate is represented by a set of two or three letters. The first letter, capitalised, denotes the general characteristic of the climate and indicates the climatic group, ranging from "A" to "E" from the equator towards the poles. The second letter, in lower case, indicates the climatic type within the group and indicates the specific characteristics of the rainfall regime, such as amount and distribution. The third letter, also in lower case, shows the mean monthly air temperature of the hottest months, or the mean annual air temperature, provided the climatic group is "B".

The Project area is classified according to climate as Cfa, although there may be a transition, to the north, for climate Aw (**Figure 5.2.1.2.a**).

Figure 5.2.1.2.a
Koppen-Geiger climate classification for Paraguay



Source: Adapted from Peel *et al*. (2021).

The capital letter "C" represents the humid meso-thermal climate of the mid-latitudes, with mild winters and average temperatures of the coldest month between 3ºC and 18ºC. The lower case letter "f" refers to the humid seasonal type. Climatic type "Cf" is characterised by rainfall evenly distributed throughout the year, without a clear dry season, with the rainfall altitude of the driest month exceeding 30 mm. The climatic type "Cfa", subtropical, in addition to the joint definitions already presented above, is characterised by a hot summer, where the average temperature of the hottest month remains above 22ºC.

5.2.1.3
Climatology of Paraguay and the Area of Influence

According to the Atlas de Riesgo de Desastres de la República del Paraguay (SEN, 2018), the summer is hot and rainy and the winter is cold and dry, with two well-defined seasons, one dry and the other rainy. The predominantly flat topography allows the entry of both warm equatorial air masses from the northern region, such as the Brazilian Amazon, and cold masses from the polar region.

The average annual temperature is around 22ºC (**Figure 5.2.1.3.a**) with a 10ºC amplitude. During summer temperatures are quite high and can exceed 40ºC in some regions, with an average of 27ºC and a relative humidity of around 80%. During winter and spring temperatures are mild with averages of 17ºC.

Figure 5.2.1.3.a
Average annual temperature - Paraguay

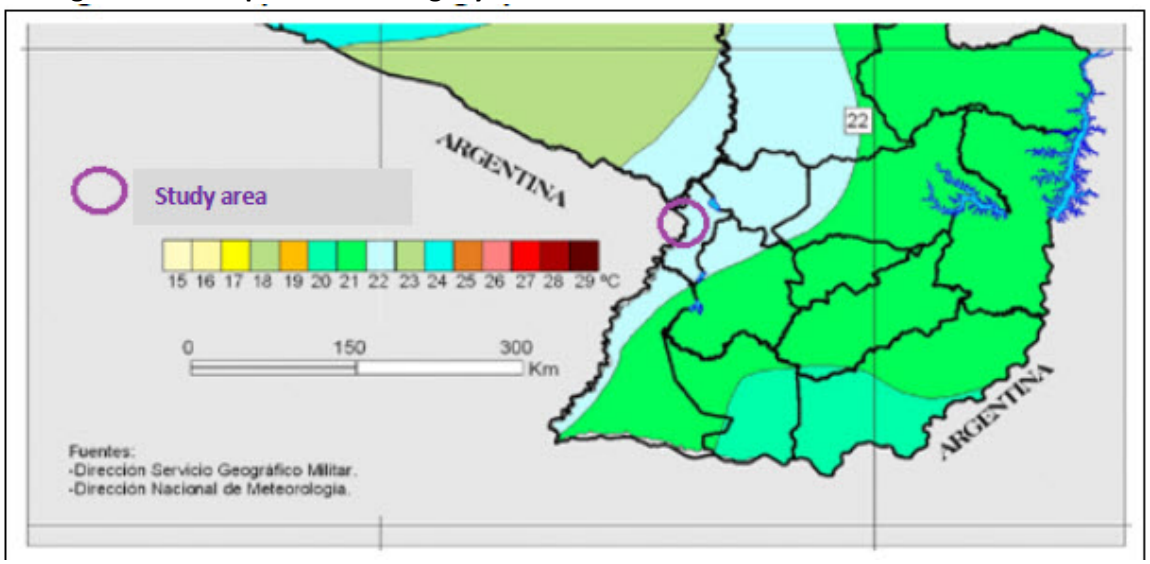
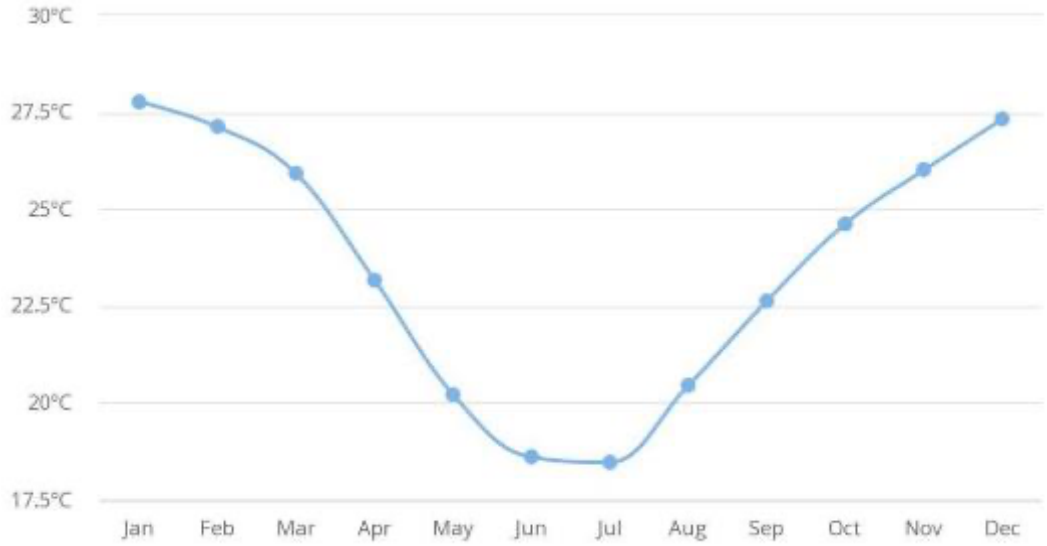


Figure 5.2.1.3.b shows the average monthly temperature in Paraguay for the period from 1901 to 2016 with data from the World Bank's Climate Change Knowledge Portal. It is evident the characterisation of two seasons, one warm and one rainy, with the highest recorded in January and the lowest in July.

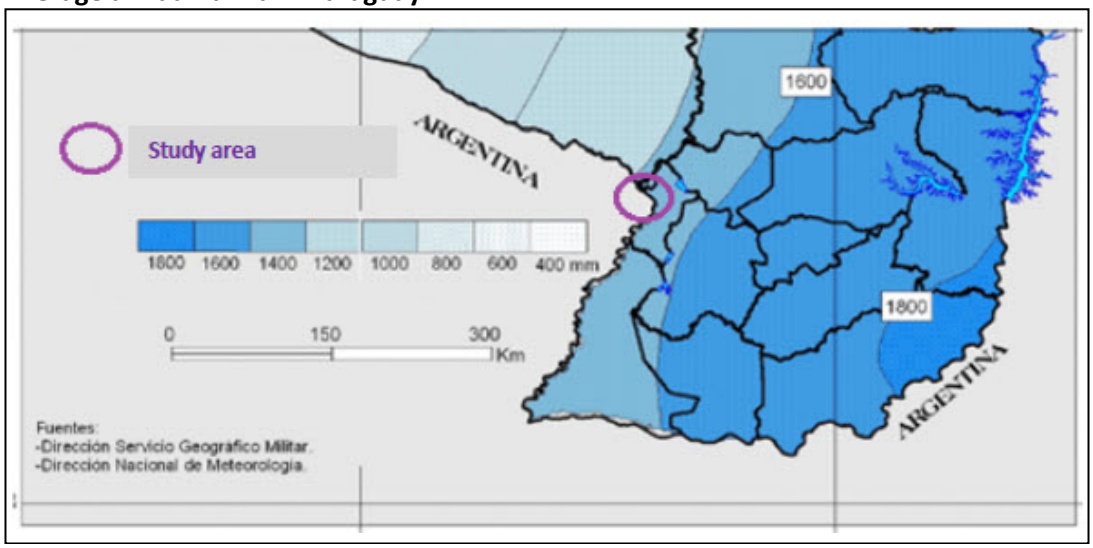
The rainy period occurs between spring and summer and the dry season between autumn and winter. The driest months are July and August, while the rainy months occur between October and February. Rainfall during the summer tends to be torrential and poorly distributed spatially. While the southeast and southeast region of the country has an average annual rainfall between 1,600 mm and 1,800 mm, where the project is located (**Figure 5.2.1.3.c**), in the northwest, the annual average is about 600 mm, which is mainly due to the distance from the ocean.

Figure 5.2.1.3.b
Average monthly temperature - Paraguay (1901 - 2016)



Source: Climate Change Knowledge Portal / World Bank.

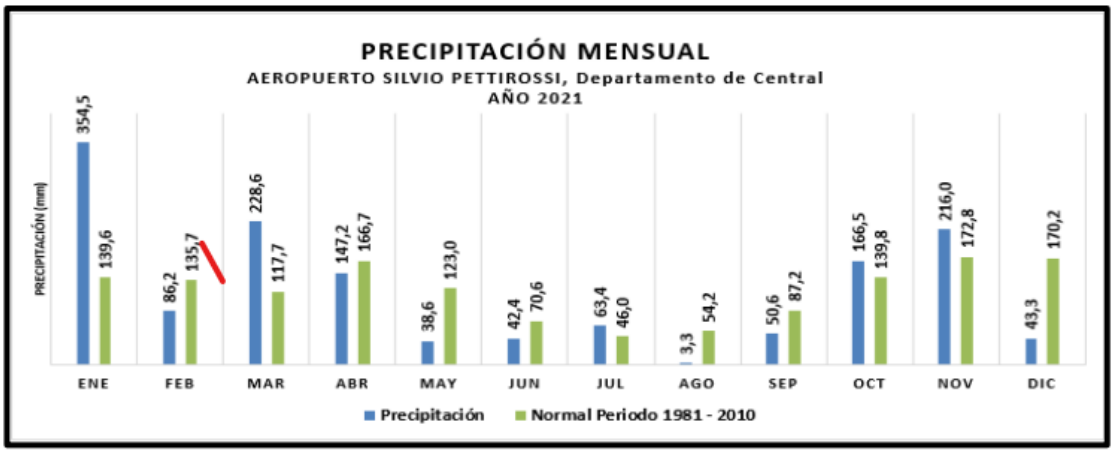
Figure 5.2.1.3.c
Average annual rainfall - Paraguay



Source: CHM-Paraguay. The purple circle indicates the area of the proposed Project.

Figure 5.2.1.3.d presents the average monthly precipitation for the Silvio Pettirossi Airport station (Luque), located 54 km from the project area, serving as a climatic reference for the proposed area, according to WMO dictates.

Figure 5.2.1.3.d
Average monthly rainfall - Paraguay (1981-2010) (mm)

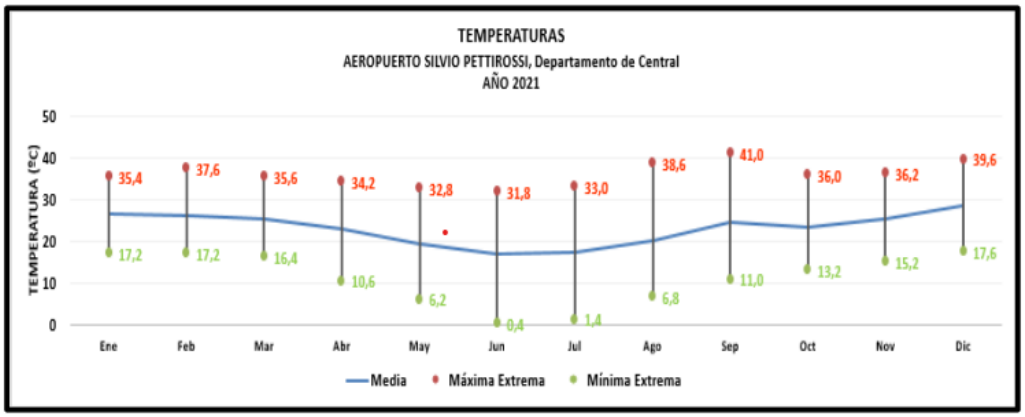


Source: National Meteorological Directorate - Climatological Yearbook, 2021.

The data show that for the months between July and August, rainfall is less than 60 mm, reflecting the driest months. The wettest months are November and December, when averages are above 170 mm.

In comparison with the temperature data (**Figure 5.2.1.3.e**), it is observed for the Airport season, that the minimums occur between May and August, when the values are below 20 ºC and the extremes can reach values close to 0º. On the other hand, the warmest period occurs between December and February, but with a peak in early spring.

Figure 5.2.1.3.e
Total monthly cumulative precipitation and monthly normal, period 1981-2010 (ºC)



Source: National Meteorological Directorate - Climatological Yearbook, 2021.

As for the wind regime, during the summer, warm and humid winds from the northwest predominate. In winter, the prevailing winds are cool and come from the southern region, driven by the South Atlantic anticyclone. In general, wind speed rarely exceeds 70 km/h. August (11.4 km/h), September (14.3 km/h) and October (12.0 km/h) are the months with the highest wind intensity in the region, the same being observed for the recorded maxima. February (8.7 km/h), March (8.2 km/h) and May (8.6 km/h) are the months with the lowest

values. Regarding the annual behaviour, it is verified that the average maximums are 61.1 km/h and the normal averages are 10.3 km/h.

Table 5.2.1.3.a

Average wind behaviour at the Silvio Pettirossi Airport station (km/h)

Months	Wind	
	Average Speed	Maximum speed
January	10.00	44.40
February	8.70	37.00
March	8.20	29.60
April	9.20	37.00
May	8.60	31.50
June	9.40	33.30
July	9.70	61.10
August	11.40	37.00
September	14.30	46.30
October	12.,00	51.90
November	10.90	48.20
December	11.10	18.50
Annual	10.30	61.10

Source: National Meteorological Directorate - Climatological Yearbook, 2021.

However, occasionally there are hurricanes with winds exceeding 160 km/h that, when they occur in the plains region, can evolve into tornado formations. According to Iensse (2018), the region presents the essential elements for tornado formation due to the encounter of warm and dry air masses; warm and moist air; and cold air, together with the action of warm and moist jet streams at low levels and subtropical jet streams at high levels.

Iensse (2018) observed a strong trend of tornadic events when *La Niña* occurs and then in neutral years. Of the countries in the South American Tornado Zone: Brazil, Paraguay, Argentina and Uruguay, Paraguay has the lowest number of occurrences with nine cases recorded between 1959 and 2018.

Among the atmospheric systems that are most conducive to the meteorological conditions for tornado formation, Iensse (2018) points out that the Atlantic Polar Front (APF) is the main one, as its passage produces barometric, thermal, hygrometric and anemometric discontinuities, resulting in strong atmospheric instability.

Finally, according to Iensse (2018), autumn is the season with the highest concentration of tornadoes in Paraguay, followed by summer and, finally, spring. **Figure 5.2.1.3.f** indicates the place of occurrence and to which atmospheric systems the recorded tornadoes were related.

Figure 5.2.1.3.f
Tornadoes recorded in Paraguay by Meteorological System (1959 - 2018)

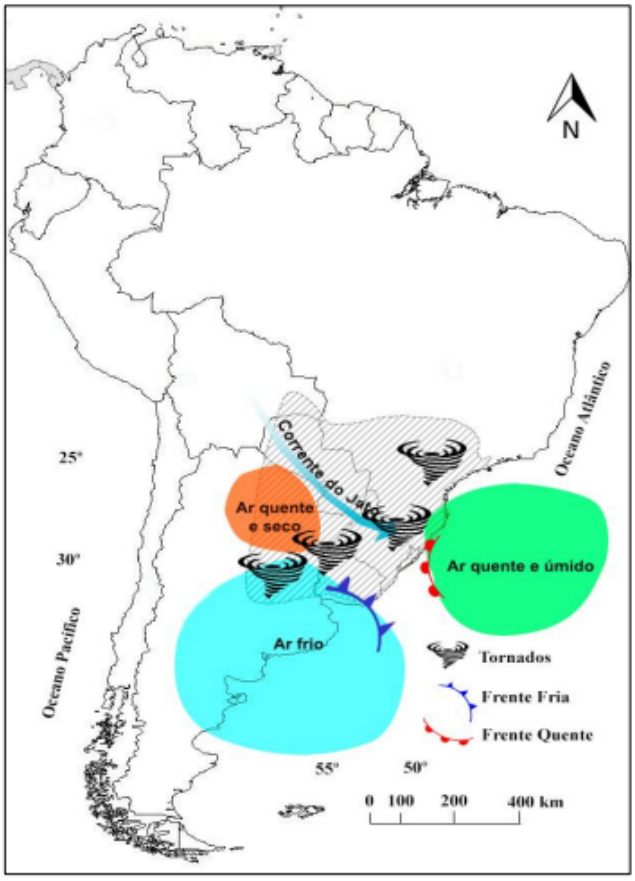


Source: Iensse (2018). The red circle marks the area of the proposed project.
Orange - Cavada
Purple - Atlantic Polar Front
Grey - Continental Tropical Mass

5.2.1.4
Extreme Events and Natural Disasters

According to the National Implementation Plan of the Sendai Framework (SEN, 2018), the territory of Paraguay is located in the South American Tornado Zone, as shown in **Figure 5.2.1.4.a.** It is a region where important convective phenomena that generate severe storms and tornadoes develop, being, even so, one of the areas where most atmospheric discharges occur in the world.

Figure 5.2.1.4.a
South American Tornado Corridor



Source: Iensse (2018).

In Paraguay, the National Emergency Secretariat (SEN) is the agency responsible for risk management and reduction, and extreme events analysed and monitored by the government include: water deficit; frost; forest fires; severe storms and floods that can occur due to excess rainfall, overflowing of the riverbed or in combination. The most recent and significant events relate to riverine and urban floods and droughts. Between 1980 and 2015, Paraguay recorded more than 1,600 extreme weather events, recurrent natural phenomena that affected more than 1.1 million people, generating socio-economic and environmental impacts.

Flood events are among the greatest scourges for the Paraguayan population, both indigenous and non-indigenous, affecting the population recurrently over the years and their main cause is natural. Considering the geographical location of Paraguay, fully inserted in the Rio de la Plata Basin, its intrinsic relationship with the main rivers of the basin has been established: Paraguay and Paraná. The Paraguay River has a fairly slow variation between its flood and dry seasons along its entire course and only registers one flood and dry season per year, the flood season being between the months of June and July, and the dry season between the months of December and February. It should be noted that the flood season is much longer than average when the El Niño phenomenon occurs. The normal rainy season in the eastern region, where the proposed project is located and is more susceptible to extreme events, occurs between October and May, with peaks recorded between October and November. Among the flood

events, urban flood events, which occur suddenly due to intense and short duration rains, are the most relevant due to the losses and damages caused by the concentration of population.

The main cause of forest fires is anthropogenic, whether accidental, intentional or negligent, while forest fires that are started by natural causes are mainly caused by atmospheric discharges. As the region is one of the most affected by atmospheric discharges in the world, natural fires are a major problem.

Severe storms or thunderstorms are formed by the vertical development of *cumulonimbus-type* clouds when cold fronts arrive. They are a permanent weather threat and a constant risk for the Paraguayan population, as well as for the country's entire infrastructure, such as transmission lines. Storms occur most frequently in two periods of the year, in September, October and part of November, as well as in March, April and part of May. The most recurrent meteorological phenomena fostered by severe storms are heavy rains that can generate flash floods, especially in urban and riverine areas; hailstorms; thunderstorms; tornadoes; and strong wind gusts, especially downbursts whose winds can exceed 200 km/h.

Table 5.2.1.4.a presents a history of the most impactful extreme weather events since 1926.

Table 5.2.1.4.a
Chronology of extreme events

Year of Occurrence	Type	Impacts	Notes
1926	Tornado	More than 300 dead and 500 injured in Itapuá.	Winds from 267 to 322 km/h.
1982-1983	Floods	More than 60,000 people affected. Historic highs of the Paraguay and Paraná rivers.	9.01 m high in Asunción.
1992	Flooding	More than 70,000 people affected.	The Paraguay River reaches 8.55 m at Asunción.
1997-1998	Flooding	More than 80,000 people affected.	The Paraguay River reaches 7.19 m at Asunción.
1998	Severe Storm	Three dead; buildings damaged; basic services affected.	Winds of 114 km/h.
1999	Drought	Affectation of San Pedro and Concepción.	SEN has delivered food to 20,000 families over four months.
2007	Forest Fires	About 5,000 fire outbreaks; environmental pollution.	San Pedro, Concepción and Canindeyú.
2008	Severe Storm	Two dead and several injured.	Falling barriers, transmission lines and trees.

Table 5.2.1.4.a
Chronology of extreme events

Year of Occurrence	Type	Impacts	Notes
2008-2009	Drought	GDP fell by 4.2% in the first quarter of 2009.	Some 40,000 families were in need of government assistance.
2012	Drought	More than 47,000 families were in need of government assistance.	Guairá; Caaguazú Caazapá Itapuá Misiones; Paraguaná; Canindeyú Presidente Hayes and Boquerón.
2012	Severe Storm	Four dead; one brain dead; more than 80 injured and 1,200 families affected.	Mariano Roque Alonso and Loma Pytâ.
2013	Drought	High livestock mortality rate; more than 8,000 families affected; more than 15,000 indigenous families affected.	Chaco; Eastern R.
2014	Forest Fires	10 days of flames in the Ypacaraí National Reserve. 4,500 ha destroyed;	Damage to the ecosystem.
2014	Tornado	Destruction of crops and structural damage.	Winds of 116 to 179 km/h at Santa Rita.
2014 - 2016	Floods	45,000 families affected in Concepción, San Pedro, Misiones, Central, Ñeembucú, Presidente Hayes and Asunción.	The Paraguay River reaches 7.88 m at the capital.
2015	Tornado	Two dead and some injured. Structural damage and destroyed crops, fallen trees and animal mortality.	Horqueta and Loreto.
2016	Forest Fires	50 ha affected and minor environmental damage.	Ybyturuzu Reserve.
2017	Forest Fires	2,000 ha affected and around 10 residences.	Cerro Corá National Park.
2017	Tornado	Two people killed and several injured. More than 15 houses destroyed.	San Javier and Ibáñez Rojas.
2017	Severe Storm	40 families affected and 26 people injured.	Winds of more than 200 km/h in Neuland.
2017	Severe Storm	15 divisions affected; people injured; structures damaged and trees down.	Winds over 100 km/h in the eastern R. and Hayes.
2017	Severe Storm	Displaced residences and power outages.	Winds of more than 100 km/h in Alto Paraná.
2018	Chlorine Leakage	In Carmen del Paraná. Leak in drinking water treatment plant.	One dead. Hundreds evacuated.

Source: Atlas de Riesgos de Desastres en la República del Paraguay, 2018.

The National Implementation Plan of the Sendai Framework (SEN, 2018) includes the mapping of risks and hazards to which the areas of the Republic of Paraguay are subject. In this way, it was possible to assess the proposed project location, Villeta, Central Department, and the classes of hazards and risks for the District.

According to the above-mentioned source, "hazard" means the probability that a natural or anthropogenic event will materialise and occur at a given time and place. It is an external physical factor and its occurrence is potentially dangerous. Risk" means the estimated

magnitude of losses (lives, property, environment or economic activities) in addition to affected goods and services at a given location for a given time, for a specific hazard.

Information on the risks and hazards to which the District of Villeta is subject is presented in **Table 5.2.1.4.b**.

Table 5.2.1.4.b
Threat to extreme events for the District of Villeta - Central Department

Threats		Risk	
Water Deficit	Media	**Water Deficit**	Media
Flooding (excessive rainfall)	Media	**Flooding (excessive rainfall)**	Baja
Flooding (overflow)	Media	**Flooding (overflow)**	Baja
Flooding (joint)	Baja	**Flooding (joint)**	Baja
Frost	Media	**Frost**	Media
Forest Fires	High	**Forest Fires**	Baja
Severe Storm	High	**Severe Storm**	High

Source: Atlas de Riesgo de Desastres de la Republica de Paraguay (SEN, 2018).

The analysis of the tables presented shows that among the extreme weather events analysed and monitored by the National Emergency Secretariat of Paraguay, the ones that represent the greatest risks for the proposed project are frost, forest fires and, especially, severe storms, remembering that these include several meteorological phenomena.

Although extreme events related to flooding, whether by overflow, excessive rainfall or combined, occur as existing, the directly affected area is located far (2 km) from the main river and its tributaries.

5.2.2
Surface Water Resources

For the characterisation of surface water resources in the Area of Indirect Influence (AII) defined for the Physical Environment, official documents were consulted, including the Atlas de Cuencas Hidrográficas del Paraguay (MADES, 2022a), the Plan de Acción Nacional para la Gestión Integrada de Recursos Hídricos (GIRH) en Paraguay (MADES, 2022b), Law 3239/07 on Water Resources of Paraguay, SEAM Resolutions 376/12, 521/19, 170/2006, 812/2010, 255/05 and 222/02, among others, as well as the study on Technical Criteria for the Delimitation and Codification of Paraguay's River Basins (ANTÚNEZ, 2012), Transboundary Diagnosis of the La Plata Basin (CIC, 2017).

With regard to water use, the Environmental Information System (SIAM) of MADES was consulted, which provides numbers of water abstraction records by type of use, by department and by river basin (period from 2019 and 2023), as well as extracted flows (period from 2010 and 2014) broken down by districts, projects and types of water use.

The analyses complemented the results of satellite image interpretations of the Digital Terrain Elevation Model (SRTM/NASA) and field surveys carried out in March 2023. The cartographic base consists of *shapefile* files made available by the General Directorate of Statistics, Surveys and Censuses.

5.2.2.1
Water Resources Context

The AII is located in the Paraguay river basin which, together with the Paraná and Uruguay rivers, constitutes the La Plata Basin that drains part of the territory of Argentina, Brazil, Bolivia, Paraguay and Uruguay. Together, the Paraguay and Paraná river basins drain an area of 2,613,000 km^2 (84% of the total of the La Plata Basin), with the Paraná river representing 58%, with an area of 1,510,000 km^2 and the Paraguay river 42% with 1,103,000 km^2 .

The hydrographic division of the La Plata River basin is shown in **Figure 5.2.2.1.a.** Of the seven contributing sub-basins, four drain areas of Paraguayan territory: Upper Paraguay, Upper Paraná, Lower Paraná and Lower Paraguay. The AII is located in the Lower Paraguay Basin.

The section of the Paraguay River in the Lower Paraguay basin is an important part of the Paraguay-Paraná Waterway and receives, on its right bank, two main tributaries: the lower Pilcomayo and Bermejo rivers. On the left bank are the Aquidabán, Jejuí, Aguaray and Tebicuary rivers.

In the Lower Paraguay, despite the contributions it receives in the upper part of its basin, to the east of the section, it would have a negative water balance if it only had its tributaries on the right bank, as their overflows do not return to the main channel, recharging lateral depressions in which the water is retained until it evaporates (CIC, 2017). However, its tributaries on the left bank - Aquidabán, Jejuí, Aguaray and Tebicuary - generate important contributions.

Figure 5.2.2.1.a
Hydrographic division of the River Plate



Source: modified from CIC (2017).

Water resources management and hydrographic division

According to Law 3239/07 on Water Resources of Paraguay, the Ministry of Environment and Sustainable Development (MADES) is responsible for regulating the sustainable and integrated management of all waters and the territories that produce them, regardless of their location, physical state or natural occurrence within the Paraguayan territory, in order to make them socially, economically and environmentally sustainable for the people who inhabit the territory of the Republic of Paraguay.

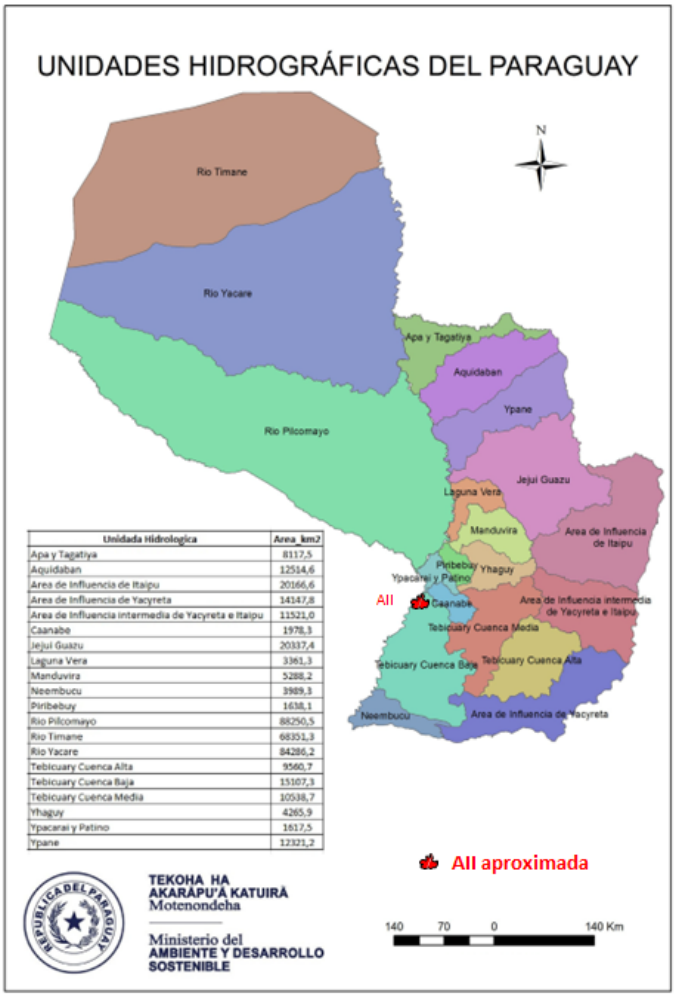
The Hydrographic Units of Paraguay are recognised by the MADES as the space for the creation of basin management and water resources planning bodies. By means of Resolutions N° 376/12 and 521/19, the Water Basins were identified and delimited at the national level. Seventeen hydrographic units of the Eastern Region and three units of the Western Region of Paraguay were recognised.

These delimitations were carried out based on the study called Technical Criteria for the Delimitation and Codification of Paraguay's Basins (ANTÚNEZ, 2012), developed within the framework of the Modernisation of the Water and Sanitation Sector Project, which has

delimited and codified all the basins of the national territory using the Pfafstetter method (Ottocodification). Thus, in the Paraguay River Basin there are 103 watersheds in the upper basin, 179 watersheds in the middle basin and 26 watersheds in the lower basin, totalling 308 watersheds tributary to the Paraguay River. In the Paraná River Basin there are 391 river basins.

The hydrographic division of Paraguay, according to Resolution SEAM Nº 376/12, is presented in **Figure 5.2.2.1.b**, considering that the AII is located in the Hydrographic Unit Tebicuary Lower Basin. In turn, this basin is subdivided into 8 basins shown in **Figure 5.2.2.1.c**: Pikysyry Stream, Saladillo Stream, Tatu Cue Stream, Tebicuary River, Paray River, Piripucu Stream, Surubi'y River and Vera Lagoon**.** The ATOME project is located in the Arroyo Surubi'y watershed, which corresponds to the AII.

Figure 5.2.2.1.1.b
Hydrographic units of Paraguay according to Resolution Nº 376/12



Unidada Hidrologica	Area_km2
Apa y Tagatiya	8117,5
Aquidaban	12514,6
Area de Influencia de Itaipu	20166,6
Area de Influencia de Yacyreta	14147,8
Area de Influencia intermedia de Yacyreta e Itaipu	11521,0
Caanabe	1978,3
Jejui Guazu	20337,4
Laguna Vera	3361,3
Manduvira	5288,2
Neembucu	3989,3
Piribebuy	1638,1
Rio Pilcomayo	88250,5
Rio Timane	68351,3
Rio Yacare	84286,2
Tebicuary Cuenca Alta	9560,7
Tebicuary Cuenca Baja	15107,3
Tebicuary Cuenca Media	10538,7
Yhaguy	4265,9
Ypacarai y Patino	1617,5
Ypane	12321,2

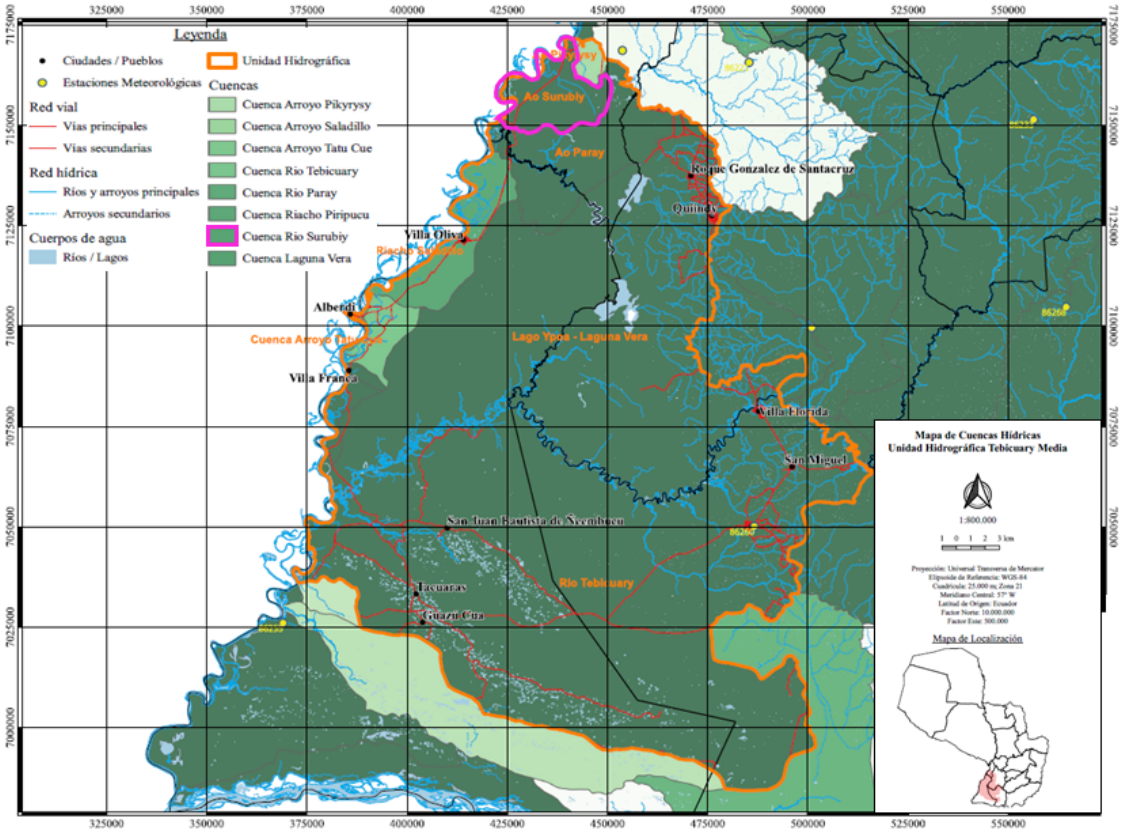
Source: modified from MADES (2022a).

Considering the classification of surface waters in Paraguay, all the watercourses of the Arroyo Surubi'y Basin are Class 2, according to Resolution SEAM Nº 255/05. According to Art. 1º of Resolution SEAM Nº 222/02, Class 2 waters are classified as such according to the following predominant uses: i) for domestic supply after conventional treatments; ii) for protection of

aquatic communities; iii) for primary contact recreation (water skiing, swimming); iv) for irrigation of vegetables and fruit plants; v) for natural and/or intensive breeding (aquaculture) of species intended for human consumption.

With regard to water councils, constituted by river basins and regulated by Resolution SEAM N° 170/2006, with the objective of constituting an executing arm of water management at the community level, there is no record of their existence for the Arroyo Surubi'y Basin, according to the National Action Plan for Integrated Water Resources Management (GIRH) in Paraguay (MADES, 2022b). In the Hydrographic Unit Tebicuary Lower Basin there is only water advice for the drainage area of this river, according to Resolution SEAM N° 812/2010.

Figure 5.2.2.1.c
Location of the Surubi'y Basin (AII) in relation to the hydrographic division of Paraguay.



Source: modified from MADES (2022a).

The main characteristics of the water resources in the areas of influence of the project are presented below.

5.2.2.2.2
Main Characteristics of Surface Water Resources in the AII

The Surubi'y Stream Basin (AII) has an approximate surface area of 361 km^2 and covers areas of the Districts of Villeta and Nueva Italia, belonging to the Central Department. The main access route is the Villeta-Alberdi road, as well as the Paraguay-Paraná waterway.

As shown in **Figure 5.2.2.1.c**, the Surubi'y Stream Basin (AII) is located in the northern portion of the Lower Tebicuary Hydrographic Unit, and is bounded to the northeast by the Pikyrysy Stream Basin, to the east and south-southwest by the Paray Stream Basin and to the west-northwest by the Paraguay River. In this section the Paraguay River is a very active meandering course that develops an alluvial plain by migration and avulsion of meanders (**Photos 01 and 02**).



Photo 01: Terport area, view from the Paraguay River.



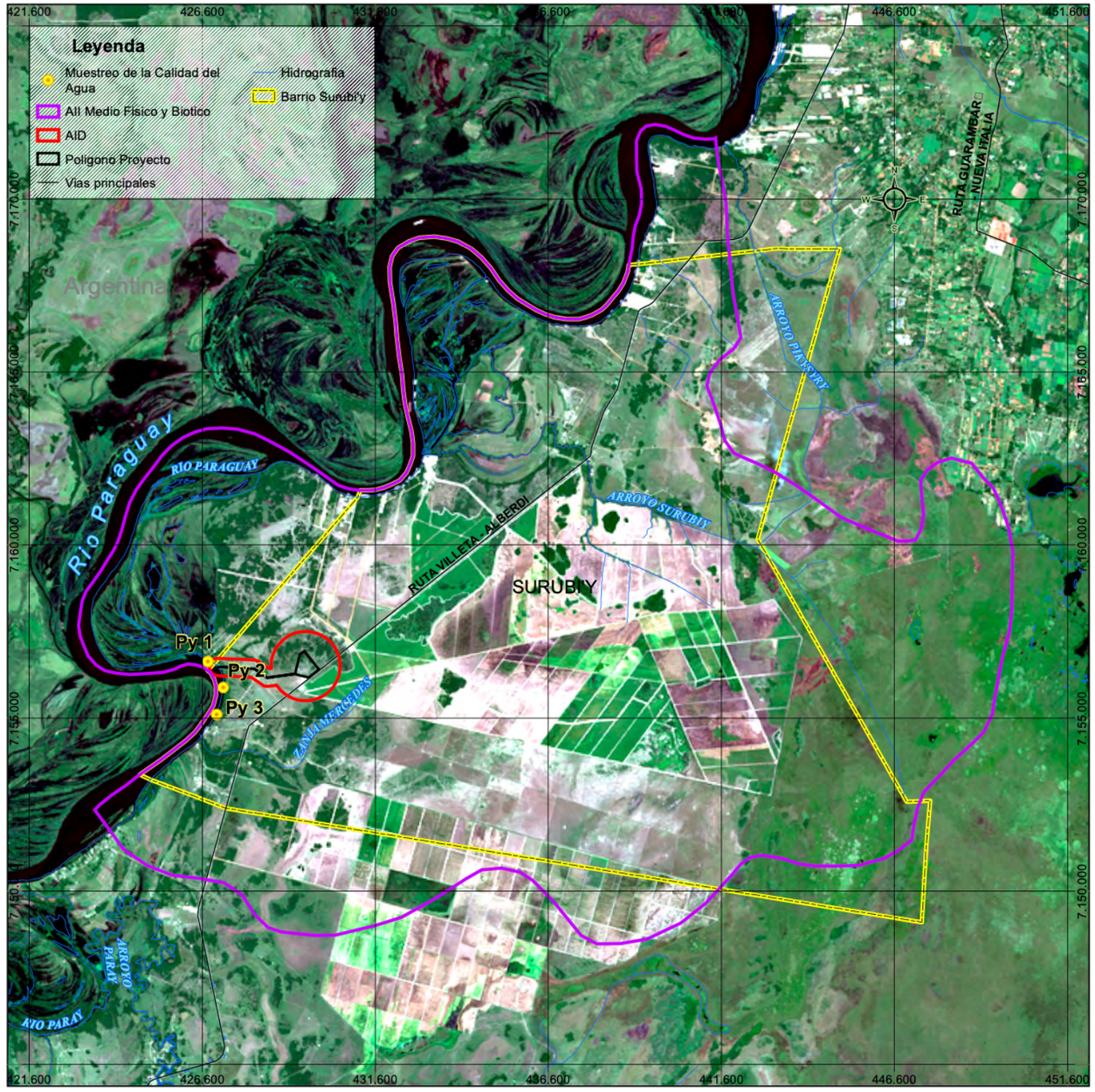
Photo 02: Paraguay River in March 2023, with its high waters.

5.2.2.2.2.1
Feeder Channels

The water bodies of the AII drain towards the left bank of the Paraguay River. The most important tributaries are the Arroyo Surubi'y (**Photo 03**) and the Arroyo Zanja Mercedes (**Photo 04**), not located in the AID or ADA of the project. In addition, there are other small intermittent drainage channels, also not located in the AID and ADA. The location of the watercourses in the AII is shown in **Map 5.2.2.2.2.1.a - Hydrographic Map** below.

Map 5.2.2.2.2.1.a - Hydrographic Map

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	5.2.2.2.1.a - MAPA HIDROGRAFICO





Carátula Juridica Legal

Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	25/10/2023

Fuente Cartográfica

Proponente, DGEEC 2012
https://www.mades.gov.py/atlas/ - ttps://eos.com/landviewer/?utm_source=Email&lat=-25.76712&lng=-57.47086&z=11&id=S2B_tile_20230408_21JVM_0&b=Red,Green,Blue&anti 2023

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:125.000



Photo 03: View of the Surubi'y stream from the Villeta-Alberdi road.

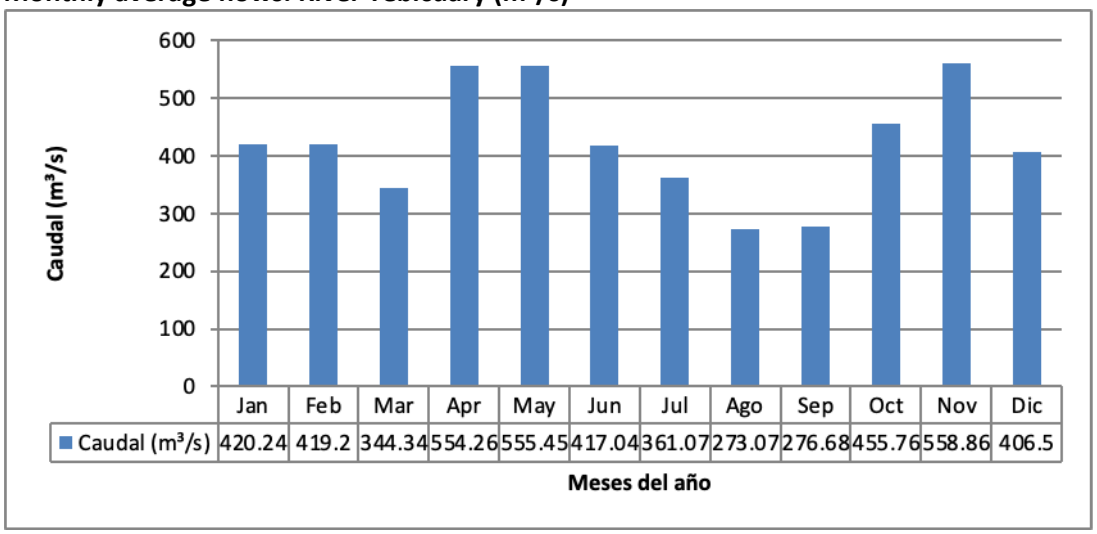


Photo 04: View of the Arroyo Zanja Mercedes from the Villeta-Alberdi road.

5.2.2.2.2.2
Hydrological Characteristics

Regarding the water regime, it should be noted that, like other water bodies in the region such as the Tebicuary River, a similar regime is expected for the IIA drainages, tributaries to the Paraguay River. Unlike the typical tropical regime, with the occurrence of a rainy and a dry season, the region has two annual maxima. The main maximum occurs in late spring, coinciding with the increase in frontal rains and the onset of summer rains. The secondary maximum occurs in late summer, when, even under abundant rainfall, evaporation loss prevents the occurrence of the annual maxima. **Figure 5.2.2.2.2.2.a** shows the distribution of monthly mean flows in the Tebicuary river.

Figure 5.2.2.2.2.2.a
Monthly average flows. River Tebicuary (m³/s)



Source: DMH-DINAC-UNESCO (1992).

However, specifically for the IIA, it should be noted that the sum of the total flows drained is much lower than those of the Tebicuary River. By way of comparison, we cite the data presented in the diagnosis of water resources in Paraguay (ECLAC, 2014), which considered the

area of the Lower Tebicuary Hydrographic Unit, except for the basin of the river of the same name, thus including the Surubi'y Stream Basin, in addition to the other 6 basins (Pikysyry, Saladillo, Tatu Cue, Paray River, Piripucu Stream and Vera Lagoon) that make up this unit (**Figure 5.2.2.2.1.2.c**), as well as the area of the Caañabe Hydrological Unit (**Figure 5.2.2.2.1.2.a**).

For this drainage area, referred to in the study as the Alberdi sub-basin, an annual average estimate of 6 m^3 /s was obtained. In the same study, the average annual flow for the Tebicuary river was 506 m^3 /s and for the Paraguay river (Asunción) it was 3,279 m /s.[3]

Still on the flows recorded in the Paraguay River at Asunción, the values for the period 1904-2002 are presented in **Table 5.2.2.2.2.2.a.** The maximum flows of the Paraguay River are generally recorded in June and the minimum flows are between November and January.

Table 5.2.2.2.2.2.a
Flows recorded in the Paraguay river (m^3 /s)

Period	Total registration	1961-1990	1971-2000	1968-1984
Year maximum monthly	Jun-1905	Jun-1983	Jun-1983	Jun-1983
Maximum monthly value	11,007	10,663	10,663	10,663
Monthly minimum year	Oct-1967	Oct-1967	Jan-1972	Sep-1969
Minimum monthly value	646	646	1,059	697
Annual average	3,200	3,205	3,727	3,279

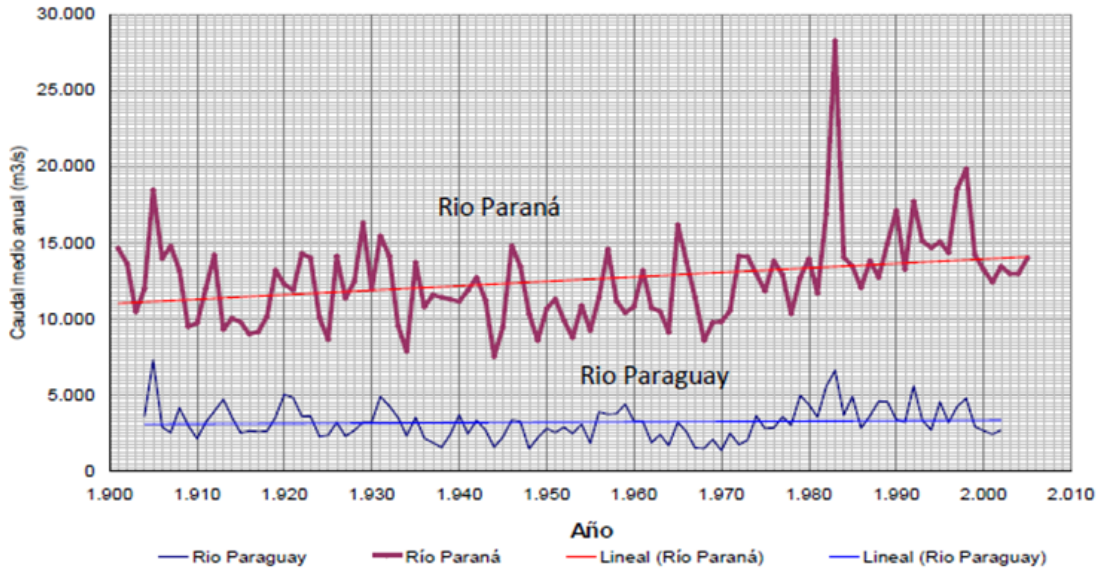
Source: ECLAC (2014).

The trend of the annual mean flows for the historical record of the Paraná and Paraguay rivers is presented below. The increasing trend line is verified (**Figure 5.2.2.2.2.b**), as indicated by the study.

In the sequence, **Figure 5.2.2.2.2.2.c** shows the monthly mean flows recorded in the Paraná River and Paraguay River, compiled by ECLAC (2014), in addition to data from the Pilcomayo River (Western Region of Paraguay, 1961-1997 series). The data for the Paraná River are related to the main axis on the left and those for the Paraguay and Pilcomayo Rivers to the secondary axis on the right.

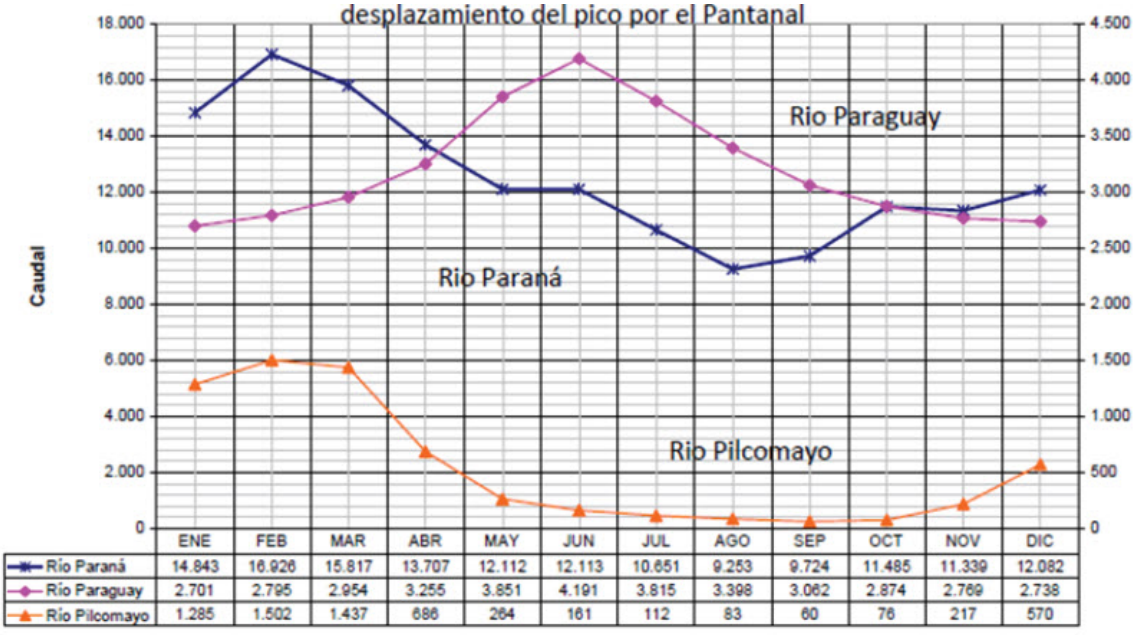
It is observed that the Pilcomayo River flood has a similar behaviour to the Paraná River flood, while the Paraguay River has a displacement due to the effect of the Pantanal (Upper Paraguay Basin). In the Paraguay River, the regime is more uniform in the distribution of flows throughout the year, with a relative maximum at the beginning of winter, which shows the influence of the Pantanal as a regulator and retarder of floods (CIC, 2017).

Figure 5.2.2.2.2.2.b
Average annual flow of the Paraná and Paraguay rivers (m^3 /s) - period 1902-2002



Source: ECLAC (2014).

Figure 5.2.2.2.2.2.c
Mean monthly flows of the Paraná, Paraguay and Pilcomayo rivers (m^3 /s)



	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC
Río Paraná	14.843	16.926	15.817	13.707	12.112	12.113	10.651	9.253	9.724	11.485	11.339	12.082
Río Paraguay	2.701	2.795	2.954	3.255	3.851	4.191	3.815	3.398	3.062	2.874	2.769	2.738
Río Pilcomayo	1.285	1.502	1.437	686	264	161	112	83	60	76	217	570

Source: ECLAC (2014).

With regard to the variation in the level of the Paraguay river, **Table 5.2.2.2.2.2.b shows** the data on the maximum and minimum levels of the river in Villeta, according to the Directorate of Meteorology and Hydrology (DMH, 2023). The historical minimum of the Port of Villeta, which had reached -0.60 m in 1969, can be observed, compared to the historical maximum of

8.94 m in 1983, well above the warning level of 5.5 m. For comparison, on 11 March 2023, as a relatively recent measurement, the river level was 4.45m.

It should be noted that these level data are also consistent with the timing of the maximum and minimum flows of the Paraguay River at Asunción (1968-1984), as shown in **Table 5.2.2.2.2.2.b** and in the graph in **Figure 5.2.2.2.2.2.b**.

Table 5.2.2.2.2.2.b
Maximum and minimum levels of the Paraguay River at Villeta

Event	Date	Level
Recent measurement	11/03/2023	4.45 m
All-time low	22/09/1969	-0.60 m
All-time high	30/05/1983	8.94 m

Source: Directorate of Meteorology and Hydrology (DMH), 2023.

Other historical records of the heights of the Paraguay River at Villeta between 1969 and 2010, as well as at Asunción, Alberdi and Pilar, in the months of March, are shown in **Table 5.2.2.2.2.2.c**, where the alert heights at each location are shown. The graph in **Figure 5.2.2.2.2.2.d** shows the data for the year 2023 (as of 23/03/2023) for the height of the Paraguay river at Villeta, superimposed with historical average, maximum and minimum data. At this date the measured height already exceeds the level considered as alert (5.5 m).

Table 5.2.2.2.2.2.c
Comparative observations of March heights of the Paraguay River between 1979 and 2010

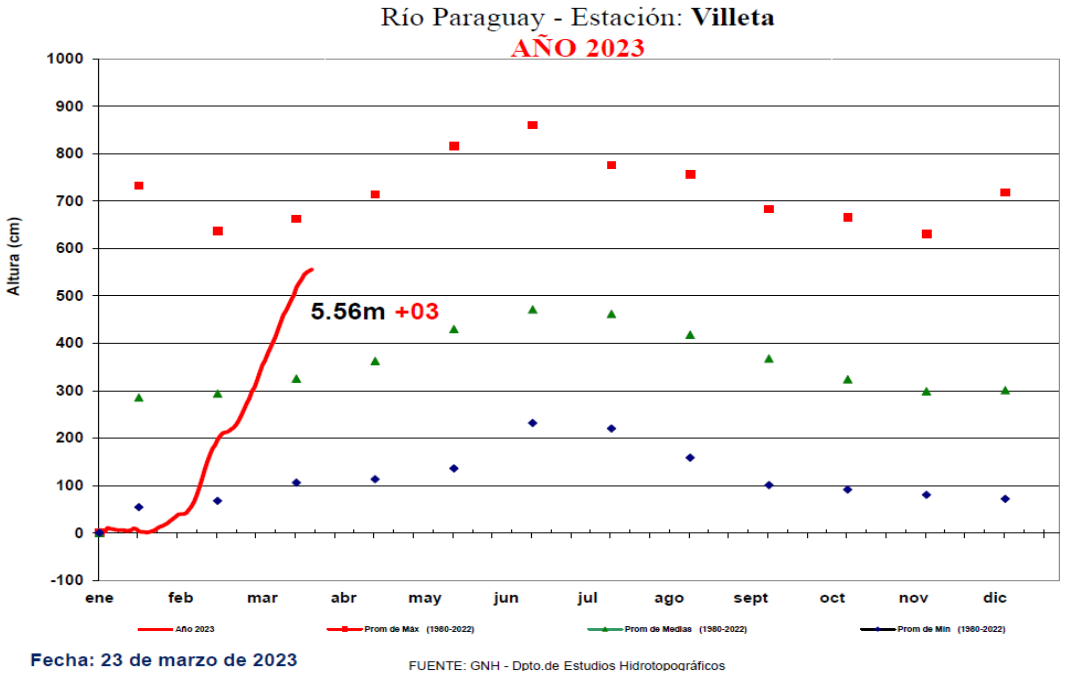
Dates	Asunción	Villeta	Alberdi	Pilar
	Warning heights (metres)			
	4.50	5.50	6.00	6.00
	Heights observed in March (metres)			
8/3/79	3.90	3.93	Y/N	5.09
8/3/80	3.09	3.17	Y/N	5.48
8/3/82	3.25	3.23	Y/N	4.71
8/3/83	6.31	6.46	Y/N	8.05
8/3/88	2.77	2.62	Y/N	3.79
8/3/08	3.82	3.92	3.90	4.88
8/3/09	1.54	1.52	1.53	3.24
8/3/10	3.74	3.84	5.00	5.30

Source: data obtained from MSPyBS, 2016.

It follows from the above that, while the tributaries of the Paraguay River in the IIA region directly express the hydrometeorological balances, with a greater influence of rainfall, the Paraguay River, due to the extension of its basin, reflects the influence of the Pantanal (Upper Paraguay).

Figure 5.2.2.2.2.2.d

Height levels of the Paraguay River at Villeta - Historical and 2023 data



5.2.2.2.2.3
Water Uses in the IIA

As highlighted above (**Section 5.2.2**), for the characterisation of water uses in the IIA, the Environmental Information System (SIAM) of MADES was consulted, which provides numbers of water abstraction records by type of use, department and river basin (period 2019 and 2023), as well as in terms of abstracted flows (period 2010 and 2014) related by districts, activity, project and surface or groundwater source, as well as basin.

However, with regard to the data per basin, there was a large lack of data in the database. Furthermore, the data per basin refer to the hydrographic unit Tebicuary Baja, which includes the set of eight sub-basins, among them the Surubi'y Stream basin, corresponding to the IIA, as presented in **Figure 5.2.2.1.c** in **Section 5.2.2.1.1.**

Thus, considering that the data on water harvesting records were more complete by department, the data available for the Central Department to which the IIA belongs was compiled. These data show that, between the years 2019 and 2023, the total number of records in the Central Department was 7,899. Of this total 53.27% correspond to domestic use; 21.34% to drinking water system; 16.18% to others; 6.79% for industrial - washing and/or refrigeration; and 0.54% for industrial - raw material. However, it should be borne in mind that Central is made up of 19 districts, including Villeta.

From the above, it is possible to verify the importance of domestic uses and catchments for supply systems in terms of number of records. However, from these data it is not possible to verify the quantitative influence of water consumption by sector. **Table 5.2.2.2.2.3.a**, below, shows the register numbers for all registered use categories.

Table 5.2.2.2.2.3.a
Number of registrations by type of water use in the Central Department - 2019-2023

Categories	Registration number	%
Rain-fed agriculture	3	0.04
Agriculture and Livestock	37	0.47
Domestic	4,208	53.27
Livestock	40	0.51
Industrial - washing and/or cooling	536	6.79
Navigation	1	0.01
Another	1,278	16.18
Agricultural irrigation - pivot	1	0.01
Drinking water system	1,686	21.34
Landfill	6	0.08
Commercial aquaculture	11	0.14
Subsistence aquaculture	1	0.01
Industrial - raw material	43	0.54
Recreativo	31	0.39
Agricultural irrigation - drip	8	0.10
Agricultural irrigation - flooding	9	0.11
Total	**7,899**	**100**

Source: MADES Environmental Information System (SIAM) - Water - Statistical Data. Available at: https://apps.mades.gov.py/siam/portal. Accessed on: 30 Apr. 2023.

Considering the quantitative data on extracted flows, the data available in the SIAM were analysed for the whole of the Villeta District. It is important to note that the Villeta District, in addition to covering practically the whole of the IIA, except for its eastern end, also includes the northern part of the IIA, up to the seat of Villeta, including areas of the Pikyrysy Creek basin and up to Arroyo Abay. To the south of the IIA, the Villeta District covers areas up to Arroyo Paray. That is to say, in addition to covering the area of the Surubi'y Creek watershed (AII), it also includes areas of the aforementioned watersheds, among others.

As with the water catchment records above, it was decided not to recover by basin due to lack of data and because it covers an even larger area than the District of Villeta, corresponding to the Lower Tebicuary hydrographic unit.

Abstraction flow data are only available for the period 2010 to 2014. Although outdated, these data are set out in full in **Table 5.2.2.2.2.3.b**, and are discussed below.

According to information provided by telephone contact from the MADES water resources department, the unit of abstraction flow normally used is m^3 /s. Considering that for all data the same unit of continuous abstraction flow (m^3 /s) has been applied, it can be observed that of the total water abstracted, about 53% corresponds to groundwater source (abstraction flow of 15,069 m^3 /s); 28.61% is a surface source (extraction flow of 8,126 m^3 /s) and 18.31% (extraction flow of 5,199 m^3 /s) refers to other categories indicated as "no mention", "no", "ESSAP", "aguatería", among others.

Excluding the data indicated as groundwater abstracted flow, the remaining flow is 13,325 m^3 /s, which is assumed to be mostly surface, abstracted from the District of Villeta (period 2010-2014). For this number, there is the following distribution by group of activities: industries (including ports) with an extraction of about 60.35% (extraction flow of 8,042 m^3 /s);

agricultural uses (including rice fields) with an extraction of 29.25% (extraction flow of 3,898 m^3 /s); and service stations and laundries corresponding to 10.39% (extraction flow of 1,385 m^3 /s).

Industrial activities include, in addition to port activities, which account for 57.21% of the sector, catchments for the paper bag factory, chicken breeding and fattening, energy substations, water purification plant, slipper factory and the industrial plant of Ataja S.A. Among the agricultural uses, the most important are livestock farming and rice cultivation, which are developed jointly.

Of the 33 records of possible surface abstractions in the District of Villeta (period 2010-2014), the watershed is identified in only four, three in the Paraguay River and one in the Ypeka'e Stream. For most of the records there is an indication of "no mention" which makes an analysis of the water balance between captured flows and available flows unfeasible. In any case, if all the abstractions recorded in the District of Villeta, in the period analysed, were extracted from the Paraguay river, the amount of surface water extracted would correspond to about 3.8 times the average flow of the Paraguay river, which is about 3,500 m /s.^{3}

In this sense, in view of this extreme value of the flow captured, the possibility is considered that among the catchments there is no explicit identification of surface, some may be underground, or even that the data filled in together with the MADES need verification with respect to the flow unit. Thus, if it is different from m^3 /s and in the event that the unit of abstraction flow is m^3 /h, the total abstracted by the activities of the District of Villeta (period 2010-2014) would correspond to 3.70 m^3 /s or about 0.10% of the average flow of the Paraguay River.

In this sense, by way of comparison and as already explained in **Section 3.2.7.2**, it is observed that the flow to be consumed by the ATOME project is 165.4 m^3 /h (0.05 m^3 /s), which corresponds to about 0.002% of the lowest historical flow of the river or about 1.3% of the total (possibly surface) flow extracted by the activities of the Villeta District (period 2010-2014).

Considering **Table 5.2.2.2.2.3.b**, note that in the column "catchment" also possible effluent treatments are indicated, such as cesspit, septic tank, soakaway; but without the possibility to distinguish the release flow.

Table 5.2.2.2.2.3.b
Water Withdrawal Records in the District of Villeta - Period 2010 to 2014

Ano	Depart.	District	Activity	Project	Basin	Flow rate	Flow rate Extraction	Depth	Source Supply
2.011	Central	Villeta	Agriculture and Livestock	Farming	Paraguay River	888	1,341	4	Superficial
2.010	Central	Villeta	Agriculture and Livestock	Livestock production - rice cultivation - gravel extraction	Tajamar	816	924	12	Superficial
2.010	Central	Villeta	Industries	Paper bag factory	Septic tank and soakaway	1,282	1,383	4	Superficial
2.010	Central	Villeta	Industries	Fuel storage plant operation	Cesspit	1,207	282	2	Underground
2.010	Central	Villeta	Industries	Oil factory	Cesspit	896	1,280	3	Underground
2.010	Central	Villeta	Industries	Rearing and fattening of broiler chickens	No mention of	922	944	6	No mention of
2.010	Central	Villeta	Industries	Operation of the industrial plant of Tripera Paraguaya S.A.	Treatment system	978	800	1	Underground
2.010	Central	Villeta	Industries	Egg and broiler chicken production	No mention of	1,235	782	13	Underground
2.010	Central	Villeta	Industries	Inland waterway port terminal for miscellaneous goods	Septic tank and soakaway	1,143	154	10	Superficial/ underground
2.011	Central	Villeta	Agriculture and Livestock	Livestock farming and rice cultivation	No mention of	1,384	32	10	Superficial
2.011	Central	Villeta	Industries	Feedlot fattening and annexes	No mention of	1,420	138	12	Underground
2.011	Central	Villeta	Industries	Nueva Italia Complex	No mention of	1,060	301	5	Underground
2.011	Central	Villeta	Industries	Villeta II 220/23 sub-station, Adm 66/23 sub-station and LT 66 Villeta II Adm transmission line.	No mention of	954	1,329	10	Superficial
2.011	Central	Villeta	Industries	Reforested wood chopping, chip factory and material storage	No mention of	1,325	530	3	Underground
2.011	Central	Villeta	Industries	Grain loading dock - port	No mention of	982	739	2	Superficial
2.011	Central	Villeta	Industries	Concrete plant, pre-cast concrete factory, steel structure factory, steel structure factory	No mention of	1,487	233	4	Underground
2.011	Central	Villeta	Industries	Flavoured water production and bottling process, alcoholic beverage bottling company	No mention of	1,437	1,250	1	Underground
2.011	Central	Villeta	Industries	Port of loading and unloading of grain	No mention of	821	191	12	Underground

Table 5.2.2.2.2.3.b
Water Withdrawal Records in the District of Villeta - Period 2010 to 2014

Ano	Depart.	District	Activity	Project	Basin	Flow rate	Flow rate Extraction	Depth	Source Supply
2.011	Central	Villeta	Industries	Agro-industrial plant operation	No mention of	1,318	1,197	4	Underground
2.011	Central	Villeta	Industries	Port of embarkation and disembarkation, fertiliser blending plant	No mention of	818	1,042	2	Underground
2.011	Central	Villeta	Industries	Implementation of Ataja SA's industrial plant operation.	No mention of	1,400	603	15	Superficial
2.012	Central	Villeta	Service station and laundry facilities	Service station	No mention of	1,350	299	8	ESSAP
2.012	Central	Villeta	Service station and laundry facilities	Construction and operation of service station - Petropar	No mention of	1,149	1,086	12	Waterworks
2.014	Central	Villeta	Rice farmers	Livestock farming and rice cultivation	0	1,117	337	10	0
2.013	Central	Villeta	Well logging	Well registration, functioning and operation of the industrial plant for the formulation and synthesis of agrochemical products.	No mention of	1,179	418	6	Underground
2.014	Central	Villeta	Opinion	Port of the city of Villeta	No	1,026	1,059	13	No mention of
2.014	Central	Villeta	Agriculture and Livestock	Livestock farming and rice cultivation	A° Ypecae	897	1,264	5	Superficial
2.014	Central	Villeta	Industries	Port of the city of Villeta	No mention of	1,204	1,066	3	No mention of
2.014	Central	Villeta	Industries	Bulk fertiliser depot, mezcal, bagging and marketing of the products - port - parking yard - fuel storage for internal use - internal access road - oil mill and extension for fertiliser depot - adaptation of the oil plant - real estate location contract - truck yard extension.	No mention of	921	562	13	Underground
2.014	Central	Villeta	Industries	Trainer factory	No	871	447	12	Superficial
2.014	Central	Villeta	Industries	Multimodal port for reception, temporary storage and shipment of grain and/or containerised cargo; fuel retailing for domestic use	Paraguay River	1,451	254	14	No

Table 5.2.2.2.2.3.b
Water Withdrawal Records in the District of Villeta - Period 2010 to 2014

Ano	Depart.	District	Activity	Project	Basin	Flow rate	Flow rate Extraction	Depth	Source Supply
2.014	Central	Villeta	Industries	Sand mining	No	963	1,295	4	Underground
2.014	Central	Villeta	Industries	Port of shipment or disembarkation, fertiliser mixing plant	No	840	446	14	Underground
2.014	Central	Villeta	Industries	Industrial casing processing plant	No	1,182	967	5	Underground
2.014	Central	Villeta	Industries	Expansion of the water purification plant	Paraguay River	1,349	64	2	Superficial
2.014	Central	Villeta	Service station and laundry facilities	Service station, canteen, greengrocer's shop, mini-market and the like	No	1,149	658	11	Underground
2.014	Central	Villeta	Well registration A.B.C.	Well logging	No	1,187	570	8	Underground
2.014	Central	Villeta	Well registration A.B.C.	Well logging	No	1,025	957	7	Underground
2.014	Central	Villeta	Well registration A.B.C.	Well logging	No	1,187	1,170	4	Underground

Source: MADES Environmental Information System (SIAM) - Water - Statistical Data. Available at: https://apps.mades.gov.py/siam/portal. Accessed on: 30 Apr. 2023.

In view of the above, in order to obtain more updated and reliable data on surface water consumption and effluent generation in the IIA, RIMA of industrial projects, preferably located in the District of Villeta and next to the MADES website, were also consulted. These data are shown in **Table 5.2.2.2.2.3.c**.

Table 5.2.2.2.3.c
Effluent flow and water abstraction of some industrial projects in the District of Villeta

Project/Proponent	District/ Place	Year	Effluent Flow/ Treatment	Water Withdrawal Flow	Source of supply
Receipt and storage of by-products/wastes from animal feed and composting industries/ ECOSOLUTIONS S.A.	Villeta	2022	No data/ septic chambers	No data	Groundwater well
Biodiesel Processing Plant for Commercialisation / Biodiesel Processing Plant for Commercialisation/. Biotova S.A.	Villeta/ Angostura	2021	0.0125 m^3 /h (300 litres/day) septic chamber	3.5 m^3 /h (3,500 litres/hour)	Groundwater well
Construction and Commissioning of Industrial Plant/ Tigre Paraguay S.A.	Villeta/ Guarambaré Route	2021	no data/ sewage treatment plant	No data	ESSAP and underground tube wells
SANTO DOMINGO RIVER TERMINAL VILLETA/COPADIN S.A.	Villeta	2021	No data/ withdrawal and treatment	80 m /h^3	ESSAP and artesian well
CONSTRUCTION AND OPERATION OF A PLANT FOR THE PRODUCTION OF ALCOHOLIC AND NON-ALCOHOLIC BEVERAGES/ BEBIDAS DEL PARAGUAY S.A.	Villeta	2020	No data/ Treatment Plants	80 m /h^3	Deep underground tube wells
Biofuels Production Industrial Complex/ ECB Group	Villeta/ Omega Green	2019	No data/ Treatment Plants	96.88 m^3 /h (950.4 m^3 /day - Hydrolysis Plant and 1,375 m^3 /day Shredder)	No data
Biodiesel Processing Plant/ Bafica Biocombustibles S.A.	Villeta/ Avay Industrial Park	2018	28 m^3 /h, treated at Effluent Treatment Plant	11 m /h^3	Industrial Park supply network
Biodiesel Processing Plant/ Company Valenta Bioenergías S.A.	Villeta/ Avay Industrial Park	2018	28 m^3 /h, treated at Effluent Treatment Plant	11 m /h^3	Industrial Park supply network
Biodiesel Processing Plant/ Renewables Desl Surconsumo S.A.	Villeta/ Avay Industrial Park	2018	28 m^3 /h, treated at Effluent Treatment Plant	11 m /h^3	Industrial Park supply network

Table 5.2.2.2.3.c
Effluent flow and water abstraction of some industrial projects in the District of Villeta

Project/Proponent	District/ Place	Year	Effluent Flow/ Treatment	Water Withdrawal Flow	Source of supply
Avay Industrial Manufacturing/ FLUOEDER S.A.	Villeta/ Avay Industrial Park	2017	~ 100 m^3 /day or 4.16 m^3 /h/ Treatment Plant	14 m /h^3	Underground/ Artesian well
Port and Fuel Depot/ TERMINALES Y LOGISTICA PORTUARIA S.A.	Villeta/Ruta Villeta-Alberdi km 14	2016	No data/ Septic Tank and Treatment Plant	5 m /h^3	Underground/ Patiño Aquifer

Source: Environmental Impact Report - MADES database. Available at: https://www.mades.gov.py/areas-tematicas/control-de-los-recursos-naturales/evaluacion-de-impacto/relatorio-de-impacto-ambiental/. Accessed on: 03 May. 2023.

As can be seen, among the RIMAs consulted, the catchment flow rates varied between 3.5 m^3 /h and 96.88 m^3 /h. Furthermore, it can be seen that the main source of water is from underground wells, in addition to the urban supply network. The RIMA of the Biofuel Production Industrial Complex/ ECB Group (Omega Green), located in part of the AID of the ATOME Plant, does not record the source of water supply. However, it is known that there is a planned water catchment from the Paraguay River for this project. At the site planned for this catchment, on the banks of the Paraguay River, it was observed that material for future works has been laid out, as shown in **Photo 07**.

In addition, during field surveys, when the entire stretch of the Paraguay River located in the IIA was traversed by boat, several implemented ports and their associated industrial plants were identified (**Photo 05**). Possibly these activities use groundwater exclusively or jointly with the Paraguay River. Also during the journey, the movement of boats was verified, the presence of several moorings for large vessels, as well as boats waiting for cargo in the vicinity of the ports (**Photos 05 and 06**).

Finally, small boat moorings were also observed (**Photo 08**), as well as small camps on the riverbanks, used by fishermen (**Photos 09 and 10**). At the southern end of the IIA and next to the Paraguay River, in the locality of Ypeka'e, are located the Fishing Club, the Private Association of Sport Fishermen, several tourist lodges and the fishing port.



Photo 05: Fertimax Industrial Complex and several vessels moored nearby on the Paraguay River.



Photo 06: Boats located between Surubi'y Mooring and Puerto Custodia on the Paraguay River.



Photo 07: Future water catchment point of the Paraguay River for the Omega Green project.



Photo 08: Small boat mooring in the town of Santa Rosa de Lima.



Photo 09: Makeshift camp in the locality of Puerto Alegre, between Puerto Santa Rosa and the planned Omega Green intake point.



Photo 10: Makeshift camp located downstream of the Surubi'y mooring, possibly used by fishermen.

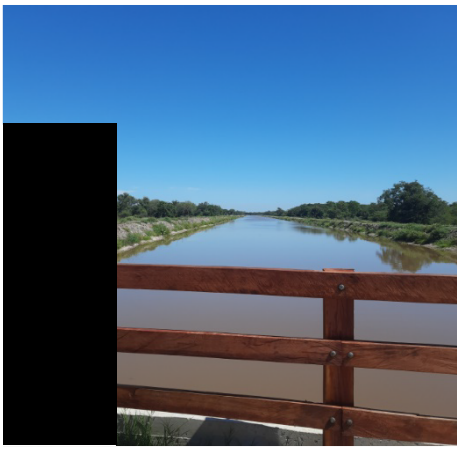


Photo 11: Canal distributing water pumped from the Paraguay river. View from Ruta Villeta-Alberdi, 3 km south of the Arroyo Surubi'y crossing. Downstream view.



Photo 12: Same channel as previous photo with upstream view.





Photo 13: Canal distributing water pumped from the Paraguay river (right photo). Downstream view of the canal from Ruta Villeta-Alberdi, about 680 m south of the Arroyo Zanja Mercedes crossing.

Photo 14: View of the water pumping point on the Paraguay river, located near the mouth of the Zanja Mercedes stream.





Photo 15: Fishpond 45 m wide and 110 m long, parallel to the Villeta-Alberdi road, near the crossing of the Zanja Mercedes stream.

Photo 16: Tajamar on the land of the San Rafael cattle ranch, adjacent to the ADA of the ATOME project, where possible eutrophication of the water due to organic matter can be observed.

From the above, it is considered that the waters of the section of the Paraguay River in the IIA are used for port activity and its associated industrial activities, other industries and notably for navigation, as it forms part of the Paraguay-Paraná Waterway. In addition, the waters of the Paraguay River are used for agricultural purposes, as well as for fishing, tourism and human consumption. It also receives effluents that impact the quality of its waters, as discussed in **Section 5.2.2.4.**

The waters of the Surubi'y and Zanja Mercedes streams, in addition to being captured for agricultural uses, are also used by neighbouring communities and residents. Rainwater contained in the tajamares, as well as groundwater wells, also constitute important alternatives for local water supply, since the flows of surface water bodies in the IIA are limited, with the exception of the Paraguay River.

5.2.2.3
Surface Water Quality

For the characterisation of surface water quality in the IIA of the Project, water samples were collected in the Paraguay River in two campaigns, the first (C1) on 21 March and the second (C2) on 14 June 2023. Three (3) collection points were defined, one of them in the place where it is estimated that water will be collected for the Project, and the other two, downstream of the same, being one of them upstream and the other downstream of the possible discharge point of the treated effluents (Py 1 - Upstream point - collection, Py 2 - Middle point - upstream and PY3 - Downstream point - downstream). These points are shown in **Figure 5.2.2.3.a** below.

The collected samples were sent for analysis of Faecal or Thermotolerant Coliforms and Total Coliforms to the Bio Control Laboratory of Industrial Microbiology, while the analyses of the physicochemical parameters were carried out at the EcoNatura laboratory of the Multilab Group, both located in Asunción. The location of the points is also shown in **Map 5.2.2.2.2.1.a - Hydrographic Map**. The results reports can be consulted in **Annex 2**, where the methodology, the laboratory analysis methods followed and the level of detection of the method can be verified.

The results of these analyses are presented in **Table 5.2.2.3.a** and discussed below, considering Resolution N° 222/2002 and the classification of the water bodies in the study area as Class 2. The results are also compared to the limits set by the US EPA, which are mentioned in the IFC General EHS Guidelines, which do not include standards for surface water quality. In **Table 5.2.2.3.a,** results that do not meet the limits of Resolution N° 222/2002 are marked in red.

Figure 5.2.2.3.a
Water sampling points



All points showed elevated levels of total coliforms (between 24,000 and > 240,000 NMP/100mL) in C1 (March/2023), but only point Py 2 exceeded the limit of 1,000 NMP/100 mL of faecal coliforms established in Resolution Nº 222/2022 for Class 2 waters (Art. 3º). In C2 (June/2023), the values of both parameters (faecal and total coliforms) decreased and there was no non-compliance with Resolution Nº 222/2022 for faecal coliforms. Faecal or thermotolerant coliforms are defined as microorganisms capable of fermenting lactose at 44-45°C, and are mainly represented by *Escherichia coli* and some bacteria of the genera *Klebsiella*, *Enterobacter* and *Citrobacter*. Among these microorganisms, only *E. coli* is exclusively of faecal origin, always present in high densities in human, mammalian and avian faeces, and rarely found in water or soil that has not received faecal contamination (CETESB, 2013). It is possible that the non-compliance result obtained in Py 2 is a consequence of the presence of animal faeces, as the region is dominated by livestock activity, with the occurrence of pastures around the sampling point.

Table 5.2.2.3.a
Water quality analysis of samples from the Paraguay River, in the IIA

Parameter	Unit	Resolution SEAM N° 222/2002	EPA (1)	Points					
				Py 1 - Top Catchment point		Py 2 - Medium Point upstream of effluent discharge		Py 3 - Down Point downstream of effluent discharge	
				C1	C2	C1	C2	C1	C2
pH	-	6.00 a 9.00	6.50 a 9.00	6.85	7.88	6.77	7.64	6.75	7.68
Turbidity	NTU	100	-	14	10	15	10	13	10
Chlorides	mg/L Cl^-	SR	860 / 230	3	10	3	8	3	12
Sulphates	mg/L SO_4^{-2}	250	-	< 2	<2	< 2	<2	< 2	<2
Non-ionisable ammonium	mg/L NH_3	0.02	-	0.02	0.02	0.01	0.02	0.01	0.02
Nitrate	mg/L N	10	-	0.5	0.6	< 0.3	0.4	< 0.3	0.2
Nitrite	mg/L N	1	-	0.002	0.003	< 0.002	0.002	< 0.002	0.003
Colour	mg/L Pt-Co	75	-	90*	112*	93*	110*	91*	111*
BOD5, 20	mg/L O_2	5	-	4.7	1.9	3.9	2.0	3.9	1.9
Dissolved oxygen	mg/L O_2	Not less than 5	-	1.46*	8.58	1.62*	8.30	1.33*	8.51
Total nitrogen	mg/L N	0.6	-	1.2*	2.3*	1.6*	0.9*	1.3*	1.5*
Total dissolved solids	mg/L	500	-	77	133	70	130	73	137
Cyanates	mg/L	0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Hexavalent chromium	mg/L	0.5	0.016 / 0.011	0.061*	0.14*	0.059*	0.24*	0.058*	0.36*
Trivalent chromium	mg/L	2	0.57 / 0.074	< 0.005	<0.03	< 0.005	<0.03	< 0.005	<0.03
Polychlorinated biphenyls (PCBs)	mg/L	SR	- / 0.000014	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Calcium hardness	mg/L $CaCO_3$	300	-	23	31	39	33	35	36
Floating matter	-	absence	-	absence	absence	absence	absence	absence	absence

Table 5.2.2.3.a
Water quality analysis of samples from the Paraguay River, in the IIA

Parameter	Unit	Resolution SEAM N° 222/2002	EPA (1)	Points					
				Py 1 - Top Catchment point		Py 2 - Medium Point upstream of effluent discharge		Py 3 - Down Point downstream of effluent discharge	
				C1	C2	C1	C2	C1	C2
Oils and fats	mg/L	absence	-	9*	8*	9*	9*	8*	7*
Total coliforms	MPN/100 mL	News	-	54,200	9,180	> 240,000	5,420	24,000	5,420
Faecal Coliforms	MPN/100 mL	1,000	-	542	348	1,750	330	700	348
Pesticides									
Endosulfan I and II	mg/L	0.056	0.00022 / 0.000056	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Diazinon	mg/L	0.005	0.00017 / 0.00017	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
4,4 DDT	mg/L	0.002	0.0011 / 0.000001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Endrin	mg/L	0.002	0.000086 / 0.000036	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chemical elements									
Aluminium (Al)	mg/L	0.2	-	2.6*	1.46*	1.92*	1.43*	2.43*	1.37*
Soluble iron (Fe)	mg/L	0.3	- / 1	2.1*	1.0*	2.1*	1.0*	2.1*	1.0*
Sodium (Na)	mg/L	200	-	5	18	5	14	5	13
Selenium (Se)	mg/L	0.01	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Manganese (Mn)	mg/L	0.1	-	0.32*	<0.05	0.32*	<0.05	0.30*	<0.05
Barium (Ba)	mg/L	2	-	0.07	0.06	0.07	0.06	0.07	0.06
Arsenic (As)	mg/L	0.01	0.34 / 0.15	0.003	0.002	0.003	0.003	0.003	0.002
Lead (Pb)	mg/L	0.01	0.065 / 0.0025	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Cadmium (Cd)	mg/L	0.001	0.0018	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Copper (Cu)	mg/L	1	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Tin (Sn)	mg/L	2	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total mercury	mg/L	SR	0.0014 /	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005

Table 5.2.2.3.a
Water quality analysis of samples from the Paraguay River, in the IIA

Parameter	Unit	Resolution SEAM N° 222/2002	EPA (1)	Points					
				Py 1 - Top Catchment point		Py 2 - Medium Point upstream of effluent discharge		Py 3 - Down Point downstream of effluent discharge	
				C1	C2	C1	C2	C1	C2
(Hg)			0.00077						
Nickel (Ni)	mg/L	0.025	0.47 / 0.052	0.001	0.002	0.001	0.001	0.001	0.001
Zinc (Zn)	mg/L	3	0.12 / 0.12	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Total phosphorus (P)	mg/L	0.050	-	0.37*	0.12*	0.34*	0.10*	0.34*	0.10*

SR: no reference.
C1 - First campaign. C2 - Second campaign.
(1) Recommended Water Quality Criteria - Aquatic Life Criteria Table. Freshwater - acute / chronic. https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table#table
*=does not meet the limits of Resolution Nº 222/2002

Also related to the organic parameters, it is verified that total nitrogen and total phosphorus exceeded the limits established by the legislation for Class 2 waters in C1 and C2. The extrapolation was at least 2 and 1.5 times the limit for total nitrogen and 6.8 and 2 times the limit for total phosphorus, respectively in C1 and C2 (**Table 5.2.2.3.a**). As for dissolved oxygen (DO), the results did not meet the minimum limit of 5 mg/L in C1 and the concentrations were 3 times or more lower than that value. These results, associated with the presence of macrophyte banks and large amounts of algae at the collection site, as observed by the laboratory team during the campaign, are indicative of eutrophication of the water body. The team also reported observing dead fish at the site during C1. In this regard, it is commented that the Ministry of Environment and Sustainable Development (MADES) collected water samples in the Paraguay River in March 2023, during the same period as C1, to investigate the causes of fish mortality in the region, and the results of the DO analysis also indicated very low values. It is not possible to pinpoint the exact causes of these low values, but according to MADES experts, they may be the result of the river flooding and the heat[1] typical of that time of the year, which increase the concentration of organic matter in the water and the oxygen demand. In C2, carried out in June 2023, the DO values were higher than in C1 and complied with the limit established in the legislation.

Despite the low DO concentrations in the water recorded at C1, the BOD in the same period, at the three sampling points, remained within the limit established in the legislation (≤ 5 mg/L), although at values close to this maximum limit, especially at PY 1 (4.7 mg/L). BOD is a measure of the oxygen demand for the decomposition of organic matter by the microorganisms present in the water samples and, therefore, higher values are indicative of a higher organic load in the water. However, it is an estimated indicator, obtained from laboratory analysis of samples kept at constant temperature, and does not take into account conditions such as heat and turbulence of the water (VALENTE *et al*., 1997), to which natural environments are subjected. Thus, it is possible to observe situations such as the one recorded in this study during C1, where the BOD values comply with the maximum limits of the legislation, but the DO concentrations evaluated in situ are well below what is allowed by this legislation. This is because the DO level in the water is influenced by other factors in addition to the decomposition of organic matter, such as losses to the atmosphere, respiration of aquatic organisms and oxidation of metal ions (ESTEVES, 1998). However, both parameters are interrelated and oscillations in the DO rate lead to oscillations in the BOD concentration. Therefore, the increase in DO concentration during C2 resulted in lower BOD values than those observed in C1.

In non-conformity with the quality standards, the presence of oils and fats was also observed with concentrations between 7 and 9 mg/L in the samples of the 3 points in both campaigns. The limits for colour, aluminium and soluble iron were also not complied with in both campaigns, as well as manganese in C1. For the other parameters, the limits established by the legislation for Class 2 waters were complied with. Taking into account the compliance of turbidity, it is considered that the presence of colour reflects a higher concentration of dissolved material than suspended material in the water. In general, the colour parameter indicates the presence of dissolved substances in the water, such as humus (organic matter from the degradation of plant matter), colloidal organic matter from domestic wastewater and industrial effluents, plankton, iron and manganese oxides (abundant in various soil types) and

[1] https://www.mades.gov.py/2023/03/12/muestras-de-agua-de-las-zonas-donde-se-denunciaron-mortandad-de-peces-seran-analizadas/

some other metals present in industrial effluents (CETESB, 2018). It should be noted that the main problem of colour in water is often aesthetic and not necessarily related to pollution problems (CETESB, 2018).

For manganese, the non-compliant values observed in the first campaign were 3 times higher than the limit set by the Resolution, and for aluminium and soluble iron, the values sampled were at least 6 and 3 times higher, respectively. It is possible that these higher concentrations reflect a characteristic of the environment, as sampling carried out in the region in previous years for another project also indicated values above the limit for these parameters, as discussed below.

There is also water quality data from the Paraguay River for another project located in the ATOME Plant IIA, more specifically the Omega Green biodiesel plant. These data come from the Environmental Impact Assessment carried out for this project, and are from sampling carried out on different dates between 2021 and 2022. Ten samplings were carried out at a single point corresponding to the site chosen for the ATOME Project water catchment, i.e. Py 1 shown in **Figure 5.2.2.3.3.a** above.

The results of the Omega Green analyses are shown in **Table 5.2.2.3.b** below, which also includes the quality standards for Class 2 waters (Art. 3º) established in Resolution Nº 222/2002 for each parameter that this resolution establishes limits for.

In **Table 5.2.2.3.b** the results that exceeded the limits of Resolution Nº 222/2002 are marked in grey. As can be seen, for pH, zinc, copper, sodium, sulphate, calcium hardness, dissolved iron and the nitrogen series (total nitrate, nitrate and nitrite) the limits established by the legislation for Class 2 waters were met. The turbidity limits were also met, however, for colour only two samples met the limit, with extrapolation of the other eight. This also shows that there is a higher concentration of dissolved material than suspended material in the water.

For BOD_5 , 60% of the results met the limit, and the extrapolations for most of the other samples were not very large.

The aluminium values sampled were 1.5 to 6 times higher than the limit set by the Resolution. In the case of total phosphorus, where all samples also exceeded the limit, the extrapolation was 2 to 3 times higher than the limit.

The highest extrapolations, however, were for faecal coliforms. Although the limit is up to 1,000 coliforms/100 mL, some samples gave 11,000; 17,600; 26,000 and even 188,000 coliforms/100 mL. The values for *Scherichia coli* are not established by the Resolution, but it is noted that the results are high for the same samples that resulted in high faecal coliforms.

Table 5.2.2.3.b
Water quality analysis of samples from the Paraguay River in the IIA - Omega Green Project

Surface water quality analysis Paraguay River	SAMPLE		#01	#02	#03	#04	#05	#06	#07	#08	#09	#10
	COLLECTION DATE	SEAM Resolution Nº 222/2002	22/11/2021	29/11/2021	09/12/2021	15/12/2021	02/02/2022	16/02/2022	03/03/2022	18/03/2022	01/04/2022	18/04/2022
	RESULT DATE		07/12/2021	14/12/2021	22/12/2021	30/12/2021	16/02/2022	03/03/2022	18/03/2022	02/04/2022	16/04/2022	03/05/2022
Parameter	**Unit**											
Fats and Oils	mg/L	Virtually absent	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total alkalinity and phenolphthalein	mg/L		26,50	28.0	28.50	28.50	30.50	25.00	31.50	30.00	30.00	30.00
Aluminium	mg/L	0.2	1.005	0.770	0.600	0.910	0.670	1.029	0.630	0.634	1.198	0.328
Ammoniacal nitrogen	mg/L		0.008	0.108	0.009	0.082	0.040	0.089	0.024	0.068	0.072	0.283
Bicarbonates	mg/L		23.50	25.90	27.47	25.93	27.14	20.75	30.00	27.75	28.20	24.45
Calcium	mg/L		14.30	9.40	10.20	10.20	9.81	8.81	8.41	8.80	8.82	8.40
Carbonates	mg/L		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zinc	mg/L	3.0	0.011	0.009	0.039	0.037	0.025	0.006	0.013	0.020	0.250	0.029
Copper	mg/L	1.0	<0.033	0.057	0.103	<0.033	<0.033	<0.033	<0.033	0.047	<0.033	<0.033
Carbon dioxide CO2	mg/L		2.92	2.10	1.03	2.57	3.36	4.25	1.50	2.25	1.80	5.55
Chloride	mg/L		17.8	60.52	44.38	36.72	18.17	16.73	15.93	18.78	17.97	9.10
Total coliforms	UFC		16,000	800,000	17,600	66,000	4,800	77,000	80,000	32,800	20,000	52,000
Faecal coliforms	UFC	1,000	2,000	188,000	1,220	11,000	3,300	5,480	26,000	17,600	1,600	6,800
Escherichia coli	UFC		0	160,000	1,080	8,800	2,160	5,000	24,000	16,000	1,200	6,400
Colour	Pt/Co	75	80	200	125	120	45	150	70	100	90	125
Electrical conductivity	uS/cm		181.6	289.0	301.0	206.0	119.3	123.7	130.9	129.7	128.8	100.5
Total hardness	mg/L		45.90	40.80	38.70	35.70	30.60	27.00	30.00	32.00	30.00	28.00
Total calcium hardness	mg/L	300	22.40	23.40	25.50	25.50	24.40	22.00	21.00	22.00	22.00	21.00
Total magnesium hardness	mg/L		13.30	17.40	13.20	10.20	6.20	5.00	9.00	10.00	8.00	7.00
Orthophosphate	mg/L		0.094	0.077	0.097	0.081	0.092	0.121	0.089	0.081	0.083	0.085
Total Phosphorus	mg/L	0.05	0.133	0.131	0.110	0.094	0.101	0.141	0.125	0.087	0.122	0.122
Dissolved Iron (Fe+2)	mg/L	0.3	0.246	0.155	0.303	0.284	0.165	0.027	0.089	0.021	0.191	0.086
Total Iron (Fe+3)	mg/L		2.28	2.12	0.754	1.00	2.24	2.88	1.64	1.69	2.70	1.96
Magnesium	mg/L		2.48	4.23	3.21	2.48	1.50	1.21	2.18	2.43	1.94	1.70
Potassium	mg/L		1.89	2.50	0.38	0.51	2.79	3.25	1.58	2.62	3.00	3.12
Nitrate (as N-NO3)	mg/L	10	0.752	0.720	0.593	0.576	0.352	0.456	0.404	0.359	0.310	0.181
Nitrite	mg/L	1.0	0.010	0.020	0.239	0.053	0.022	0.022	0.028	0.046	0.016	0.007
Total Nitrogen Kjeldahl	mg/L	0.6	0.060	0.316	0.120	0.120	0.122	0.196	0.085	0.128	0.206	0.398
pH	UpH	6.0 - 9.0	7.20	7.53	7.39	7.42	7.507	7.13	7.72	7.47	7.63	7.06
Reactive Silica	mg/L		17.49	17.57	18.76	19.52	21.06	18.55	22.48	20.93	19.44	18.81
Total solids	mg/L		168.0	255.9	165.0	145.3	92.2	112.4	76.0	104.0	118.2	90.0
Total suspended solids	mg/L		46	82.5	26.9	21.1	17.2	26.4	18.6	12.0	26.2	20.0
Sodium	mg/L	200	8.64	43.01	34.28	26.46	11.87	13.94	13.65	11.96	11.65	8.48
Sulphate	mg/L	250	5.19	10.02	9.73	9.92	<0.30	6.00	5.21	3.64	4.46	4.98
Water temperature	Grades C.		29	28.7	30	29.0	30	28.0	30.6	28.2	24.0	25.0
Turbidity	UTN	100	64.40	85.90	56.90	33.80	46.50	64.90	39.40	38.10	30.80	28.20
D.B.O.5	mgO2/L	5	9.4	5.8	5.5	3.2	0.9	0.6	2.0	5.1	4.3	2.4
D.Q.O.	mgO2/L		25.67	34.06	47.60	20.00	13.72	30.39	20.38	30.05	82.52	38.11

Although there are no limits for total coliforms in the Resolution, they are seen to be extremely high for almost all samples, especially for the 29/11/2021 sample, when it reached 800,000 total coliforms/100 mL.

5.2.2.4
Main Hydraulic and Hydrological Characteristics in the ADA

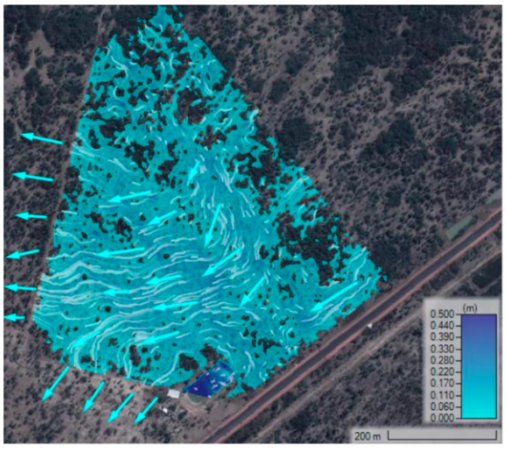
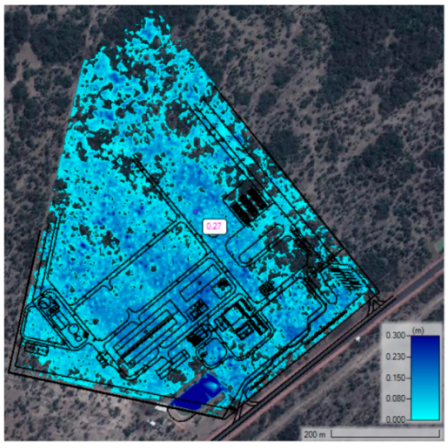
Hydrological and hydraulic studies were carried out in the ADA to determine the peak water levels and runoff pattern in the ADA. The full results are presented in the report in **Annex 3**.

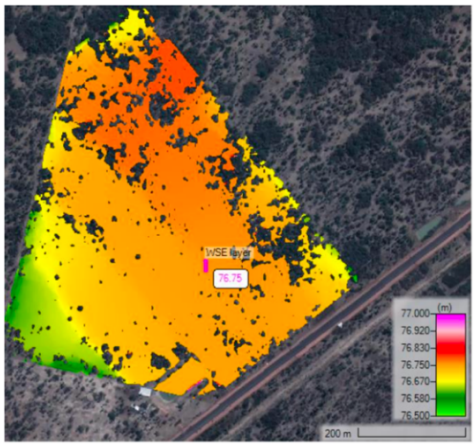
According to the results, it was verified that the property has an altered drainage caused by the presence of channels used for rice plantations and the presence of works of art of the Villeta-Alberdi road, which lead the water out of the property. Likewise, the dike effect of the road acts as a barrier to the passage of water towards the ATOME property.

In this regard, the main characteristics found are summarised below:

- Stormwater is the main source of water on the site. That is, the rain that falls locally on the land itself, so perimeter channels should be provided for the management of surface runoff following the general pattern of westward runoff (See **Figure 5.2.2.4 - A**).
- The maximum water depth is between 25 and 30 cm for a 25-year recurrence (**Figure 5.2.2.4 - B**) and the maximum water level is +76.80 (**Figure 5.2.2.4 - C**), therefore, a platform for the construction of the industry of +77.80 and even higher should be considered to generate a minimum slope of 0.5% to the internal storm drainage system of the industry.
- The site is at an average elevation (+76.50) that could be impacted non-significantly by flooding from the Paraguay River, given that these levels are reached on average every 150 years (+77.26) (Reason for raising the ground level by filling).

Figure 5.2.2.4
Results of hydrological and hydraulic studies

	
A - Runoff pattern in the ADA.	B - Depth of water on the site

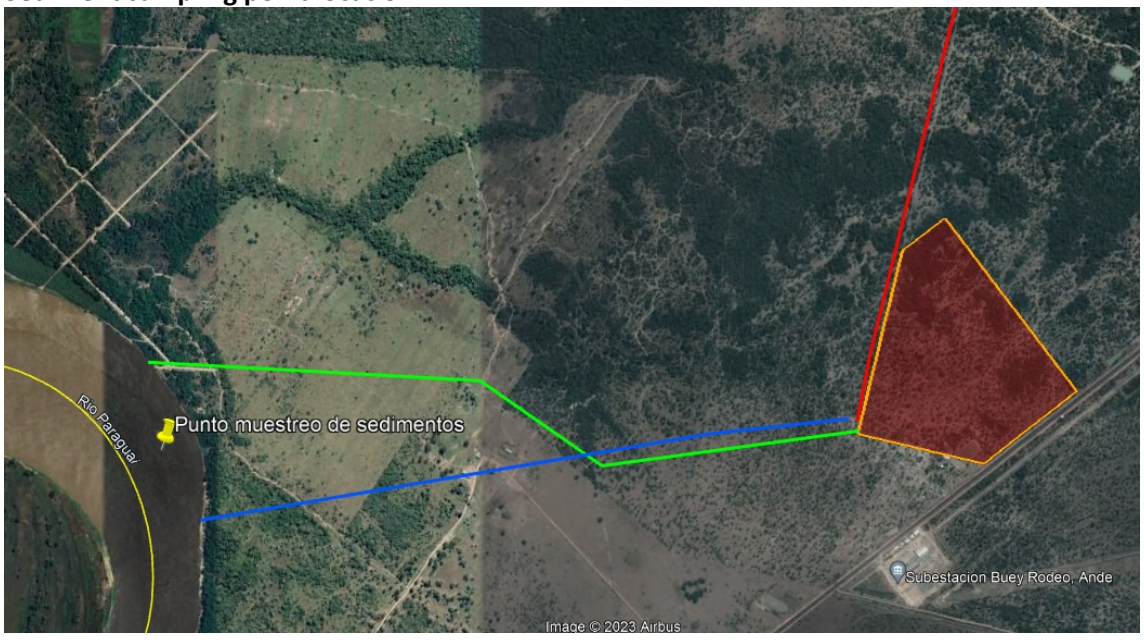
	
C - Maximum water level.	

Source: Report in **Annex 3**.

5.2.2.5
Sediment Quality

At the location where the Project plans to collect water and discharge treated effluent, a bottom sediment sample was collected from the Paraguay River for analysis of the existing sediment quality. The collection was carried out at the midpoint between the two locations most likely to be chosen for the Project's water intake and treated effluent discharge, at coordinates 25.710233S, -57.726728W, as shown in **Figure 5.2.2.5.5.a**.

Figure 5.2.2.5.a
Sediment sampling point location



The sample was taken on 19 September 2023 by a technician from the Water Quality Laboratory of the Faculty of Exact and Natural Sciences - FACEN of the National University of Asunción. Below are some photos taken during the collection.




Photos 01 and 02: Bottom sediment sampling in the Paraguay River.

The sediment sample was collected using a 5 litre volume Van Veen type hand dredge, used to collect samples in unconsolidated bottom environments. The collected sediment was placed in an airtight plastic bag which was duly identified and sent to the FACEN laboratory for analysis of a series of physical and chemical parameters, including metals.

Since there is no Paraguayan legislation related to sediment quality, the results obtained were compared with the limits established by the Canadian Guidelines on Sediment Quality for the Protection of Aquatic Life (Table 1. Interim Guidelines on Freshwater Sediment Quality), of the Canadian Council of Ministers of the Environment (CCME) and also the limits of the British Columbia Ministry of Environment (BC MOE Working Guidelines for Sediments).

The results of these analyses are presented in **Table 5.2.2.5.a** and discussed below, considering the limits in Table 1 of the Canadian Guidelines mentioned above. The Canadian Protocol establishes two guideline values: the TEL (*Threshold Effect Level*) and the PEL (*Probable Effect Level*). These guideline values are based on total concentrations and the probability of occurrence of adverse effects on biota as a result of exposure to these concentration levels. The lower limit (TEL) represents the concentration below which adverse effects to aquatic organisms are rarely expected. The upper limit (PEL), on the other hand, represents the concentration above which adverse effects to organisms are frequently expected (VILLA, 2011). In the range between TEL and PEL are values where such effects are occasionally expected to occur (SILVÉRIO, 2003). The BC MOE effect level categories are equivalent to those of the CCME.

The laboratory report is presented in **Annex 2**.

The results of the sediment analyses indicated values below the PEL for all parameters assessed, which have reference values set by the CCME and/or by the BC MOE (**Table 5.2.2.5.a**). Most of these parameters also showed concentrations below the TEL, the minimum effect range within which adverse effects on aquatic biota rarely occur. The exception was the parameter nickel, for which a value was recorded in the range between the TEL and the PEL of the BC MOE, a range in which adverse effects on aquatic biota can occasionally occur.

Nickel occurs naturally in soil, water, air and the biosphere in very low concentrations. It reaches the hydrosphere through removal from the atmosphere (dry and wet deposition), soil

and rock erosion, municipal waste and industrial effluents (CETESB, 2022). This metal is also found in fertilisers and soil amendments used in agricultural areas (FILIZOLA *et al*., 2002) and can be deposited in sediments by precipitation, complexation, adsorption on clay and aggregation with aquatic biota (CETESB op.cit.). The presence of nickel at concentrations above the limit effect level (TEL) in the study area may be the result of deposition of material transported from cultivated areas in the region and deserves attention, as there is a potential for contamination of the water column in case of sediment resuspension, due to natural or anthropogenic causes, such as sediment dredging.

Table 5.2.2.5.a
Results of the quality analysis of the sediment sample

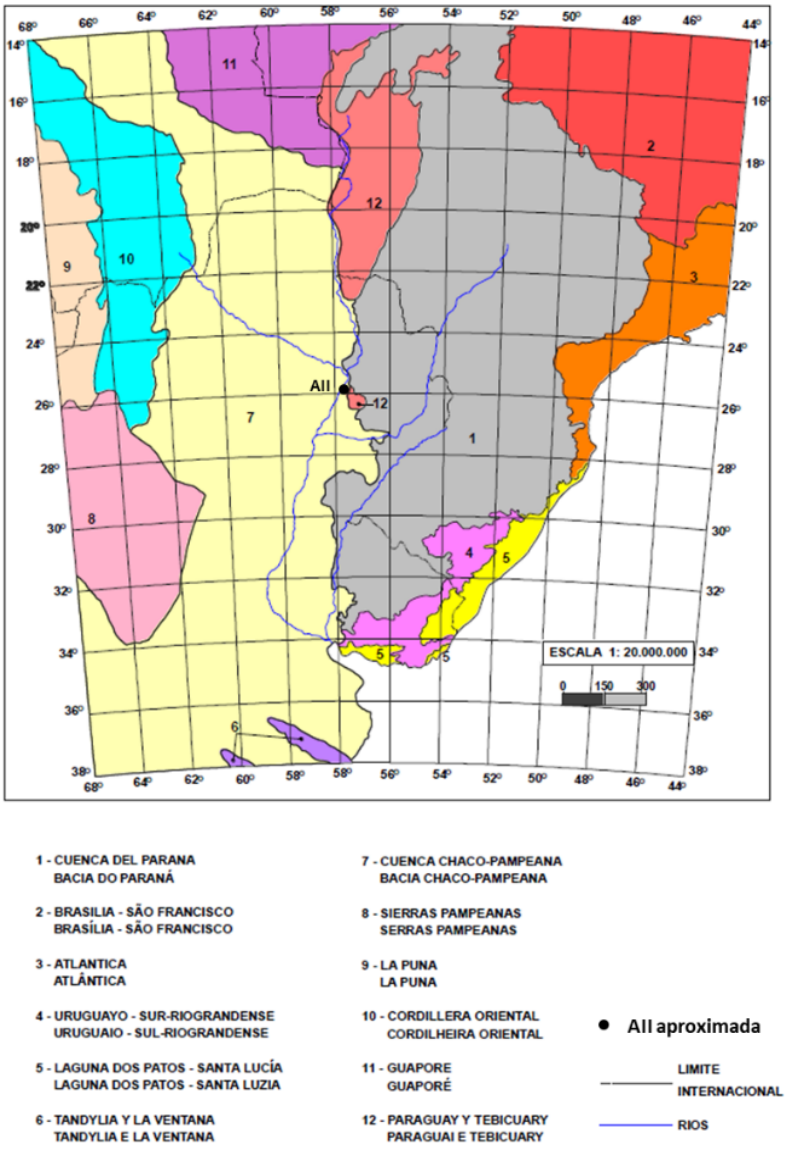
				CCME		BC MOE	
Parameter	**Method**	**Unit**	**Result**	**TEL**	**PEL**	**TEL**	**PEL**
Temperature	SM 2550 B	°C	25.0	-	-	-	-
Humidity	Gravimetric - NN	% w/w	40.6	-	-	-	-
Total phosphorus	SM 4550-P B, SM 4550-P E	mg/kg	103.0	-	-	-	-
Total solids	SM 2540 B	mg/kg	351.85	-	-	-	-
NTK (as N)	SM 4550-N B	mg/kg	7.30	-	-	-	-
Dissolved Organic N (as N)	SM 4550-N B	mg/kg	5.00	-	-	-	-
Aluminium (Al)	SM 3500-Al D	mg/kg	6.65	-	-	-	-
Boron (B)	SM 4500-B B	mg/kg	< 5.0	-	-	-	-
Total Iron (Fe)$^{+3}$	SM 3500-Fe D	mg/kg	2,597.50	-	-	21,200	43,766
Cadmium (Cd)	SM 3500-Cd B	mg/kg	0.30	0.6	3.5	-	-
Chromium (Cr) Total	SM 3500-Cr D	mg/kg	6.90	37.3	90	-	-
Hexavalent chromium (+6)	SM 3500-Cr D	mg/kg	1.33	-	-	-	-
Nickel (Ni)	SM 3030, SM 3500-Ni B	mg/kg	22.50	-	-	16	75
Lead (Pb)	SM 3500-Pb B	mg/kg	< 0.1	35	91.3	-	-
Silver (Ag)	SM 303, SM 3500-Ag B	mg/kg	9.60	-	-	-	-
Total mercury (Hg)	SM 3500-Hg B	mg/kg	< 0.1	0.17	0.486	-	-
Zinc (Zn)	SM 3030, SM 3500-Zn B	mg/kg	50.30	123	315	-	-

5.2.3
Geology and Geotechnics

5.2.3.1
Geology

The IIA is located at the eastern edge of the Chaco-Pampean Basin Morphostructural Geological Province (LOPES, 2001), close to the Paraná Basin Province, as shown in **Figure 5.2.3.1.a.**

Figure 5.2.3.1.a
Morphostructural Geological Provinces - La Plata Basin and Adjacent Areas



Source: Modified from LOPES, 2001.

The Chaco-Pampean Basin is characterised as an intra-plate basin, with Paleozoic origins, but with sedimentary sequences that extend into the Quaternary, giving it a record of about 500 million years in its strata, although with some gaps. The average thickness of all the sediments that make up the basin is about 4 km, reaching a maximum thickness of up to 6 km (DRAGONE, 2013).

Its development is considered complex and is marked by several phases of subsidence and uplift, with the following depositional sequences being identified in the basin: Cambro-Ordovician, Siluro-Devonian, Neopalaeozoic, Mesozoic and Cenozoic.

The Paraná Basin, also of Paleozoic origin, has several sedimentary sequences and sediment thicknesses up to about 7 km. According to Milani *et al*. (1998), six super-sequences are recognised, reflecting cycles of deposition and subsidence, in particular: Ivaí River Supersequence (Ordovician-Silurian), Paraná Supersequence (Devonian), Gondwana I Supersequence (Carboniferous-Eo-Triassic), Gondwana II (Meso-Neo-Triassic), Gondwana III (Neo Jurassic-Eocretaceous), Serra Geral Magmatism and Bauru Supersequence (Lower Cretaceous), the latter associated with the end of its depositional cycles.

According to the Geological Map of Paraguay (SSME, 2014) and Geological Map of Sheet 5469 - Paraguarí (BARTEL *et al*., 1996), Quaternary Sediments (Qa), associated with the Chaco-Pampean Basin, are found in the study area, as well as occurrences of rocks of the Caacupé Group (Sc2). The latter are considered to belong to the Ivaí River Supersediment of the Paraná Basin. The stratigraphic units of the rocks found in the IIA are given in **Table 5.2.3.1.a.**

Table 5.2.3.1.a
Stratigraphic units occurring in the IIA

ERA	PERIOD	TECTONIC UNIT	LITHOSTRATIGRAPHIC UNITS	
Cenozoic	Quaternary	Chaco-Pampean Basin	Qa-Quaternary sediments	Sand, clay, silt and gravel lenses.
Palaeozoic	Ordoviciano Silurian	Parana Basin	Sc2- Caacupé Group	Conglomerates intercalated with arcosean and coarse sandstones.

Source: SSME, 2014.

The identified units are described below. The respective spatial distribution is presented in **Map 5.2.3.1.a - Geology Map.**

Caacupé Group

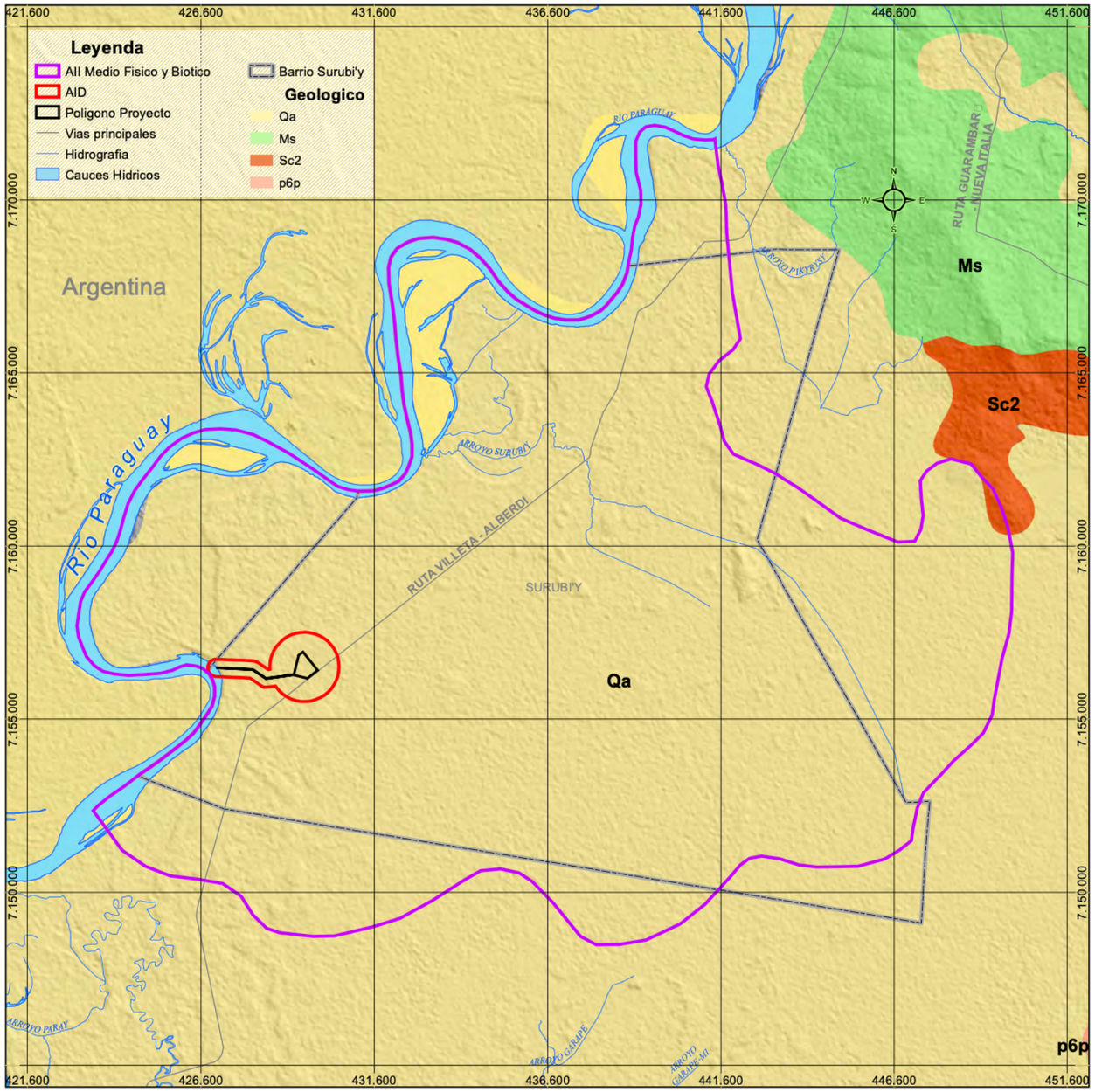
The Caacupé Group is described as being composed of the Paraguarí Formation and the undifferentiated Cerro Jhu and Tobatí formations (PAR 86 PROJECT; BARTEL *et al*., 1996). The Paraguarí Formation forms the base of the Caacupé Group, consisting of a package of clastic conglomerates. The conglomerates are intercalated with thick arkosic sandstones, especially in the upper part of the package.

The typical description includes polymict conglomerates with rounded and sub-rounded clasts, ranging in size from a few centimetres to almost 30 centimetres. The conglomerates consist of quartz and, to a lesser extent, rhyolite, gneiss and quartzite clasts. The genesis of this formation is related to the environment of fluvial fans and interbedded channels.

The Cerro Jhú and Tobatí Undifferentiated Formation consists basically of arkosic sandstones and saccharoidal sandstones. From the base, thick sandstones with conglomerate intercalation are present, which transgress the thinner and better selected sandstones in the upper parts of the formation. They also include thick to medium-sized, well-stratified Archaean sandstones. The genesis is associated with sedimentation with continental facies at the base, deltaic and marine facies and zone exposed to transgression.

Map 5.2.3.1.a - Map of Geology

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	5.2.3.a - MAPA GEOLOGICO





Carátula Juridica Legal

Proponiente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	25/10/2023

Fuente Cartográfica

Proponiente, DGEEC 2012
https://www.ssme.gov.py/vmme/images/mapa%20geologico/mapa%20geologico.rar
2023

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:125.000

The rocks of the Caacupé Group are indicated on **Map 5.2.3.1.a** in a restricted portion of the Project IIA, to the northeast (**Photo 01**). This region includes small hills with maximum altitudes of 20 m. However, detections of areas of conglomerate extraction, also called ripio, east of the Ruta Villeta-Alberdi and north of the Arroyo Surubi'y, between this and the Arroyo Pikysyry, also indicate the existence of rocks of the Caacupé Group in other areas of the IIA, although in limited extensions.



Photo 01: Thick to medium, well-stratified sandstone blocks, related to the Caacupé Group, observed north of the IIA.

Quaternary sediments

In the IIA, Quaternary sediments are associated with sedimentary deposits, deposited in a wide belt along the Paraguay River and marking the fluvial plain. They are consolidated to unconsolidated and of variable textures, composed of fine clayey sands, organic clays, silty clays and, sometimes, gravels.

Orué (1996) considers a wide distribution of this Quaternary sedimentary cover, in particular along the plains of the Paraguay River and therefore considered a wide strip of 900 km in length and an average width of 80 km.

Regarding the environmental aspects of Quaternary sediment formation, this author points out three categories or environments of formation, related to the evolutionary dynamics of the river: i) Ancient Terraces, ii) Sub-recent Floodplains and iii) Present Floodplains.

Deposits related to the Old Terraces are mainly deposited on top of Ordovician-Silurian deposits. They consist of alluvial-colluvial, pre-current alluvial and ferruginous laterites, as well as fine- to medium-grained consolidated to unconsolidated clastic detritus. They are located in a discontinuous band along the topographically higher, non-floodable areas. In the IIA they are distributed above 60 m above sea level, mainly between 60 and 70 m, covering almost the entire IIA, except for the low areas near the Paraguay River (**Photo 02**).

The deposits of the Sub-recent Alluvial Plains correspond to periodically flooded interfluvial areas. They are sandy, silty-clay or conglomerate in nature, constituting laterally discontinuous deposits, as they result from the filling of channels by vertical accretion, abandonment of

meanders or formation of marginal dykes. Their lengths range from hundreds to thousands of metres, with thicknesses of up to 20 m. In the IIA, they are distributed at altitudes of less than 60 m above sea level, mainly in low areas and located near the Paraguay River (**Photo 03**).

On the other hand, the Current Plains, formed from recent alluvium, are thin with a thickness of about 0.5 to 1 m and reflect a succession of strata that include sediments accumulated by the current dynamics of the river, soils developed in fluvial plains, as well as sandy and conglomeratic deposits of lateral accretion. They constitute the areas along the Paraguay River subject to frequent flooding where depositional conditions prevail in a fluvial-lacustrine environment and bank and channel deposits (**Photos 04 and 05**), even in its tributaries, forming dykes, sand bars, alluvial islands and abandoned meander-fill deposits.

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Photo 02: Areas of Old Terrace Deposits with more evolved soils of the Aquic Paleudalf type, in the area of Estancia Santa Lola, between the Villeta-Alberdi Road and the Paraguay River.</td><td>Photo 03: Sub-recessional alluvial deposits located between the mouth of Arroyo Zanja Mercedes and Amarradero Cargil Ypeka'e, with very clayey strata and superficial alteration soils of the Typic Udifluvent type.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Photo 04: Current alluvial plain of the Paraguay River, located to the west of the Project. At this point extensive sandbanks are submerged due to the flooding of the river.</td><td>Photo 05: Current alluvial plain of the Paraguay River, located near Terport Villeta, where sandbanks and marginal dykes are flooded by the rising river.</td></tr>
</table>

5.2.3.2
Geotechnics

For the geotechnical characterisation of the AID and ADA, the preliminary geotechnical report carried out for the ATOME Plant (TAF, 2023) was consulted, in addition to studies carried out for the Buey Rodeo Substation construction project (CÁCERES BÁEZ, 2019) and for the Omega Green Industrial Plant Project (TAF, 2022), both located near the ATOME Plant. In addition, information from the technical report on the drilling of wells in the ATOME Project area (HIDROSERVIC, 2023) was also analysed. Geotechnical information of interest for the present study is presented below.

As a result of the well drilling report on the plant site, up to a depth of 96 m, it was possible to verify that the entire sedimentary sequence drilled corresponds to medium-grained to clayey sediments. Water inputs were identified at two depths: between 30-42 m and between 48-50 m, in strata of sandstones intercalated to more clayey layers.

In relation to the geotechnical studies of the ADA of the ATOME Plant, nine soil borings were carried out, with extraction of samples and SPT (*Standard Penetration Test*) tests at each metre of drilling to a depth of 30.45m.

The water table was found to be between 8.0 m and 8.7 m deep, it being noted that this position is dependent on the rainfall regime and the level of the Paraguay River. The results of the SPT tests indicated the presence, up to depths between 5.00 m and 9.00 m, of yellowish-grey silty clays, of medium to low compactness, with NSPT penetration values in the order of 5 to 20.

Underlying, and down to depths between 13 and 19 m, a stratum of predominantly silty clays or clayey silts was found, with sandy intercalations, presenting variable resistance, in some cases with peaks from 12.00 m onwards. In some boreholes with high penetration values (between 20 and 40) and in others, significant decreases in penetration values were found. The lower stratum detected was considered to consist of dense to very dense silty sand or sandy silt type material, with NSPT values above or close to 50.

These data together with other tests carried out (CPTu and DPSH) and samplings in test pits allowed us to characterise the presence of an upper stratum of fine soils, mainly characterised as silty clays, down to depths of approximately 10.00 m to 15.00 m. These soils show low resistance in the first 10.00 m to 12.00 m, then with peaks in depth. These soils present low resistance in the first 10.00 m to 12.00 m, then with peaks in depth. From about 20.0 m onwards, in all cases, very dense silty sands are found, with no rocks present up to 40.0 m depth.

The geotechnical study pointed out that the very thick upper stratum, mainly due to a probable high presence of salts, dispersive characteristics and high expansion rates, does not have good characteristics for the reuse of excavated materials for backfilling. Therefore, care should be taken for their use as backfill, using them only after stabilisation. Alternatively, the use of selected borrow was indicated,

the closest available option being the riprap mined northwest of the IIA, north of Surubi'y Creek, between it and Pikysiry Creek.

In the area of the Buey Rodeo Substation, seven boreholes were drilled to depths of 8.45 m and standard penetration tests (SPT) were performed, among other analyses. No groundwater table was detected during the boreholes, carried out in August 2019.

From the analysis of the borehole profiles in this area, a predominance of silty clay, grey in colour with brown, yellowish and brown stains, was observed from the surface to the final depth of the boreholes. In addition, the presence of clayey silt was observed between depths of approximately 4.50 m to 6.50 m.

In terms of consistency, the strata show a varied consistency, firm to very firm in places, up to the end of the boreholes. The number of blows in the SPT test varied between a minimum of 7 and a maximum of 30, but predominantly between 10 and 20, indicating a predominance of hard consistency soils.

In the Omega Green area, 28 soil borings were carried out, with sample extraction and SPT testing. The final depths of the boreholes ranged from 25.10 m to 40.45 m. The water table was found to be between 6.3m and 7.8m deep. For information, it was noted that during the period when the fieldwork was carried out, the level of the Paraguay River was between +1.50 and +2.09 at the Villeta hydrometric ruler (July 2022).

The results of the SPT tests indicated the presence, to depths between 2.00 m and 6.00 m, of yellowish-grey silty clays, of medium to low compactness, with NSPT penetration values in the order of 5 to 20. Underlying, a stratum of predominantly silty sands was found, with intercalations of silty clays or clayey sands, presenting variable resistance, extending to depths of more than 30.00 m.

The NSPT varied between 20 and 40 in some boreholes and in others significant decreases in penetration values were found. However, in most cases there was a decrease in resistance in the range of influence of phreatic variation. At approximately 30 m depth, a stratum composed of greyish silty clays with medium to hard consistencies (representative NSPT between 20 and 40) was detected.

Based on the CPTU tests, in order to obtain permeability parameters and consolidation coefficients, an upper stratum of variable thickness between 3.00 m and 6.00 m of fine-grained material was observed in all cases, classified mainly according to the test as silty clays. Subsequently, and up to the end of the boreholes (up to a depth of 25m), a predominant layer of silty sands was found, with clayey intercalations. In all cases, the occurrence of very dense, highly over-consolidated material (high OCR) was also reported in the first 2.00 m to 3.00 m. These high OCR values translate into high OCR values. These high OCR values translate into high undrained shear strength values in the first few metres.

The test pits confirmed the occurrence of stable soils at excavations up to approximately 3 m, mainly due to the presence of silty clay strata. In turn, the permeability tests in the field also showed the impermeability of the initial layer, especially in cases where it is very hard, in the first 2.00 m to 3.00 m.

Thus, it was confirmed that surface water accumulations occur easily after precipitation, not only because of the flat topography, but also because of the formation of a suspended water level, formed on top of the impermeable clay extract.

Chemical tests on samples of the upper stratum, obtained from test pits and boreholes, identified the presence of highly soluble sulphates in some cases, implying that these may present a weak chemical aggressiveness to concrete.

With respect to the Crumb dispersion tests, carried out on 7 samples, collected at depths between 1.5 and 2 m, it was found that 2 were classified as non-dispersive, 1 slightly dispersive, 2 dispersive and 2 highly dispersive. However, with the Pinhole test, performed on 5 samples (obtained at depths greater than 2 m), 3 were considered non-dispersive and 2 slightly dispersive.

In any case, the field inspections carried out by the TAF team (2022) also showed signs of the presence of dispersive soils and the formation of tubifications and deterioration of slopes and soil on the surface.

The same was also observed during the field visits of the present study, especially along the edge of the Arroyo Zanja Mercedes and in its immediate vicinity, where pipes were observed parallel to the Villeta-Alberdi Route (**Photo 06**). In addition, erosive processes were also noted along the edge of the Arroyo Surubi'y, as well as along the edge of the Paraguay River, some resulting in sedimentation points related to these drainages. Intense erosive processes with turbification were also observed at points along the latter, mainly in places with implantation of earthworks (cuts and embankments) (**Photo 07**).



Photo 06: Erosional processes near the edge of the Arroyo Zanja Mercedes.



Photo 07: Tubifications and other erosive processes on the banks of the Paraguay river in a section with earthworks.

From the secondary data collected, attributes obtained in the geotechnical studies carried out in the ADA and around the Project, in addition to field observations, it was possible to identify the main characteristics of the geological materials present and the respective potential geotechnical conditions that will require good management practices during construction, which are shown in **Table 5.2.3.2.2.a.**

Table 5.2.3.2.2.a
Main characteristics/geotechnical conditions of the quaternary sediments occurring in and around the ATOME plant area

TYPES OF MATERIALS	POTENTIAL GEOTECHNICAL CONDITIONS
Quaternary sediments Sand, clay, silt and gravel lenses.	1. Seasonal flooding in the Current Floodplains and occasional flooding in the Sub-recessional Floodplains; 2. Floods in areas with flat relief and water table suspended above clay strata; 3. Lateral and vertical erosion of the channel and banks during the rainy season and/or in the case of embankments, including landslides and falling soil blocks; 4. Possibility of precarious stability of excavation walls, mainly at depths greater than 3 m; 5. Low bearing capacity at points where inconsistent strata occur; 6. Formation of tubifications in dispersive soils; 7. Suppression of foundations and underground networks in case of surface dispersive soils; 8. Intense sedimentation of drainage channels; 9. Need to use borrow material in areas with dispersive soils, presence of salts and high expansion rates.

5.2.4
Hydrogeology

The Hydrogeological Map of the La Plata Basin (CIC; CPRM, 2015) and its explanatory note (DINIZ *et* al., 2015) were consulted for the hydrogeological surveys of the Project's study areas. Thus, the distributions of hydrogeological units in the IIA and IDA, types of aquifers, component lithologies and productivity estimates were analysed. This information was complemented with the data presented in the Hydrogeological Study carried out for the ATOME Project (VICTOR GONZÁLEZ ASOCIADOS, 2022) and the chemical analysis report of the water from the well located at the site, carried out by the Laboratory of Exact and Natural Sciences of the University of Asunción.

Considering the geology of the IIA and IDA, which is predominantly made up of Quaternary sediments, the Project study area is characterised by the occurrence of granular hydrostratigraphic units, where water is found in the pores of the sedimentary deposits, i.e. in the spaces (primary and/or secondary) between the grains.

According to the Hydrogeological Map of the La Plata Basin (CIC; CPRM, 2015), the entire IIA and IDA are located in the hydrostratigraphic unit called Qa - Quaternary Sediment, as shown in **Map 5.2.4.a - Hydrogeological Map**, made up of deposits of sands, silts, clays, gravels and conglomerates. The regional hydraulic characterisation of this unit classifies it as a Gr(4) class, i.e. a granular hydrostratigraphic unit of normally low but locally moderate productivity, which means that the water supply is sufficient to satisfy local supply or private consumption.

Regarding groundwater salinity in the region, considering the electrical conductivity values of the samples analysed, which represent an approximation of the total content of dissolved salts, the IIA is located in the range of 500 - 1000 µS/ cm (DINIZ *et al*., 2015). Even according to regional

studies in the La Plata Basin, the IIA aquifer is located in an area classified as having a medium to high degree of natural susceptibility to being affected by a pollutant load.

Regarding the contamination and salinisation of regional aquifers, studies carried out in Gran Asunción indicate that the Patiño aquifer's vulnerability to contamination increases where the water table is low and where there are very deep boreholes, with excessive pumping, which favours the salinisation of the water. In a 2 to 8 km wide strip in front of the Paraguay river, the presence of salt water from a slightly variable depth was verified. For saltwater intrusion, although it requires geohydraulic conditions that favour it, the origin of the Chaco as it passes through the Paraguay River was considered (SEAM; IDB, 2017).

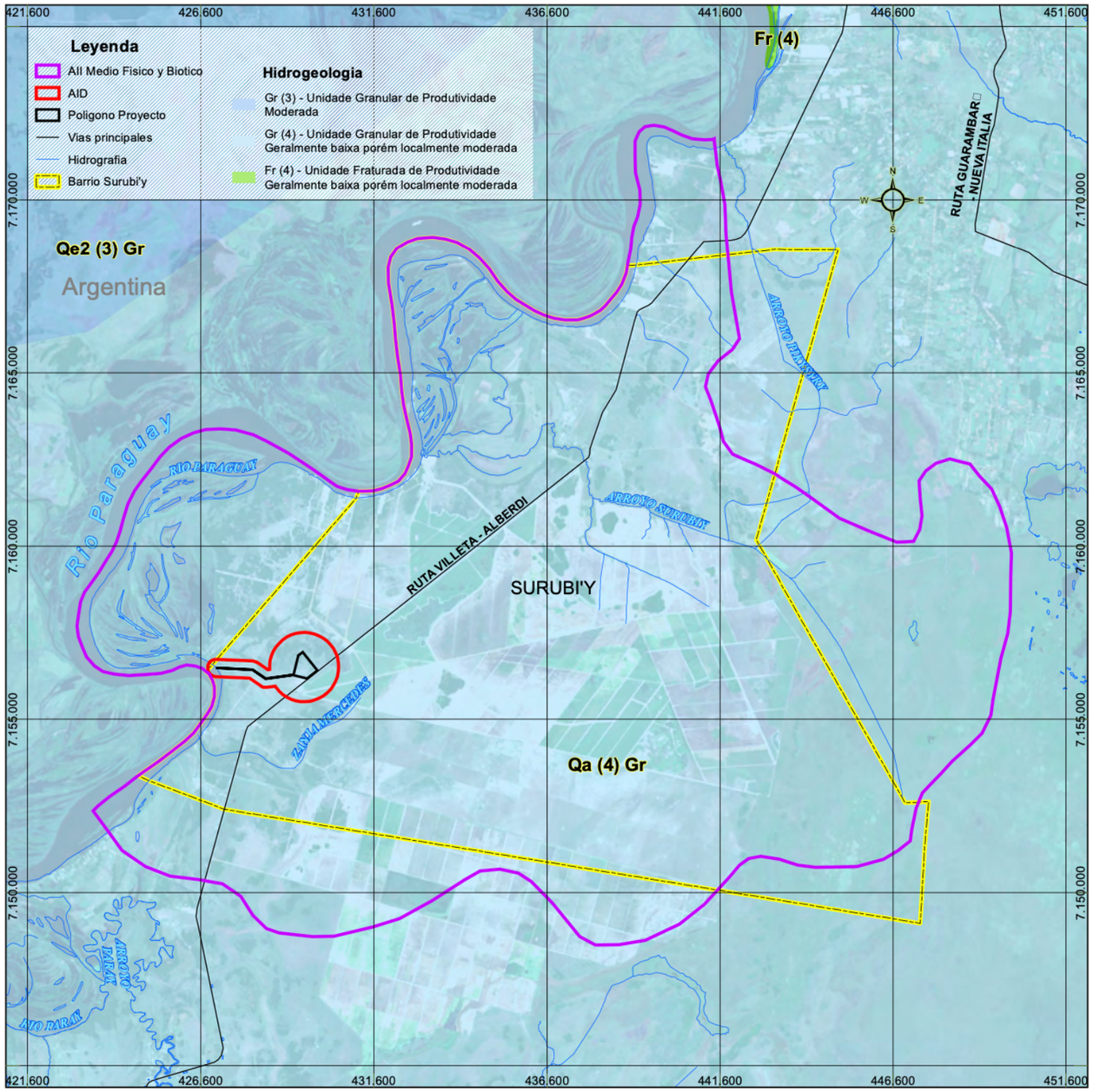
The hydrogeological study carried out for the ATOME Plant Project (VICTOR GONZÁLEZ ASOCIADOS, 2022), also considers the possibility of salinisation of local groundwater, with continuous pumping, due to possible increases in mineralisation by natural salts, under the influence of humid Chaco sediments.

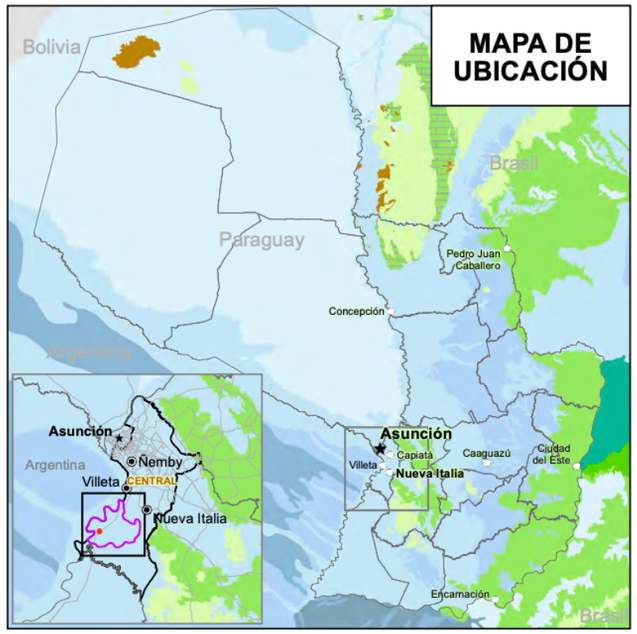
Regarding the productivity of the well drilled in the Project area, a maximum exploration flow rate of 50,000 litres per hour was determined, with a dynamic level located at a depth of 22 m and a maximum depth of 96 m (HIDROSERVIC, 2023). Therefore, in view of the above, the technical report on the drilling of the well recommends not to exceed this maximum flow rate and to carry out periodic monitoring of the salinity of the water in relation to the pumped flow rate. Furthermore, the study also confirmed that lithologically the local aquifer corresponds to Quaternary geological formations, with low to regular hydrogeological possibilities in the area of interest.

In order to characterise the water quality of the deep tubular well located in the Project area, samples were taken on 30/01/2023 and chemical tests were performed. The results of the chemical analyses were compared with the Paraguayan Reference NP 2400180/11 - Sixth edition. Drinking Water - General Requirements. As non-compliance with these requirements are mentioned in **Table 5.2.4.a** below.

Map 5.2.4.a - Hydrogeological Map

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	5.2.4.a - MAPA HIDROGEOLÓGICO





Carátula Juridica Legal

Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	25/10/2023

Fuente Cartográfica

Proponente, DGEEC 2012
mapa_hidrogeologico_de_la_cuenca_del_plata.pdf
https://rigeo.cprm.gov.br/handle/doc/17606
2023

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:125.000

Table 5.2.4.a
Parameters with non-compliance with NP 2400180/11 - Sixth edition. Drinking Water - General Requirements

Parameter	Reference	Result
Conductivity (µS/cm)	1,250	7850
Turbidity (NTU)	5	8.21
Organic Matter (mg/L)	3	11.88
Total distilled solids (mg/L)	600	4,710
Total solids (mg/L)	1,000	4,715
N-Amoniacal (mg/L)	0.05	1.58
Chloride (mg/L)	250	3,448
Sulphate (mg/L)	250	542.43
Total alkali (mg/L)	250	358.92
Total hardness (mg/L)	400	1,070
Calcium (mg/L)	200	340
Magnesium (mg/L)	50	53.5
Sodium (mg/L)	200	1,852.01
Total Iron (mg/L)	0.3	0.6
Total Coliforms (CFU)	0	18
Faecal Coliforms (CFU)	0	2

It follows from the above that the water from the well is already mineralised and contains organic contamination, and can be considered undrinkable and therefore unfit for human consumption without treatment.

According to the interview with the neighbour of the ATOME plant (**Section 5.4.2.2**), the property has a 20.0 m deep well from which water is drawn for drinking. In turn, the wastewater goes to a cesspit and they also use water from the area for animal husbandry. Thus, depending on groundwater flow and other surrounding uses, organic contamination can be transmitted from one point of the aquifer to another.

The aquifer in the area is of the unconfined type. It is an aquifer consisting of deposits of sands, silts, clays, gravels and conglomerates. Sometimes confining layers of clay or rocks may occur, creating deep confined aquifers.

A second groundwater quality analysis was then carried out, this time taking a sample from one of the three 3 metre deep piezometers installed on the Plant site, specifically the one located at coordinates 429,620.00 m E; 7,156,365.00 m S. The location of the piezometer on the Plant site and a photo of its inlet is shown in **Figure 5.2.4.**below.

Figure 5.2.4.a
Location of piezometer for groundwater quality sampling



The collected sample was sent for analysis of physicochemical parameters at the EcoNatura laboratory of the Multilab Group, located in Asunción. The results of the analysis are shown in **Table 5.2.4.a**. The parameters whose values do not comply with the reference limits of Resolution SEAM N° 222/2002 are highlighted in red.

Table 5.2.4.a
Groundwater quality analysis

Parameter	Reference value (1)	Result
pH	6.00 a 9.00	7.17
Turbidity	100 NTU	14 NTU
Chloride	SR (2)	20 mg/L Cl^-
Sulphates	250 mg/L $SO4^{-2}$	3 mg/L $SO4^{-2}$
Non-ionisable ammonium	0.02 mg/L NH_3	0.02 mg/L NH_3
Nitrate	10 mg/L N	1 mg/L N
Nitrite	1 mg/L N	< 0.002 mg/L N
Colour	75 mg/L Pt-Co	46 mg/L Pt-Co
BOD (5 days, 20° C)	5 mg/L	202 mg/L O_2*
Dissolved oxygen (DO)	Not less than 5 mg/L O_2	0.22 mg/L O_2*
Total Nitrogen	0.6 mg/L	2.9 mg/L*
Total dissolved solids	500 mg/L	597 mg/L*
Cyanates	0.2 mg/L	< 0.2 mg/L
Hexavalent chromium	0.5 mg/L	0.27 mg/L
Trivalent chromium	2 mg/L	< 0.03 mg/L
Polychlorinated biphenyls (PCBs) (3)	SR	< 0.0002 mg/L
Calcium hardness	300 mg/L $CaCO_3$	102 mg/L $CaCO_3$
Floating matter	Absence	Absence
Oils and fats	Absence	4 mg/L*

Table 5.2.4.a
Groundwater quality analysis

Parameter	Reference value (1)	Result
Pesticides		
Endosulfan I and II	0.056 mg/L	< 0.010 mg/L
Diazinon	0.005 mg/L	< 0.001 mg/L
4,4 DDT	0.002 mg/L	< 0.0005 mg/L
Endrin	0.002 mg/L	< 0.001 mg/L
Chemical elements		
Aluminium (Al)	0.2 mg/L	0.2 mg/L
Soluble iron (Fe)	0.3 mg/L	0.7 mg/L*
Sodium (Na)	200 mg/L	94 mg/L
Selenium (Se)	0.01 mg/L	< 0.001 mg/L
Manganese (Mn)	0.1 mg/L	1.16 mg/L*
Barium (Ba)	2 mg/L	0.8 mg/L
Arsenic (As)	0.01 mg/L	0.058 mg/L*
Lead (Pb)	0.01 mg/L	0.002 mg/L
Cadmium (Cd)	0.001 mg/L	< 0.0005 mg/L
Copper (Cu)	1 mg/L	< 0.05 mg/L
Tin (Sn)	2 mg/L	< 0.05 mg/L
Total mercury (Hg)	SR	< 0.0005 mg/L
Nickel (Ni)	0.025 mg/L	0.001 mg/L
Zinc (Zn)	3 mg/L	< 0.05 mg/L
Total phosphorus (P)	0.05 mg/L	0.24 mg/L*

(1) Reference Values: SEAM Resolution No 222/2002, Art. 3 (Class 2 waters).
(2) SR: no reference.
(3) Polychlorinated biphenyls analysed: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180.
(4) * = does not meet the limits of Resolution SEAM Nº 222/2002

The report of results can be found in **Annex 2**, where the laboratory analysis methods followed can be verified.

In total, non-compliance with SEAM Resolution Nº 222/2002 was found for nine parameters: BOD, Dissolved Oxygen (DO), Total Nitrogen, Total Dissolved Solids, Oils and Fats, Soluble Iron, Manganese, Arsenic and Total Phosphorus.

Elevated BOD levels, as well as non-compliance in relation to phosphorus and nitrogen, are indicative of the presence of organic matter in the water. Phosphorus is strongly associated with soils and sediments through a series of chemical reactions and, for this reason, movement of this compound through leaching is not common (LOGAN, 1995). Thus, although it is an important component of the lithosphere, the presence of phosphorus in groundwater is mainly due to anthropogenic activities (FOPPA *et al*., 2004), such as the installation of septic tanks and the excessive application of organic waste, especially in sandy soils or fractured rocks (LOGAN, 1995). Faecal organic matter and detergents used in domestic activities are known to be the main source of phosphorus in natural waters (CETESB, 2018). Also important sources of phosphorus enrichment are drained waters from agricultural and urban areas, as well as industrial effluents from some industries (e.g. fertiliser industries, pesticides, general chemicals, food canning, slaughterhouses, meat processing plants and dairies) (CETESB, 2018) (CETESB, 2018).
As for nitrogen, the presence of nitrogenous compounds in water is indicative of contamination of aquifers (ALABURDA & NISHIHARA, 1998). In terms of drinking water quality, nitrate and nitrite are the nitrogenous forms of interest for human health and ammonium is of interest because it confers odour to water (FINEZA, 2008). In this assessment, total nitrogen has extrapolated the limit

established in Resolution N° 222/2002, but nitrate, nitrite and ammonium presented concentrations well below the maximum values allowed by the legislation.

The non-conformities related to Oils and Fats and Arsenic are also indicative of water contamination, which may be due to the infiltration of waste from domestic activities as well as agricultural activities, which are common in the Project region. The possibility of aquifer contamination due to infiltration of compounds from industrial activities in the Villeta region must also be considered.

The presence of iron and manganese in higher concentrations may be a natural condition, influenced by the local geology. Analyses of surface water in the Project area also indicated elevated values of these parameters, as presented in **Section 5.2.2.3**.

The results obtained show that the water at the point assessed does not meet some of the reference values for Class 2 water and therefore cannot be used for the purposes foreseen for this class without appropriate treatment.

5.2.5
Geomorphology

The study of the representation of macro forms or morpho-structures of the South American relief (ROSS *et al*., 2019), places Paraguay in areas of: i) Precambrian Orogenic Belts; ii) Paleo-Mesozoic Sedimentary Basins; and iii) Cenozoic Sedimentary Basins.

Figure 5.2.5.a shows the spatial distribution of the aforementioned morpho-structures, subdivided into morpho-sculptures. While the macro forms or morphostructures are associated with the geological mega structures of Cratons, Orogenic Belts and Sedimentary Basins inherited from Gondwana, produced by the pre- and post-Cretaceous erosional phases, the morphosculptures result from the erosional weathering of the climatic diversity that acted and still acts over time.

It is observed in **Figure 5.2.5.a** that, in the eastern portion of Paraguay, the areas related to the morphostructure of the Precambrian Orogenic Belt Orogenic Belts (2) are distributed mainly towards the north. These areas maintain continuity into Brazilian lands and are called Planaltos and Sierras del Alto Paraguay/Bodoquena (2.5) and Depresiones de Miranda-Bodoquena (2.8).

Figure 5.2.5.a
Macro Relief Map and IIA of the ATOME Plant



Source: Modified from ROSS *et al.*, 2019.

Related to the morphostructure of the Paleo-Mesozoic Sedimentary Basins, the Plateaus and Chapadas of the Paraná Basin can be distinguished in the eastern part of the country (4.1). The areas of morphostructure of the Cenozoic Sedimentary Basins occur along the western portion of Paraguay, represented by the Plains and Wetlands unit of the Beni-Mamoré basins of the so-called Chaco (6.1.5); and, in the south and southwest of the eastern portion, known as the Plains and Hills unit of the Paraguay-Paraná-Prata Basins (6.1.6).

The IIA covers mainly the area belonging to the latter unit, plus restricted portions of the Planaltos and Chapadas unit of the Paraná Basin.

In order to better locate the representativeness of these geomorphological units in the IIA of the Project and to carry out a description and analysis of the relief, the following maps are presented: **Map 5.2.5.a - Hypsometric Map** and **Map 5.2.5.b - Slope Map**. These were digitally elaborated with

Geographic Information System (GIS) using SRTM data (*Shuttle Radar Topographic Mission/NASA*) and contour lines every 5m. In addition, the physiographic units of Paraguay were considered, according to the work of López-Gorostiaga *et al.* (1995).

According to the latter, the physiographic-geomorphological units are related to the predominant lithological material in each unit, where hills, mountain ranges, hills (high, medium and low), alluvial plains (high, medium and low or floodable) and alluvial valleys stand out. **Table 5.2.5.a** summarises the characteristics of the physiographic or relief units distributed in the IIA.

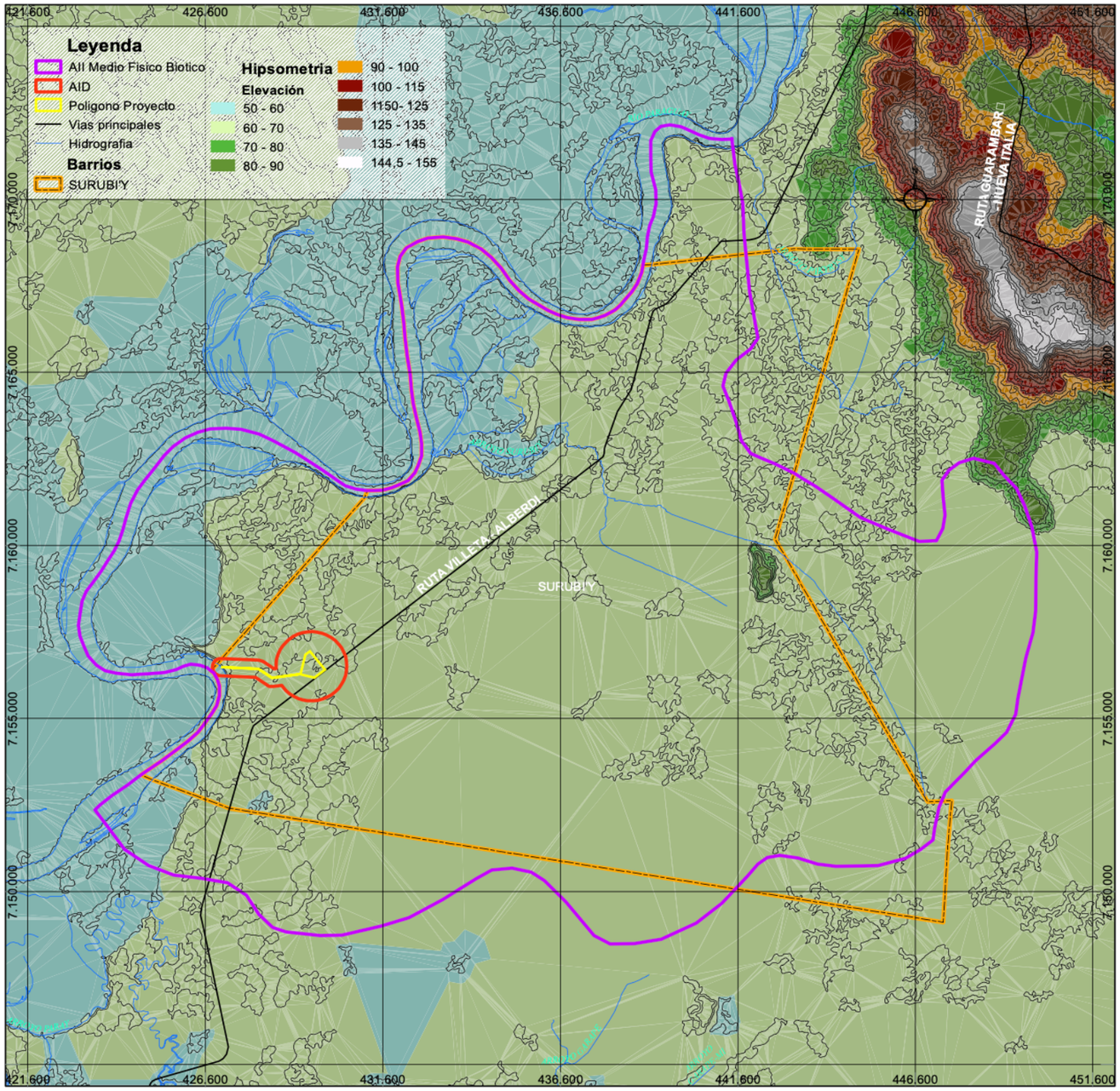
Table 5.2.5.a
General characteristics of the relief units of Paraguay

Physiographic Units	General characteristics
Hills	Isolated Inselberg-type bodies, protruding above flattened surfaces; they are conical or truncated in shape. Predominant lithology types are alkaline, sandstone, granite and basalt. They are usually covered with tree and shrub vegetation and grassland.
Lomadas	The relief is undulating and varied in shape, depending on the drainage network and lithology, with flattened and convex surfaces dissected by u- and v-shaped valleys. They vary in elevation from 150-450 m a.s.l., with gentle to steep slopes (4-15 %), generally covered with natural vegetation or crops.
Plains	High Plains: These are flat to semi-flat, with gentle slopes (1-3%) and poor to moderate drainage, reaching heights of 80-200 m above sea level. Corresponding to them, they are differentiated into inland plains and recent valleys, made up of alluvial and fluvial sediments of Quaternary sands, silts and clays. The vegetation cover is represented by grasslands, pastures and a few gallery forests.
	Low Plains: They have semi-flat to flat relief, with gentle slopes (1-3%) and moderate to poor drainage, reaching heights between 70-150 m.a.s.l. The vegetation is represented by grasslands that generally cover the whole area, and are therefore used for livestock purposes.
	Floodplains: These are flat, with slopes of less than 1%, very poor drainage, with flooded and floodable areas, and have heights ranging between 55-80 m.a.s.l. They are the depressed area formed by the confluence of the Paraná and Paraguay rivers and parts of the Paraguay River Floodplain to the north, formed by recent alluvial and fluvial sediments, consisting of sands, silts and clays, with organic matter (peat). These are the so-called marshes and swamps, with abundant lagoons and paleochannels of ancient meanders near the riverbeds of these rivers. The vegetation cover is represented by grasslands and scrubland, with isolated islands of scrubland.

Source: adapted from LÓPEZ-GOROSTIAGA *et al.* (1995).

Map 5.2.5.a - Hypsometric Map

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	5.2.5.a - MAPA HIPSOMETRICO



Map 5.2.5.b - Slope Map



Carátula Juridica Legal

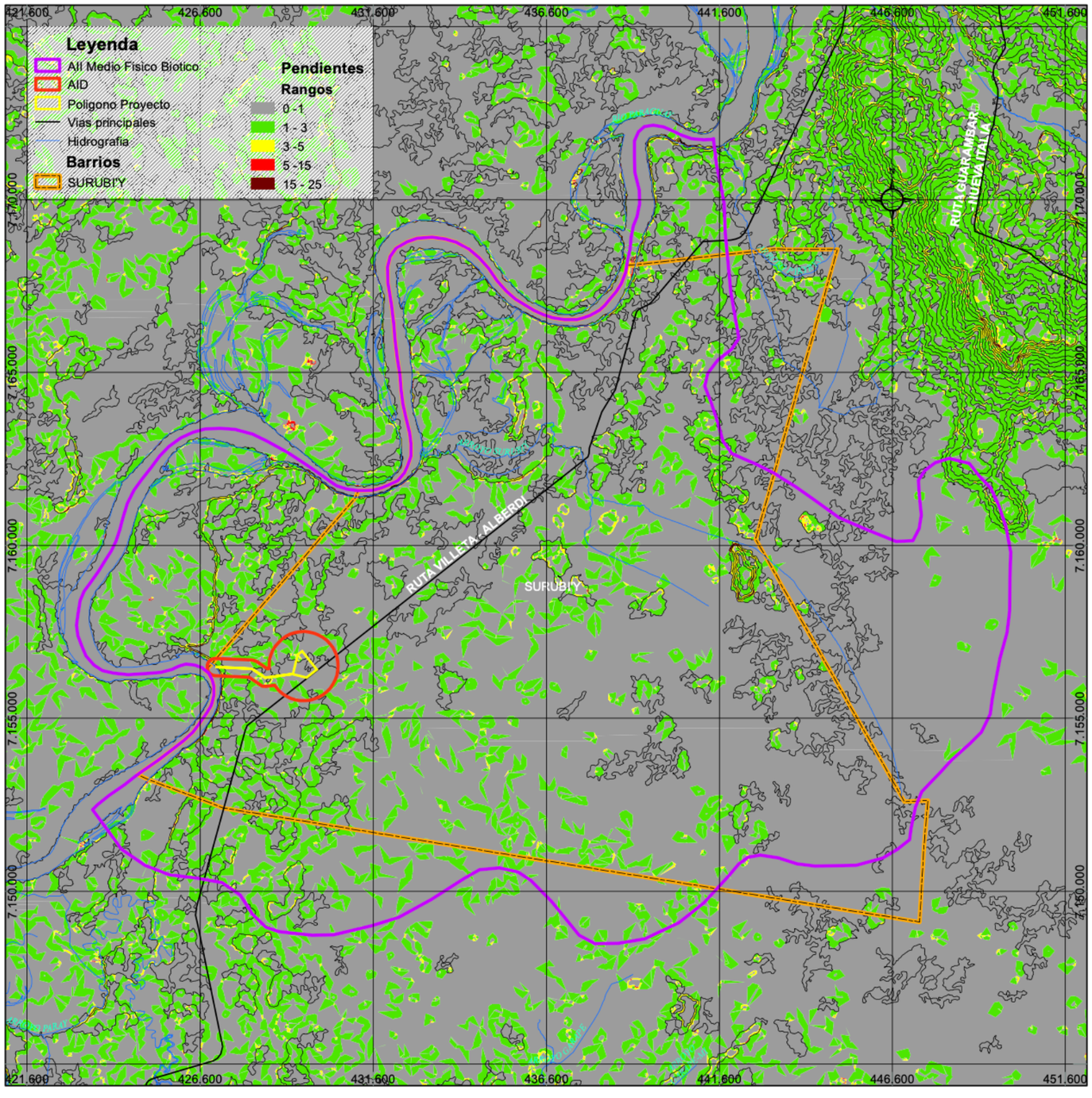
Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	25/10/2023

Fuente Cartográfica

Proponente, DGEEC 2012
2023

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:125.000





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Escala 1:125.000

5.2.5.1
Relief Types

Based on the physiographic-geomorphological units identified in Paraguay (**Table 5.2.5.a**) and on the maps of hypsometry (**Map 5.2.5.a**) and slope (**Map 5.2.5.b**) prepared, in addition to the field surveys, it was possible to identify three types of relief units along the IIA of the Project, namely, hills, low plains and floodplains, which are described below.

Low Plains

The Hypsometry Map (**Map 5.2.5.a**) shows that almost the entire IIA is located between 60 and 70 m above sea level (m.a.s.l.), except in the areas close to the Paraguay River, where there are areas with elevations below 60 m, identified as "flood plains", and in restricted areas to the northeast of the IIA, where there are portions with elevations between 70 and 90, considered as "hills".

Therefore, almost the entire extension of the IIA, including AID/ADA, is in "low plains" relief (**Photo 01**), which is part of the geomorphological unit of "plains" and "hills" of the Paraguay-Paraná-Prata Basins, related to Cenozoic sedimentation. In these terrains, slopes of less than 1% predominate, with undulations mainly up to 3% and eventually 5% (**Map 5.2.5.b**).

They correspond to a semi-flat to flat relief and have moderate to poor drainage. Further east and southeast of the IIA, in addition to the stretch approximately between the AID and Arroyo Surubi'y, there is a greater predominance of slopes below 1%, marking a plain with very poor to flooded drainage and widely used for rice cultivation. These areas are dominated by the Typic Albaqualf soil unit.

Along the Surubi'y Stream, closer to the Villeta-Alberdi Route, and up to the north of the IIA, in addition to the Typic Albaqualf soils, soils of the Typic Natrudalf type predominate, both with poor drainage. The latter type is more susceptible to erosion processes, especially in cases of earth movement and soil exposure, due to the marked textural difference of its horizons. In the rest of the "Low Plains" area, what can be observed is the predominance of Aquic Paleudalf type soils with very poor drainage.

On the banks of the Paraguay River, these "low plains" are intercepted by the process of lateral and marginal erosion of the river, presenting natural landslides towards the river (**Photo 02**). However, sometimes these processes are also caused by the anthropic use of these border areas, either by deforestation and exposure of the soil, or by earthworks, waterproofing, boat movements, etc.



Photo 01: Flat to semi-flat relief of the "low plains" unit in the AID On the right of the photo, rice cultivation can be seen.



Photo 02: View from the "low plains" relief, close to Proyecto Omega, from the Paraguay River, where erosion processes with landslides can be observed on its banks.

Flood Plains

As already highlighted, the relief areas of the "floodplains" are mainly located at elevations below 60 m, corresponding to the current and sub-recent floodplains of the Paraguay River, partially flooded during the river's flood periods (**Photos 03 and 04**).



Photo 03: Floodplain relief, seen from the access road to the Guyrati/Ypeka'e Fishing Club, southwest of AII.



Photo 04: Floodplain relief, seen from the Paraguay River, downstream of the Port of Londrina.

It corresponds to flat relief, with slopes of mostly less than 1%, reaching 3%, with very poor drainage, with flooded and flooded areas. This is the depressed area formed by recent alluvial and fluvial sediments. They are made up of Quaternary sediments of sands, silts and clays, with organic matter (peat).

In part and along the Paraguay River there are some lagoons and paleochannels of old meanders near the present riverbeds and with some islands. The cover soils have very poor drainage and correspond to Typic Udifluvent and Aquic Udifluvent, characteristic of formation on recent fluvial sediments. Like the lowland plain areas, these lands also suffer from lateral fluvial erosion of the Paraguay River in concave riverbed sections, resulting in soil mass movements.

Hills

In **Map 5.2.5.a - Hypsometry**, elevations between 70 and 90 m can be seen as small hills, one located as an isolated body near the bed of the Arroyo Surubi'y and another hill to the northeast of the IIA and which has continuity beyond the limits of the IIA, already in the area of the District of Nueva Italia (**Photo 05**). In these terrains, slope ranges vary mainly between 1 and 3%, with slopes ranging from 3 to 5% and up to 15% (**Map 5.2.5.b**).

These elevations above 70 m above sea level correspond to some rock cores of the Caacupé Group, deposited in the Silurian period and belonging to the Paraná Sedimentary Basin. Thus, they are representative of the geomorphological unit of Planaltos and Chapadas of the Paraná Basin. The alteration soils of these rocks correspond to Rhodic Paleudult, with a fine sandy texture and good drainage.



Photo 05: Hills located north of the IIA in the District of Nueva Italia, formed by sandstones of the Caacupé Group, covered by Ultissolos.

5.2.6
Soils

The identification of the soil classes that occur throughout the areas of influence of the Project was carried out on the basis of the "Study of Soil Reconnaissance, Land Use Capacity and Preliminary Land Use Planning Proposal for the Eastern Region of Paraguay" (LOPEZ-GOROSTIAGA *et al.*, 1995). The overlapping of the study area with the Soil Map of the Eastern Region resulted in the identification of three soil orders, according to the *Soil Taxonomy* classification of the United States Department of Agriculture (USDA, 1992), namely: Alfisol, Entisol and Ultisol.

The soil units mapped in the study area are presented in **Table 5.2.6.a** and their spatialisation in **Map 5.2.6.a - Soil Map**. In the case of consortiations, a single symbol is used per unit, but in the case of associations, two or more symbols are used for each soil unit.

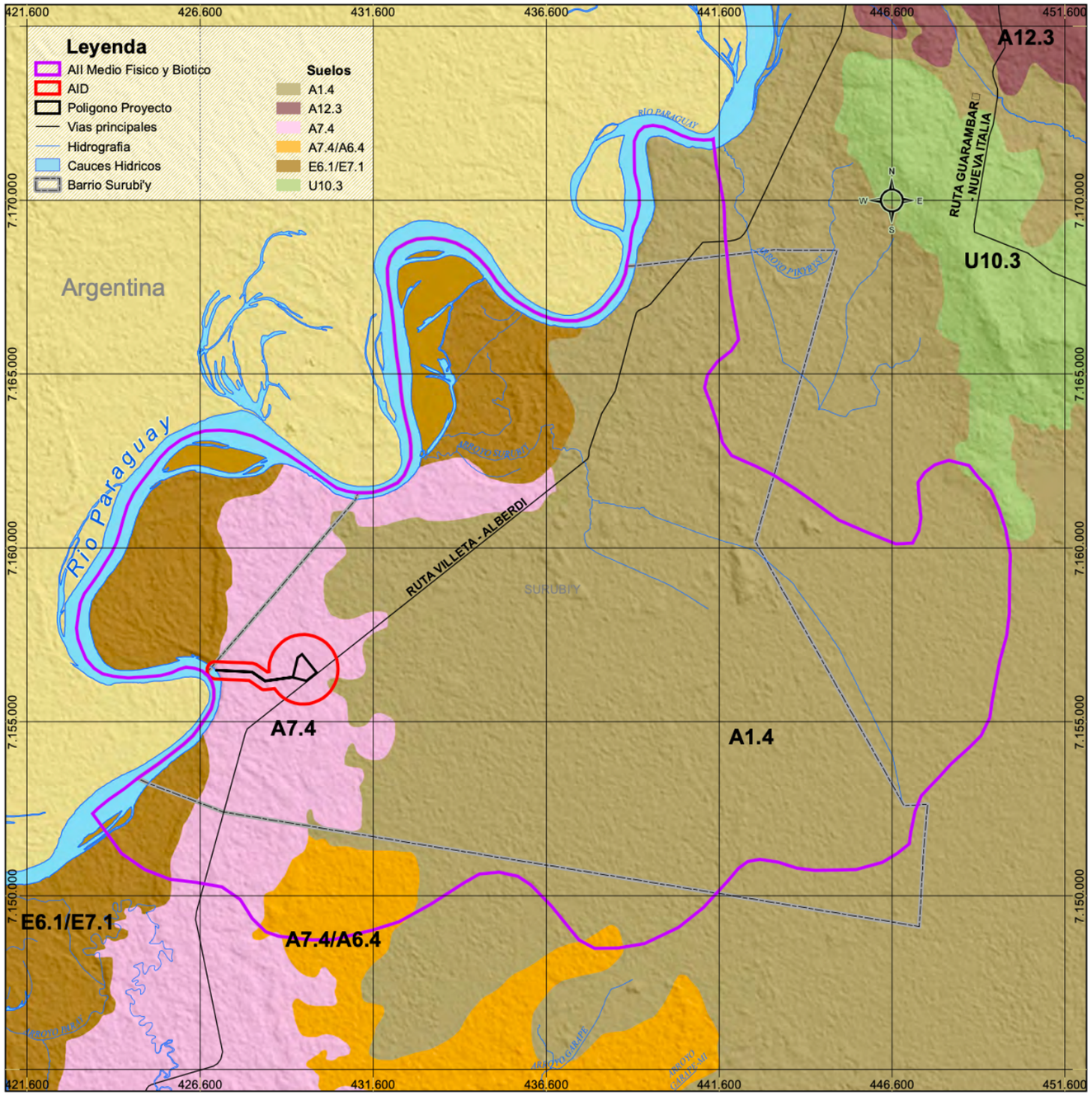
Consortia are areas of soils that are dominated by a single taxon and similar soils, where at least half correspond to the same taxonomic unit, the remainder being so similar that they do not affect the categorical level of the taxon; up to 15% limiting or 25% non-limiting inclusions are allowed. Associations containing two or more dissimilar taxa occurring in a known or regular

pattern, where none of these taxa cover more than 50% of the area, but which can be separated at more detailed scales, are also allowed up to 15% limiting or 25% non-limiting inclusions.

Three consortia and three soil associations were mapped in the IIA. The description of the main soil types of the IIA, based on the above-mentioned study (LOPEZ-GOROSTIAGA *et al*., 1995), is shown below.

Map 5.2.6.a - Soils Map

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	5.2.6.a - MAPA DE SUELOS





Carátula Juridica Legal

Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
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Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	25/10/2023

Fuente Cartográfica

Proponiente, DGEEC 2012
Fonte: https://esdac.jrc.ec.europa.eu/images/Eudasm/latinamerica/images/maps/download/py13000_2so1.jpg 2023

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:125.000

Table 5.2.6.a
Soil units occurring in the IIA and categories of symbology elements

Units	Symbols	Order	Large Group	Sub Group	Textural subdivision	Landscape	Origin	Relief (%)	Drainage	Pedreg. and/or rockiness
Consortium	A1.4 Lls/A6n	Alfisol	Albaqualf	Typic	Fine clayey	Plain	Thirsty. Aluv.	0-3	Flooded	Null
Consortium	A7.4 Lls/A5n	Alfisol	Paleudalf	Aquic	Fine clayey	Plain	Thirsty. Aluv.	0-3	Very poor	Null
Association	A7.4 Lls/A5n	Alfisol	Paleudalf	Aquic	Fine clayey	Plain	Thirsty. Aluv.	0-3	Very poor	Null
	A6.4 Lls/A5n	Alfisol	Paleudalf	Albaquic	Fine clayey	Plain	Thirsty. Aluv.	0-3	Very poor	Null
Association	A3.4 Lls/A4n	Alfisol	Natrudalf	Typic	Fine clayey	Plain	Thirsty. Aluv.	0-3	Poor	Null
	A1.4 Lls/A4n	Alfisol	Albaqualf	Typic	Fine clayey	Plain	Thirsty. Aluv.	0-3	Poor	nil
Association	E6.1 Lls/A5n	Entisol	Udifluvent	Aquic	Sandy	Plain	Thirsty. Aluv.	0-3	Very poor	nil
	E7.1 Lls/A5n	Entisol	Udifluvent	Typic	Sandy	Plain	Thirsty. Aluv.	0-3	Very poor	Null
Consortium	U10.3 La/B2n	Ultisols	Paleudult	Rhodic	Francosa fine	Lomada	Aren.	3-8	Good	Null

Source: LOPEZ-GOROSTIAGA *et al.*, 1995.

Alfisol

Alfisols do not have an expressive organic matter accumulation horizon on the surface, do not have wide and deep cracks, do not have a humic epipedon and are not clayey on the surface. They are mineral soils that do not have an oxic subsurface horizon either.

In this Order are incorporated all soils which have a nitric horizon or which have an argillic or kandic horizon with a base saturation of 50% or more, calculated by the sum of cations and determined with neutral ammonium acetate. Also belonging to this Order are soils which have a fragipan with a clay sheet lining 1 mm or more thick in some part.

The mapped units include the Suborder Aqualf and Udult. The Aqualf correspond to Alfisols that have an acidic moisture regime, marked by water saturation at some period of the year, or if they were subjected to artificial drainage practices, they maintain the characteristics associated with seasonal waterlogging. In general, they are found on hills, but mainly on wide alluvial plains and in depressions with slow surface drainage.

They have a restricted permeability, because they have developed and remain under the seasonal influence of a high water table; because they contain a clay layer below the soil surface, they have a very low hydraulic conductivity, which restricts the gravitational movement of water and consequently prolongs the saturation period. Udult soils are soils of the Alfisol order from humid or sub-humid regions that have a humid uodic regime.

The following Alfisol subgroups were identified in the study area:

Typic Albaqualf

The soils have an ochric horizon, 20 cm thick, brown to dark brown when wet and light brownish-grey when dry. This epipedon has a sandy loam texture, with 13 % clay; structure in subangular blocks, very small and weakly developed; slightly plastic and also sticky. The argillic horizon, which appears immediately below has a clay content of 58%, is therefore clayey in texture, dark reddish-grey in the upper part and dark brown or dark greyish-brown in the lower layers. The argillic structure is strongly developed, in small subangular blocks in the upper part and in angular blocks, also small from 30 cm to 150 cm depth. It has a very hard consistency when dry and very plastic and very sticky when wet.

The argillic horizon has a base saturation of over 50% throughout its depth, the cation exchange capacity of the soil is 20 cmol/Kg and that of the clay is over l6cmol/Kg. The dominant cations of the exchange bases are calcium, magnesium and sodium, although in the deeper layers the sodium content exceeds that of magnesium.

As an association unit, it is found in large areas of floodable alluvial plains, from the east of the Esteros del Ypoá region to the surroundings of the Paraguay River (A1.4), including in the IIA along the Villeta-Alberdi Route, from where part of it is used for rice cultivation (**Photo 01**). In association with Typic Natrudalf (A3.4), it grows from the Arroyo Surubi'y to the north of the IIA, reaching as far as Villeta, in poorly drained plains.

Typic Natrudalf

Natrudalf soils are Alfisols that have an udic moisture regime and have a natric horizon, with the presence of sodium (Na), corresponding to an argillic horizon with special properties such as columnar and less commonly prismatic and blocky structure.

The ochric horizon has a brown to dark brown colour, if humid, and yellowish brown when dry. The texture is sandy loam up to 27 cm and the structure is in subangular blocks, very small and moderately developed. The organic matter content is less than 1.5%, acid pH, although the base saturation is greater than 50%. The argillic horizon begins at a depth of 27 cm, with an abrupt transition to the ochric horizon. The textural class is clayey and the structuring is strong, in angular blocks in the nitric horizon, which extends from 57 cm depth (**Photo 02**). As already highlighted in the IIA it is associated with Typic Albaqualf (A3.4/A1.4).



Photo 01: Typic Albaqualf in floodplains, near the workshop of the rice mill Eladia S.A.



Photo 02: Exposure adjacent to Arroyo Surubi'y of Typic Natrudalf with abrupt texture change and grey clayey horizon with columnar structure.

Aquic and Albaquic Paleudalf

Paleudalf are deep soils which do not have a lithic or paralytic contact within 150 cm of the mineral soil surface, and which, within this vertical distance, the clay percentage does not decrease by 20% (relative) or more of that layer which has the maximum content. The humidity regime is acidic and the temperature corresponds to hyperthermic. There is no natric horizon or fragipan and the cation exchange capacity of the clay is higher than 16 mE/100 g in most of the argillic horizon.

The Aquic Paleudalf does not exhibit the textural change between ochric and argillic of a 15% clay difference or more within a vertical distance of 2.5 cm, but has the presence of low intensity mottling of colour, within the top 75 cm of the soil. It also shows acidic conditions in some sub-horizon within 75 cm of the upper soil boundary. In the IIA they are distributed near the Paraguay River, between the Udifluvents and the Albaqualf, including in the AID and around the Arroyo Zanja Mercedes and have a fine clayey texture (A7.4) and very poor drainage (**Photos 03 to 06**).

The Aquic Paleudalf (A7.4) in association with the Albaquic Paleudalf (A6.4) occur in a restricted area south of the IIA, extending to Paray Creek. The soils in this Subgroup (A6.4) have the characteristics defined for the Paleudalfs, but are distinguished in that, in one or more horizons within 75 cm of the mineral soil surface, they are mottled with colour intensity of 2 or less and are saturated with water at some time (acidic conditions), they also have an increase of 15% or more clay (absolute) within a vertical distance of 2.5 cm at the upper limit of the argillic.



Photo 03: Aquic Paleudalf on the banks of the Paraguay River, near Puerto Londrina.



Photo 04: Aquic Paleudalf on the edge of the Paraguay River in the area of Estancia Lola.



Photo 05: Aquic Paleudalf on the edge of the Arroyo Zanja Mercedes with linear erosions parallel to the Ruta Villeta-Alberdi, as a result of poor road drainage.



Photo 06: Aquic Paleudalf in the ADA, where a fine clayey texture and signs of very poor drainage can be seen on the surface.

Entisol

Includes poorly evolved soils, made up of mineral or organic material less than 20 cm thick, without any type of diagnostic B horizon. This Order includes soils considered "recent", because the time in which the formative factors have acted has been short and the soils do not have natural genetic horizons or only present a beginning of horizons, of weak expression. Entisols can consist of very recent alluvial sediments or have bedrock at shallow depths; they can have different colours, such as grey, brownish yellow and red. Some Entisols are deep, sandy and sandy loam, which have only an ochric horizon and may have an albic, outwash horizon immediately below.

Subgroups Typic Udifluvent (E7.1) and Aquic Udifluvent (E6.1) are recognised in the IIA. The former have an Udic moisture regime and are found in the plains and river valleys, but no longer in the physiographic environments of hills or at higher altitudes. The latter are Udifluvent soils with the distinguishable character of acidic conditions, which means the presence of mottling within 50 cm of the surface and having a colour intensity (chroma) of 2 or less, and also having one or more layers that are saturated with water at some period of the year.

As an association unit, both (E6.1 and E7.1) occur together in floodplain landscapes and flat topography. Drainage is very slow and many areas are subject to prolonged periods of flooding or waterlogging. Generally, gallery forest formation is observed when drainage is freer and soil permeability is higher, or when the water table is located deeper; but when drainage is poor and the water table is high, the conditions of prolonged water saturation make grasses the predominant vegetation, which suggests a greater participation of Aquic Udifluvent in this association. In the IIA, they are particularly prominent along the Paraguay river (**Photo 05** in **Section 5.2.3.1** and **Photo 07** below).



Photo 07: Aquic Udifluvent on the banks of the Paraguay River, near the town of Puerto Alegre, on Sub-recent Alluvial Deposits.

Ultisoles

They comprise soils consisting of mineral material, which have as differential characteristics low or high activity clay, conjugated with low base saturation and high aluminium concentration. The B textural horizon (Bt) is found immediately below any type of surface horizon, except for the hytistic horizon.

Most soils in this class show a clear increase in clay content from the surface horizon to the B horizon, with or without a decrease in the underlying horizons. The transition between the A and B horizons is usually clear, abrupt or gradual.

These are soils of variable depth, from strongly to imperfectly drained, reddish or yellowish in colour, and more rarely light greyish. The texture varies from sandy to clayey in the A horizon, and from medium to very clayey in the Bt horizon, always with an increase in clay from the A horizon to the Bt horizon. They are strongly to moderately acidic, with high to low base saturation, predominantly kaolinitic and with a Ki molecular ratio generally varying from 1.0 to 3.3.

The mapped unit corresponds to Suborder Udult, i.e. soils of the order Ultisol from humid or sub-humid regions that have a humid Udic regime. The Great Group is Paleudult, which represents the category of Udult soils of ancient development.

The Subgroup is the Rhodic Paleudult (U10.3), which has below the ochric epipedon an argillic horizon, shows an increased illuvial clay content with cation exchange capacity of more than 16mE/100g, but whose base saturation is less than 50% in the lower layers of the argillic.

These soils occur in a very restricted area to the northeast of the IIA, near Laguna Verá, south of Nueva Italia, in a hilly landscape with a relief of 0-3%. They are characterised by good drainage and no stoniness. They are soils with a thin loamy texture, originating from sandstones of the Caacupé Group.

5.2.7
Mineral Resources

The investigation of the mining resources of the IIA was carried out by consulting the Quarry Cadastre Map (MOPC, 2023a) and the Mining Cadastre Map (MOPC, 2023b), updated in March 2023 and made available by the Ministry of Public Works and Communications of Paraguay. This consultation allowed the location of the quarries, as well as the identification of the phase and location of the polygons of the mining processes.

Figure 5.2.7.a shows the active and inactive quarries in Departamento Central and also the location of the mining process with intersection with the IIA. This process is in the application phase by the company Elken Paraguay S.A. and overlaps with the only quarry located in the IIA.

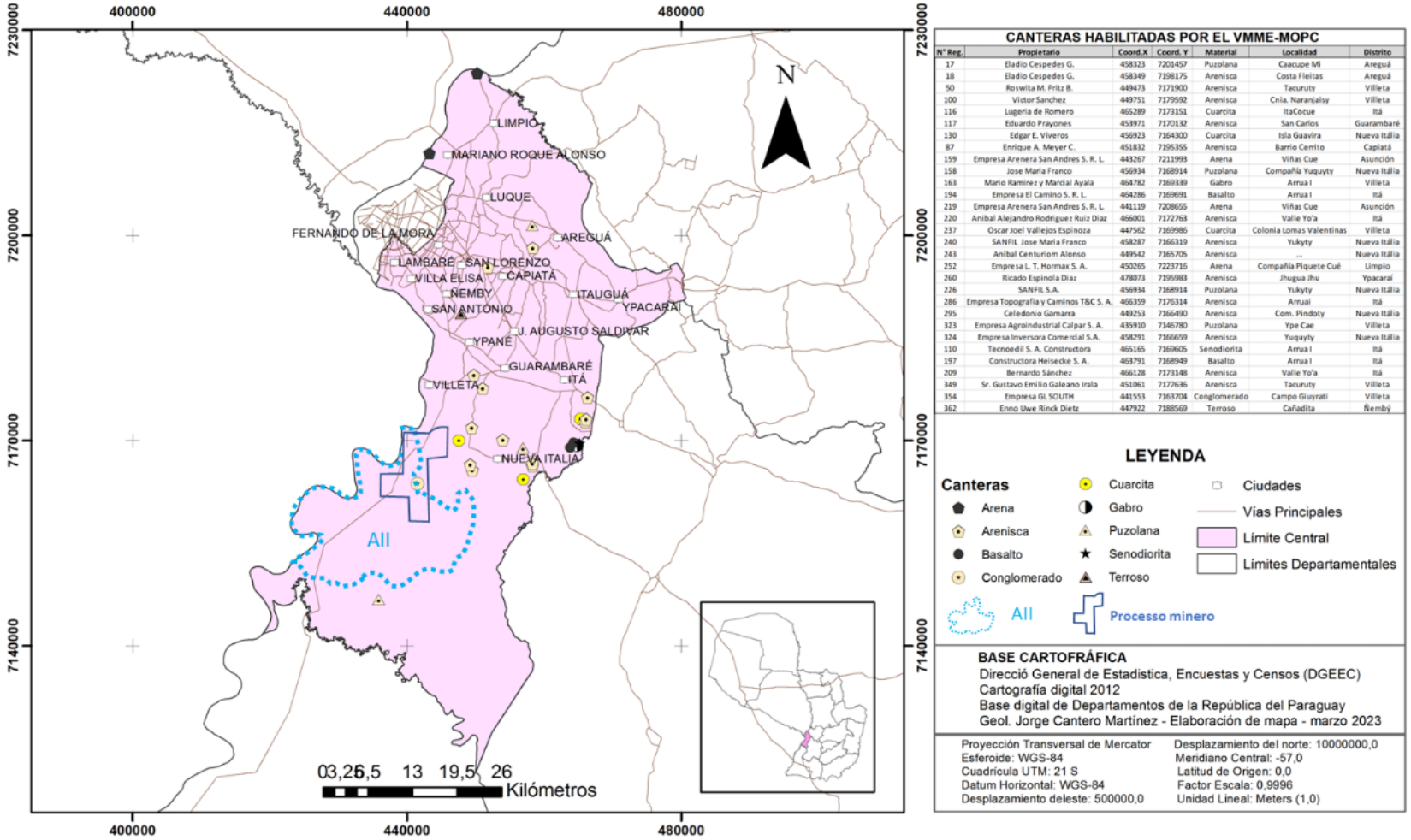
The quarry, located on the north-eastern border of the IIA, in the locality called Campo Guyrati in Villeta, is owned by the company GL SOUTH. It involves the extraction of conglomerate, also known as "ripio", used in road construction and backfill processes. Its location is associated with rocks of the Caacupé Group containing sandstones, as well as conglomerates. From the

observation of **Figure 5.2.7.a**, it can be seen that both the mining process and the existing quarry in the IIA do not affect the AID/ADA.

During the field visit and tour along the Paraguay River it was also possible to see a dredger that extracts sand from the Paraguay River bed for filling and which uses electric traction (**Photos 01 and 02**). Filling consists of the process of sucking the sand from the river bed and pumping it to the filling site with the hydromix. From the point of extraction to the point of utilisation, the suctioned sludge is transported by pipeline for up to 7 km. The material is dumped on land and the water from the hydromix returns by gravity to the river.

	
Photo 01: Dredge extracting sand from the Paraguay River used for refulfilling, near the mouth of the Arroyo Surubi'y and the Astillero Chaco Paraguayo Sur.	**Photo 02:** Sludge ejection pipeline connecting to the dredge, with floats, in area re-filled by dredge (previous photo).

Figure 5.2.7.a
Active and inactive quarries in the Central Department and mining process in the IIA



CANTERAS HABILITADAS POR EL VMME-MOPC

N° Reg.	Propietario	Coord.X	Coord. Y	Material	Localidad	Distrito
17	Eladio Cespedes G.	458323	7201457	Puzolana	Caacupe Mi	Areguá
18	Eladio Cespedes G.	458349	7198175	Arenisca	Costa Fleitas	Areguá
50	Roswita M. Fritz B.	449473	7171900	Arenisca	Tacuruty	Villeta
100	Victor Sanchez	449751	7179592	Arenisca	Cnia. Naranjalsy	Villeta
116	Lugeria de Romero	465289	7173151	Cuarcita	ItaCocue	Itá
117	Eduardo Prayones	453971	7170132	Arenisca	San Carlos	Guarambaré
130	Edgar E. Viveros	456923	7164300	Cuarcita	Isla Guavira	Nueva Itália
87	Enrique A. Meyer C.	451832	7195355	Arenisca	Barrio Cerrito	Capiatá
159	Empresa Arenera San Andres S. R. L.	443267	7211993	Arena	Viñas Cue	Asunción
158	Jose Maria Franco	456934	7168914	Puzolana	Compañía Yuquyty	Nueva Itália
163	Mario Ramírez y Marcial Ayala	464782	7169339	Gabro	Arrua I	Villeta
194	Empresa El Camino S. R. L.	464286	7169691	Basalto	Arrua I	Itá
219	Empresa Arenera San Andres S. R. L.	441119	7208655	Arena	Viñas Cue	Asunción
220	Anibal Alejandro Rodriguez Ruiz Diaz	466001	7172763	Arenisca	Valle Yo'a	Itá
237	Oscar Joel Vallejos Espinoza	447562	7169986	Cuarcita	Colonia Lomas Valentinas	Villeta
240	SANFIL Jose Maria Franco	458287	7166319	Arenisca	Yukyty	Nueva Itália
243	Anibal Centuriom Alonso	449542	7165705	Arenisca	...	Nueva Itália
252	Empresa L. T. Hormax S. A.	450265	7223716	Arena	Compañía Piquete Cué	Limpio
260	Ricado Espinola Diaz	478073	7195983	Arenisca	Jhugua Jhu	Ypacaraí
226	SANFIL S.A.	456934	7168914	Puzolana	Yukyty	Nueva Itália
286	Empresa Topografia y Caminos T&C S. A.	466359	7176314	Arenisca	Arruai	Itá
295	Celedonio Gamarra	449253	7166490	Arenisca	Com. Pindoty	Nueva Itália
323	Empresa Agroindustrial Calpar S. A.	435910	7146780	Puzolana	Ype Cae	Villeta
324	Empresa Inversora Comercial S.A.	458291	7166659	Arenisca	Yuquyty	Nueva Itália
110	Tecnoedil S. A. Constructora	465165	7169605	Senodiorita	Arrua I	Itá
197	Constructora Heisecke S. A.	463791	7168949	Basalto	Arrua I	Itá
209	Bernardo Sánchez	466128	7173148	Arenisca	Valle Yo'a	Itá
349	Sr. Gustavo Emilio Galeano Irala	451061	7177636	Arenisca	Tacuruty	Villeta
354	Empresa GL SOUTH	441553	7163704	Conglomerado	Campo Giuyrati	Villeta
362	Enno Uwe Rinck Dietz	447922	7188569	Terroso	Cañadita	Ñemby

LEYENDA

Canteras
- Arena
- Arenisca
- Basalto
- Conglomerado
- Cuarcita
- Gabro
- Puzolana
- Senodiorita
- Terroso

- Ciudades
- Vías Principales
- Límite Central
- Límites Departamentales
- AII
- Processo minero

BASE CARTOFRÁFICA
Direcció General de Estadistica, Encuestas y Censos (DGEEC)
Cartografía digital 2012
Base digital de Departamentos de la República del Paraguay
Geol. Jorge Cantero Martínez - Elaboración de mapa - marzo 2023

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Cuadrícula UTM: 21 S
Datum Horizontal: WGS-84
Desplazamiento deleste: 500000,0
Desplazamiento del norte: 10000000,0
Meridiano Central: -57,0
Latitud de Origen: 0,0
Factor Escala: 0,9996
Unidad Lineal: Meters (1,0)

Source: Modified from MOPC, 2023a; 2023b.

5.2.8
Air Quality

Air quality in a region is the result of several components, many of which are difficult to predict and control, such as the emission sources at the site and the climatic conditions, particularly wind and rainfall patterns.

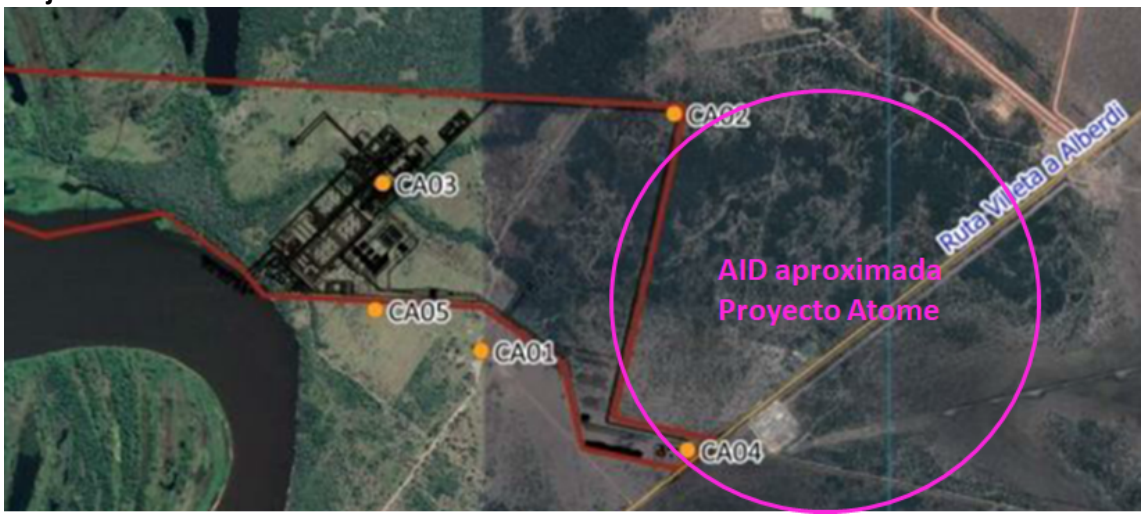
Emission sources with the potential to influence air quality indices range from industrial areas, roads, urban centres, fires and even windblown particles in areas without vegetation cover.

The main Paraguayan regulations dealing with the control of atmospheric emissions are contained in Law No. 5.211/14 on Air Quality, Decree No. 1269/2019 and Resolution SEAM No. 259/15. In particular, the latter regulation establishes the permissible parameters of pollutants. It is worth noting that in March 2021 the first reference air quality monitoring station was installed in Paraguay, located in the Guasu Metropolitano Park, in Asunción, according to information from MADES (2021).

5.2.8.1
Air Quality in the IIA

Considering that in the regional context of the Project there are no air quality monitoring stations operated by environmental agencies that present an adequate historical series of data, data collected by another project located in the IIA and near the AID/ADA of the ATOME Plant, more specifically the site of the future Omega Green Biodiesel Plant, has been compiled. As part of this survey, air quality measurements were taken at 5 points, as shown in **Figure 5.2.8.1.a**. **Table 5.2.8.1.a** shows the locations and descriptions of these points.

Figure 5.2.8.1.a
Omega Green Project air quality monitoring points and their location relative to the ATOME Project AID



Source: Modified from OMEGA GREEN, 2022.

Table 5.2.8.a
Coordinates of the air quality monitoring points of the Omega Green Project

Point	UTM coordinates (21H S)		Description
	East (m)	North (m)	
CA01	428,146.13	7,156,373.25	The southern edge of the plot as a representative of the air quality of the house to the south. One of the two monitoring sites.
CA02	428,994.00	7,157,320.00	The northern edge of the plot as representative of the air quality of the northern environment.
CA03	427,624.78	7,156,991.04	Located in the centre of the plot
CA04	429,056.00	7,155,746.00	Entrance of the plot as representative of the surroundings of the Villeta-Alberdi Route.
CA05	427,640.99	7,156,431.82	The southern edge of the plot as a proxy for the air quality of the house to the south. One of the two monitoring locations

Source: Omega Green, 2022.

The parameters PM_{10} and $PM_{2,5}$, constituted by particles smaller or equal to 10 and 2.5 microns, respectively; carbon monoxide (CO), nitrogen oxide (NO_2), ozone (O_3) and sulphur oxide (SO_2) were evaluated. The measurements were carried out in three campaigns, for 24 h, performed between August and September 2022, as shown in **Table 5.2.8.b** below.

This table also shows the data obtained, as well as the comparison with the short-term standards established by SEAM Resolution N° 259/15. Values in bold indicate values above the short-term standards.

From **Table 5.2.8.b**, it can be seen that the pollutants of greatest concern relate to particulate matter. The measurements indicated that the national standards were exceeded on five occasions, three at point CA01 and two at point CA05. At point CA01, non-compliances occurred for PM_{10} on 06/09/2022 and for $PM_{2,5}$ on 23/08/2022 and 06/09/2022. At point CA01, all non-conformities occurred on 06/09/2022 for both PM_{10} and $PM_{2,5}$.

Thus, it is considered that on the latter date there may have been unfavourable conditions for the dispersion of the pollutant, mainly at these two points located in closer proximity to the unpaved access roads. At point CA04, despite being located next to the Villeta-Alberdi road, no non-compliance was observed with respect to the short-term pattern, although its values were higher than those of points CA02 and CA03, located at points further away from the roads and with greater vegetation cover.

Table 5.2.8.b
Air Quality Results - Omega Green Project

Pollutants (units)	24 h average*.	Camp.	Date CA01	CA01	Date CA02	CA02	Date CA03	CA03	Date CA04	CA04	Date CA05	CA05
PM_{10} (µg/m³)	150.0	1	23/08/2022	73.84	27/08/2022	29.24	25/08/2022	37.26	26/08/2022	79.02	24/08/2022	59.19
PM_{10} (µg/m³)	150.0	2	06/09/2022	**919.64**	10/09/2022	50.37	08/09/2022	48.21	09/09/2022	95.68	07/09/2022	**831.36**
PM_{10} (µg/m³)	150.0	3	20/09/2022	4.35	24/09/2022	19.70	22/09/2022	12.24	23/09/2022	22.77	21/09/2022	8.19
$PM_{2,5}$ (µg/m³)	30.0	1	23/08/2022	**35.72**	27/08/2022	9.40	25/08/2022	13.71	26/08/2022	27.84	24/08/2022	15.97
$PM_{2,5}$ (µg/m³)	30.0	2	06/09/2022	**158.00**	10/09/2022	10.44	08/09/2022	11.95	09/09/2022	28.93	07/09/2022	**101.99**
$PM_{2,5}$ (µg/m³)	30.0	3	20/09/2022	1,52	24/09/2022	7,26	22/09/2022	2,79	23/09/2022	12,61	21/09/2022	2,05
CO (µg/m³)	10,000.0	1	23/08/2022	620	27/08/2022	220	25/08/2022	680	26/08/2022	520	24/08/2022	510
CO (µg/m³)	10,000.0	2	06/09/2022	200	10/09/2022	70	08/09/2022	460	09/09/2022	340	07/09/2022	250
CO (µg/m³)	10,000.0	3	20/09/2022	160	24/09/2022	100	22/09/2022	340	23/09/2022	490	21/09/2022	130
NO_2 (µg/m³)	200.0	1	23/08/2022	3.85	27/08/2022	3.42	25/08/2022	3.16	26/08/2022	3.99	24/08/2022	3.92
NO_2 (µg/m³)	200.0	2	06/09/2022	4.08	10/09/2022	2.42	08/09/2022	2.82	09/09/2022	3.,46	07/09/2022	3.66
NO_2 (µg/m³)	200.0	3	20/09/2022	0.84	24/09/2022	2.67	22/09/2022	2.10	23/09/2022	2.80	21/09/2022	1.72
O_3 (µg/m³)	120.0	1	23/08/2022	2.53	27/08/2022	2.06	25/08/2022	2.61	26/08/2022	2.67	24/08/2022	1.85
O_3 (µg/m³)	120.,0	2	06/09/2022	2.74	10/09/2022	1.71	08/09/2022	2.30	09/09/2022	2.39	07/09/2022	2.67
O_3 (µg/m³)	120.0	3	20/09/2022	0.64	24/09/2022	2.25	22/09/2022	1.08	23/09/2022	2.03	21/09/2022	1.48
SO_2 (µg/m³)	20.0	1	23/08/2022	0	27/08/2022	0	25/08/2022	0	26/08/2022	0.23	24/08/2022	0
SO_2 (µg/m³)	20.0	2	06/09/2022	0	10/09/2022	0	08/09/2022	0	09/09/2022	0	07/09/2022	0
SO_2 (µg/m³)	20.0	3	20/09/2022	0	24/09/2022	0	22/09/2022	0	23/09/2022	0	21/09/2022	0

* except for CO and O_3 , for which the averages adopted by the Resolution correspond to the 8 h period, and for NO_2 , for which the 1 h period is considered.
Source: OMEGA GREEN, 2022.

5.2.8.2
Air Quality in the DAI

This Section presents the background levels, baseline and/or background values, which are representative values of air quality in the AID prior to project implementation.

For this purpose, specific measurements have been carried out for the Project, with installation of the measuring equipment at a point within the Plant site (see **Figure 5.2.8.2.2.a**). The parameters monitored were:

1) Particulate matter (PM);
   - Total Particulate Matter (TMP)
   - Inhalable particles (PM)$_{10}$
   - Inhalable particles (PM)$_{2.5}$
2) Sulphur dioxide (SO);$_2$
3) Carbon monoxide (CO);
4) Carbon dioxide (CO);$_2$
5) Ozone (O);$_3$
6) Nitrogen dioxide (NO).$_2$

Figure 5.2.8.2.a
Installation site of the air quality monitoring station



The Air Quality Monitoring Station is of the "KUNAK AIR PRO" type, a methodology that is being widely used in Europe and also applied in Latin America and has the following characteristics:

– Autonomous monitoring station for pollutants and meteorological parameters integrated in the same equipment;
– Electrochemical sensors to measure gaseous compounds: NO_2 ; O_3 ; SO_2 and CO;

- Integrated non-dispersive infrared (NDIR) sensor to measure the gaseous parameter CO_2 ;
- Optical particle counter to measure particulate matter ($PM_{2.5}$, PM_{10} and PTS);
- Integrated weather sensors: ambient temperature, relative humidity, atmospheric pressure, as well as wind speed and direction;
- Cloud-based data storage and management;
- Power supply by solar panel;
- Communication via 3G/4G, via conventional data chip;
- Management platform for advanced statistical analysis and calculation of the Air Quality Index.

Photo 01 shows a view of the Monitoring Station installed in the field and **Photo 02** shows details of the measuring equipment.



Photo 01: View of the KUNAK equipment installed in the field.



Photo 02: View of gas cartridges and front view - OPC.

Table 5.2.8.2.a below presents the technical measurement specifications of the KUNAK monitoring station.

Table 5.2.8.2.a
Measuring technical specifications of KUNAK equipment

Parameter	Measurement units	Measuring principle	Measuring range	Resolution	Detection limit
CO	µg/m³ - ppb	Electrochemical	0 - 12,000 ppb (A) 0 - 500 ppm (B)	1 ppb (A) 0,01 ppm (B)	10 ppb (A) 0,02 ppm (B)
CO_2	µg/m³ - ppm	Non-dispersive infrared	0 - 5,000 ppm	1 ppm	<20 ppm
NO_2	µg/m³ - ppb	Electrochemical	0 - 5,000 ppb	1 ppb	2 ppb
O_3	µg/m³ - ppb	Electrochemical	0 - 2,000 ppb	1 ppb	3 ppb
SO_2	µg/m³ - ppb	Electrochemical	0 - 10,000 ppb	1 ppb	3 ppb
PTS	µg/m³		0 - 15.000 µg/m³	1 µg/m³	1 µg/m³
$PM_{2.5}$	µg/m³	Optical particle counter	0 - 2.000 µg/m³	1 µg/m³	0.5 µg/m³
PM_{10}	µg/m³	Optical particle counter	0 - 10.000 µg/m³	1 µg/m³	0.5 µg/m³

Measurements were carried out in the period from 12 May to 02 June 2023, totalling between 18 and 22 measurement days for the different parameters.

The values obtained were compared with the air quality standards established by Resolution SEAM Nº 259/2015, in addition to the Global Air Quality Guidelines (GCA) of the "WHO - World Health Organization", in its latest update of 2021.

In addition to the parameters listed in **Table 5.2.8.2.2.a**, the following parameters were also measured: Air Quality Index (AQI); Dew Point (ºC); Humidity (%); Atmospheric Pressure (hPa); Outdoor Temperature (ºC); Average Wind Speed (m/s); Maximum Wind Speed (m/s); and Wind Direction (Deg).

Results

The full results of the air quality monitoring campaign, background values, carried out in the area of the future ATOME Plant are presented in the report in **Annex 4.**

The values obtained for the monitored parameters were compared with the air quality standards established by Resolution Nº 259/2015 of the Secretariat of the Environment of Paraguay (SEAM), the Municipal Ordinance N° 18/18 of Villeta and the WHO 2021 - Global Air Quality Guidelines, which serve as a reference for the IFC.

and the IFC's General EHS Guidelines shown in **Table 5.2.8.2.b**.

Table 5.2.8.2.a
National and international air quality standards

		Resolution SEAM N° 259/2015	Municipal Ordinance No. 18/18	WHO 2021
$PM_{2,5}$ (µg/m)³	Annual average	15	15	5
	Average 24 h	30	30	15
PM_{10} (µg/m)³	Annual average	-	-	15
	Average 24 h	150	150	45
O_3 (µg/m)³	Average 8 h	120	120	100
NO_2 (µg/m)³	Annual average	40	40	10
	Average 1 h	200	200	-
	Average 24 h	-	-	25
SO_2 (µg/m)³	Average 24 h	20	20	40
	Average 10 min	-	-	-
CO (µg/m)³	Average 8 h	10	10	
	Average 24 h	-	-	4,000

As verified in the **Annex 4** Report and **Tables 5.2.8.2.c**, **5.2.8.2.d** and **5.2.8.2.e**, the ambient levels of monitored and legislated air pollutants were always below national and international air quality standards. Measurements of CO_2 were made, but there are no air quality standards for this parameter.

Table 5.2.8.2.c
Particulate Matter

Days	Date	$PM_{2.5}$, 24-hour average (µg/m³)					PM_{10} , 24-hour average (µg/m³)					PTS, 24-hour mean (µg/m³)
		Media	Res. SEAM 259/2015	Order. 18/18	WHO 2021	IFC General Guidelines	Media	Res. SEAM 259/2015	Order. 18/18	WHO 2021	IFC General Guidelines	Media
1	12/05/23	3.0	30	30	15	25	5.0	150	150	45	50	5.70
2	13/05/23	3.0	30	30	15	25	6.0	150	150	45	50	7.75
3	14/05/23	**10.0***	30	30	15	25	13.0	150	150	45	50	15.74
4	15/05/23	4.0	30	30	15	25	7.0	150	150	45	50	9.24
5	16/05/23	4.0	30	30	15	25	8.0	150	150	45	50	11.20
6	17/05/23	7.0	30	30	15	25	**15.0***	150	150	45	50	20.66
7	18/05/23	7.0	30	30	15	25	**15.0***	150	150	45	50	21.49
8	19/05/23	7.0	30	30	15	25	**15.0***	150	150	45	50	**22.53***
9	20/05/23	9.0	30	30	15	25	**15.0***	150	150	45	50	19.98
10	21/05/23	7.0	30	30	15	25	9.0	150	150	45	50	11.83
11	22/05/23	3.0	30	30	15	25	4.0	150	150	45	50	5.47
12	23/05/23	4.0	30	30	15	25	6.0	150	150	45	50	8.63
13	24/05/23	5.0	30	30	15	25	10.0	150	150	45	50	14.57
14	25/05/23	5.0	30	30	15	25	11.0	150	150	45	50	16.79
15	26/05/23	8.0	30	30	15	25	14.0	150	150	45	50	19.72
16	27/05/23	4.0	30	30	15	25	8.0	150	150	45	50	11.46
17	28/05/23	2.0	30	30	15	25	3.0	150	150	45	50	4.57
18	29/05/23	2.0	30	30	15	25	4.0	150	150	45	50	5.04
19	30/05/23	3.0	30	30	15	25	4.0	150	150	45	50	5.44
20	31/05/23	6.0	30	30	15	25	9.0	150	150	45	50	13.80
21	1/06/23	3.0	30	30	15	25	6.0	150	150	45	50	8.37
22	2/06/23	3.0	30	30	15	25	6.0	150	150	45	50	7.55

Note: pink(*) is the highest average of the season.

Table 5.2.8.2.2.d
Gaseous Pollutants O_3 , NO_2 and SO_2

Days	Date	O_3 , 8-hour average (µg/m³)					NO_2 , 1 hour average (µg/m³)				NO_2 , 24-hour average (µg/m³)		SO_2 , 24-hour average (µg/m³)				
		Media	Res. SEAM 259/2015	Order. 18/18	WHO 2021	IFC General Guidelines	Media	Res. SEAM 259/2015	Order. 18/18	IFC General Guidelines	Media	WHO 2021	Media	Res. SEAM 259/2015	Order. 18/18	WHO 2021	IFC General Guidelines
1	12/05/23	13.74	120	120	100	100	0.00	200	200	200	-	25	0.00	20	20	40	20
2	13/05/23	13.74	120	120	100	100	0.00	200	200	200	-	25	0.00	20	20	40	20
3	14/05/23	19.63	120	120	100	100	0.00	200	200	200	-	25	**2.62***	20	20	40	20
4	15/05/23	13.74	120	120	100	100	0.00	200	200	200	-	25	0.00	20	20	40	20
5	16/05/23	19.63	120	120	100	100	0.00	200	200	200	0.55	25	0.00	20	20	40	20
6	17/05/23	27.48	120	120	100	100	1.88	200	200	200	0.90	25	0.00	20	20	40	20
7	18/05/23	31.41	120	120	100	100	1.88	200	200	200	1.04	25	0.00	20	20	40	20
8	19/05/23	33.37	120	120	100	100	0.00	200	200	200	0.53	25	0.00	20	20	40	20
9	20/05/23	11.78	120	120	100	100	0.00	200	200	200	0.15	25	0.00	20	20	40	20
10	21/05/23	33.37	120	120	100	100	0.00	200	200	200	0.24	25	0.00	20	20	40	20
11	22/05/23	27.48	120	120	100	100	0.00	200	200	200	0.66	25	0.00	20	20	40	20
12	23/05/23	25.52	120	120	100	100	0.00	200	200	200	0.75	25	0.00	20	20	40	20
13	24/05/23	**43.19***	120	120	100	100	1.88	200	200	200	1.05	25	0.00	20	20	40	20
14	25/05/23	35.33	120	120	100	100	**3.76***	200	200	200	**2.71***	25	0.00	20	20	40	20
15	26/05/23	35.33	120	120	100	100	0.00	200	200	200	2.11	25	0.00	20	20	40	20
16	27/05/23	11.78	120	120	100	100	0.00	200	200	200	0.40	25	0.00	20	20	40	20
17	28/05/23	21.59	120	120	100	100	0.00	200	200	200	0.06	25	0.00	20	20	40	20
18	29/05/23	17.67	120	120	100	100	0.00	200	200	200	0.08	25	0.00	20	20	40	20
19	30/05/23	9.82	120	120	100	100	0.00	200	200	200	0.17	25	0.00	20	20	40	20
20	31/05/23	13.74	120	120	100	100	1.88	200	200	200	0.79	25	0.00	20	20	40	20
21	1/06/23	15.70	120	120	100	100	1.88	200	200	200	1.34	25	0.00	20	20	40	20
22	2/06/23	23.56	120	120	100	100	1.88	200	200	200	1.62	25	0.00	20	20	40	20

Note: pink is the highest average of the season.

Table 5.2.8.2.e
Gaseous Pollutants CO and CO_2

Days	Date	CO, 8-hour average (mg/m³)				CO_2 , 24-hour average (ppm)
		Media	Res. SEAM 259/2015	WHO 2021	Order. 18/18	Media
1	12/05/23	0.2	10	10	10	-
2	13/05/23	0.2	10	10	10	474.5
3	14/05/23	0.2	10	10	10	494.9
4	15/05/23	0.2	10	10	10	493.7
5	16/05/23	0.2	10	10	10	-
6	17/05/23	0.3	10	10	10	477.2
7	18/05/23	0.3	10	10	10	474.1
8	19/05/23	0.3	10	10	10	479.7
9	20/05/23	0.3	10	10	10	480.3
10	21/05/23	0.2	10	10	10	473.7
11	22/05/23	0.3	10	10	10	466.7
12	23/05/23	0.3	10	10	10	474.8
13	24/05/23	0.3	10	10	10	463.8
14	25/05/23	0.3	10	10	10	469.6
15	26/05/23	**0.4***	10	10	10	464.1
16	27/05/23	0.3	10	10	10	475.7
17	28/05/23	0.2	10	10	10	474.6
18	29/05/23	0.2	10	10	10	468.7
19	30/05/23	0.2	10	10	10	468.9
20	31/05/23	0.3	10	10	10	500.7
21	1/06/23	0.3	10	10	10	496.8
22	2/06/23	0.3	10	10	10	505.0*

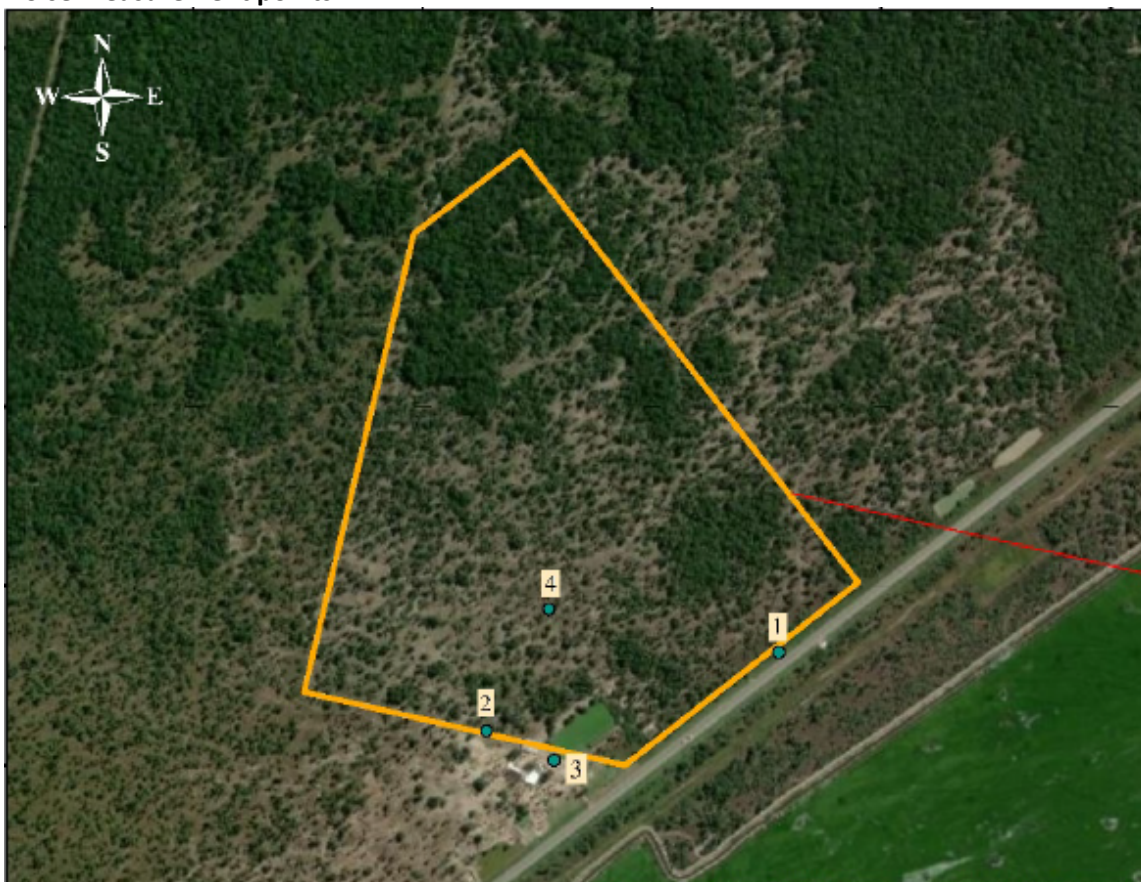
5.2.9
Noise

This Section presents the results obtained from the noise measurement campaign carried out in the surroundings and at the ATOME Plant between 30 September and 10 October 2023.

5.2.9.1
Methodology

The noise measurement campaign was carried out by the company Tecnoambiental S.R.L., considering four (4) points selected according to land use and noise sources. The location of these points is shown in **Figure 5.2.9.1.a**.

Figure 5.2.9.1.a
Noise measurement points



The selection of measurement points was based on the methodology proposed by Segués (2008), for the targeted selection of measurement points according to land use and noise sources, which consists of a prior analysis of the dynamics of the activity, land use and the establishment of a zoning of the study area. On the other hand, the main sources of noise, traffic routes, industries, sensitive areas, etc. were analysed.

Table 5.2.9.1.a lists the four (4) selected measurement points and their description.

Table 5.2.9.1.a
Description of Measurement Points

Item No.	UTM Coordinates 21J Longitude / Latitude	Description of Measurement Points
1 - Main access to the ATOME property	429,867 E / 7,156,319 S	This is the point of circulation of mobile emission sources, such as machinery and heavy lorries and other types of vehicles of different sizes linked to the construction and operation/maintenance stage of the project. It is also a strategic point for measuring noise levels, due to its proximity to the Villeta-Alberdi road.
2 - ATOME Property Boundary - Near the neighbour's barn	429,506 E / 7,156,319 S	Area close to the neighbours' homes on the adjoining property, who are the main critical receptors of the noise levels generated by the industry, due to the proximity of the installation of certain equipment and service areas, as well as continuous work during the construction and operation/maintenance stage, in general.
3 - Main access to the neighbour's house	429,589 E / 7,156,185 S	Registration point located at the main access to the neighbours' homes, the neighbours would be direct receptors of the noise levels that could be produced in the different stages of the industry, which could affect their health and alter their quality of life.
4 - Future area of fixed noise emitting sources	429,583 E 7,156,373 S	This corresponds to a sector of the industry where there are sources of emissions such as machinery and equipment in continuous operation (mainly compressors), which could generate high noise levels, which could affect occupational and residential levels.

Source: Tecnoambiental (2023).

The measurement was carried out with two Class 2 sound level meters that comply with the IEC 61672-1 and IEC PUB 651 standards, the PCE-322A and the Minipa MSL-1355B sound level meter, respectively. **Annex 5** presents the Sound Pressure Level Monitoring Results Report prepared by Tecnoambiental S.R.L., which includes the technical specifications of the sound level meters, as well as the calibration certificates.

Data collection was carried out for 20 hours continuously at the 4 measurement points. The sound level meters were programmed to measure with frequency weighting A, in a range of 30 to 130 dB. The sound level meters were placed on a tripod to place them at a distance of approximately 1.5 m above the ground, and they were placed no closer than 3 m from any reflective surface (wall, structures, obstacles).

For the purpose of sound pressure level measurements and limits, the Paraguayan regulations related to noise have been taken into account. It is important to mention that there is a recent law related to noise, Law N° 6390/2020, which regulates noise emission and repeals Law N° 1100/1997. The most recent one does not establish limits, leaving this definition to the municipality.

In the municipality of Villeta, Law 1.100/97 is regulated by Ordinance 25/2017, which amends and updates Ordinance 2/94, which regulates the system of advertising and noise nuisance in the district of Villeta, in accordance with the provisions of said Law.

Ordinance 25/2017 establishes the period from 06:00 to 12:00 hours and from 14:00 to 20:00 hours for the operation of industrial facilities located in residential areas and which produce annoying noise. It also establishes that industrial facilities must adopt the necessary devices to reduce the noise produced.

As the Municipality of Villeta has not established specific limits in its ordinances, in the absence of these, Law N° 1100/1997 was used as a reference.

Article 9 of Law N° 1100/1997 establishes that noise and sounds that exceed the average levels transcribed in **Table 5.2.9.1.b** are considered annoying.

Table 5.2.9.1.b
Noise levels established by Law 1100/1997

Scope	Night 20:00 a 07:00	Day 07:00 a 20:00	Day (Occasional peak) 07:00 a 12:00 14:00 a 19:00
	Measured in decibels "A" - DB (A) 20-40		
Residential areas, specific use areas, public spaces: recreational areas, parks, squares and public roads.	45	60	80
Mixed areas, transitional areas, town centre areas, specific programmes, service areas and public buildings	55	70	85
Industrial area	60	75	90

Source: Law N° 1100/1997 on Prevention of Noise Pollution.

The values obtained in the campaign were also compared with the limits set by the IFC EHS guidelines, presented in **Table 5.2.9.1.c**.

Table 5.2.9.1.c
Limits set by the IFC

Receiver	L_{Aeq} (dB)	
	Day 07:00 - 22:00	Night 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

Source: Environmental, Health, and Safety (EHS) Guidelines - Noise Management (IFC, 2007).

5.2.9.2
Results of Current Noise Level Measurements

As described in **Section 5.2.9.1**, noise measurements were carried out at four points, two of them at the plant boundary (P1 at the main access and P2 at the neighbour's property boundary), P3 at the main access of the neighbour's house and P4 at the future location of fixed industry noise sources (e.g. compressors).

The measured values were compared with the standards established in the regulations on the subject, and the zones were classified as industrial considering the agro-industrial characteristics of the area and the fact that the municipality does not have a land-use plan declaring the zoning. Only in point 3, measured next to the neighbouring house, the measured values were compared with the standards established for residential areas due to the presence of people living in the neighbouring property. It should be noted that the Paraguayan regulations and the IFC guidelines consider different periods as daytime and nighttime, so the results are expressed indicating the time range considered in each case.

Table 5.2.9.2.a shows the baseline results surveyed per period, compared to the limits set in the legislation. In order to characterise the daytime and night-time periods by a single representative value for each period at each surveyed point, the L_{Aeq} was considered for the whole measurement period within the time band considered for each case[1] .

P1 exceeded the IFC recommended level for the night-time period at industrial receivers. The noise levels recorded were caused by the different mobile sources, mainly large trucks travelling along the road at high speeds, with even more frequent traffic at night and in the early hours of the morning.

In P3 the daytime and nighttime limits established by both the IFC and Law 1100/97 for residential receptors were exceeded. P3 corresponds to the rural productive establishment's dwelling, where various activities are regularly carried out for the care and maintenance of the farm with equipment and tools that generate noise, the breeding of farm animals that emit their own sounds and is also influenced by the Villeta-Alberdi road that is located in front of the property.

Final considerations

Given the location of the proposed Plant site, on the edge of a road, it is understood that the area already has ambient noise in excess of the standards set for residential areas, which is the current situation at the neighbouring property, the nearest critical receptor and in the absence of the plant in operation.

According to IFC recommendations, for residential areas, noise impacts should not exceed 3 dB and/or result in levels above 55 dB during the day period and 45 dB during the night period.

Although there is only one critical receptor (1 residence) in the vicinity of the Project, Sound Pressure Level (SPL) modelling was carried out, developed by CSI, the methodology and results of which are presented in Chapter 6.0 and also in the report in **Annex 6.**

1 The values were calculated by CSI (see report in **Annex 6**), based on the results of noise measurements presented in **Annex 5** (Tecnoambiental, 2023).

Table 5.2.9.2.a

Characteristics of each measurement point, values measured in the daytime and night-time periods, and reference levels set by the standards.

Point	Location of the measurement point	RL_{Aeq} (Values measured in the campaign)				Law 1100/1997 Industrial area		Law 1100/1997 Residential areas		IFC / WHO Industrial Area	IFC / WHO Residential areas	
		Daytime Paraguay 7 am - 8 pm	Daytime IFC 7 am - 10 pm	Nocturno Paraguay 8 pm - 7 am	Nocturnal IFC 10 pm - 7 am	Daytime	Nocturno	Daytime	Nocturno		Daytime	Nocturno
P1	Main access to the property	66	65	62	62	75.0	60.0	-	-	70.0	-	-
P2	ATOME Property Boundary - Close to neighbour's barn	58	57	54	55	75.0	60.0	-	-	70.0	-	-
P3	Main access to the neighbours' house	65	65	66	67			60.0	45.0		55.0	45.0
P4	Future area of stationary noise emitting sources	56	55	53	53	75.0	60.0	-	-	70.0	-	-

5.3
Biotic Environment

5.3.1
Vegetation and Flora

The characterisation of the vegetation and flora to be affected by the project was carried out in the office, consisting of the survey and analysis of available information on the project region and its Indirect (AII) and Direct (AID) Areas of Influence, including satellite images and bibliographic information, such as scientific articles and publications by MADES, SEAM and INFONA.

In addition, a field survey was carried out in March 2023 by botanical specialists throughout the directly affected area of the project to characterise the natural vegetation and existing plant species on the site.

The information obtained will be used to create the **Land Cover and Land Use Map** (**Map 5.3.1.2.a**) of the AID and ADA, based on satellite images in a GIS environment.

5.3.1.1
Area of Indirect Influence (AII)

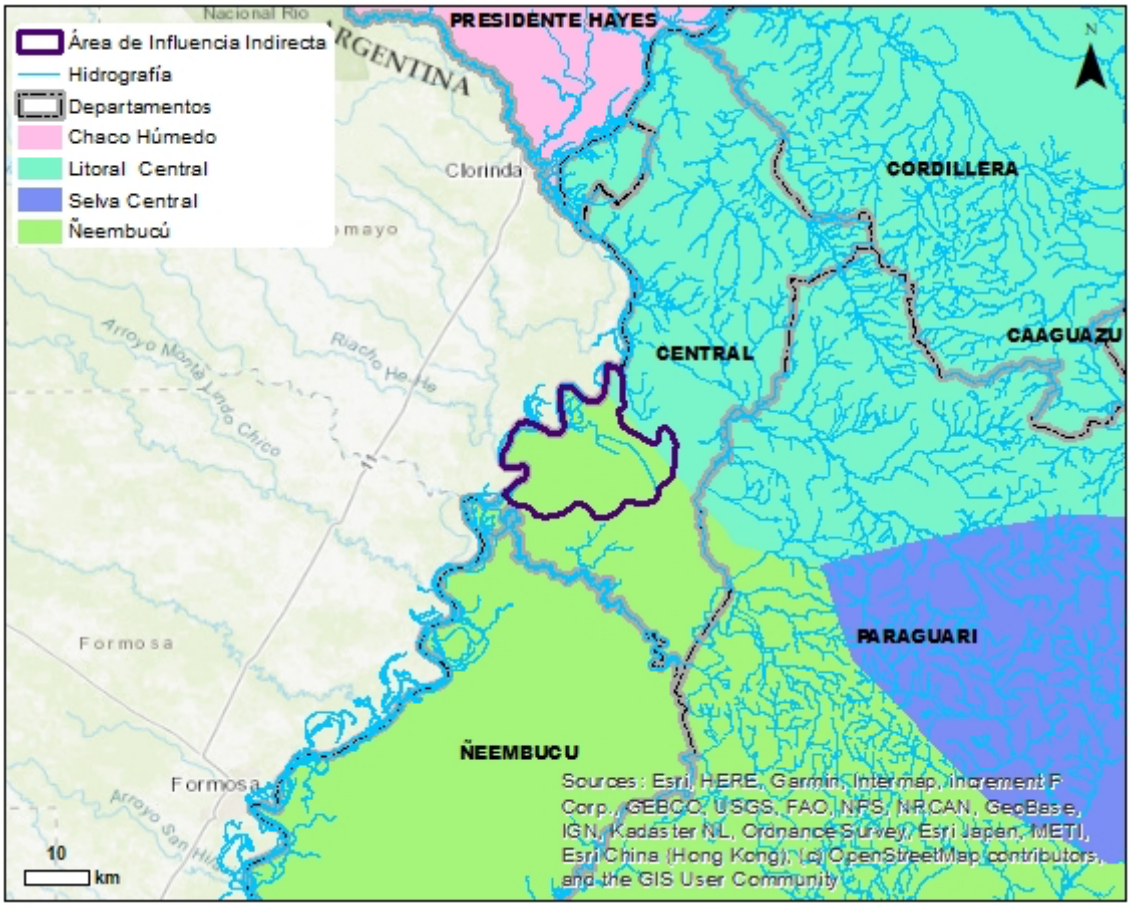
Characterisation of the ecoregion

The IIA is mainly located in the district of Villeta, in the Central Department. According to the classification of the Ministry of Environment and Sustainable Development (MADES) through Resolution N° 614/2013, the IIA is located within the Ñeembucú Ecoregion (**Figure 5.3.1.1.a**), with an extension of approximately 35,700 km^2 , covering a portion of the Central Department and whose boundaries correspond to the north with the Central Littoral Ecoregion, to the south with the Paraná River, to the east with the Central Forest Ecoregion and to the west with the Paraguay River. Among the characteristics of this Ecoregion, it is mentioned that the average annual temperature is between 22 and 23 °C and the average annual rainfall is 1,500 mm. The characteristic soils are alluvial, hydromorphic and rich in organic matter (Acevedo *et al*., 1990).

Studies and descriptions of the vegetation and flora in the area include the works of Tortorelli (1966), Acevedo *et al*. (1990), Mereles (2004 and 2007), Vogt & Mereles (2005), Pérez de Molas and Céspedes (in Macedo Sienra, A., Villalba, 2009) and De Egea *et al*. (2012). All of them mention the mosaic of woodland vegetation and hydromorphic savannas with *Copernicia alba*, typical of the Paraguay river basin.

Tortorelli (1966) states that the vegetation in the area corresponds to a wooded savannah, characterised by a dominant herbaceous tapestry and isolated trees and shrubs. Acevedo *et al*. (1990) use this description and report that the woody species do not exceed 15 metres in height, where the most characteristic species are *Luehea divaricata, Peltophorum dubium, Tabebuia* spp, *Holocalyx balansae, Ficus* spp, *Albizia hassleri, Ocotea* spp and *Nectandra spp.*

Figure 5.3.1.1.a
Ecoregions in the Project's Area of Indirect Influence



Source: Ecoregions of Paraguay, Resolution SEAM Nº 614/2013.

Mereles (2004 and 2007) describes the forests and savannahs in the areas of influence of the Paraguay River as flood forest, semi-deciduous sub-humid forest and Karanda'y hydromorphic savannah (*Copernicia alba*). The flood forest is characterised by its presence in areas of periodic flooding, developed on clayey and highly structured soils, tending to form pure populations of *Prosopis nigra, Prosopis ruscifolia* or *Albizia inundata*.

The semi-deciduous sub-humid forest developed on sandy loam soils, in the Eastern and Western region along the coast of the Paraguay River, where rainfall does not exceed 1,700 mm and where approximately 50% of the vegetation loses its leaves during flowering. They have 3 to 4 strata and lianas and epiphytes in their interior. The characteristic species of these forests are *Albizia niopoides, Allophylus edulis, Anadenanthera colubrina, Apuleia leiocarpa, Astronium balansae, Chloroleucon tenuiflorum, Cordia americana, Cordia glabrata, Copaifera langsdorfii, Eugenia uniflora, Guarea kunthiana, Jacaratia spinosa, Peltophorum dubium, Protium heptaphyllum, Sorocea bonplandii, Tabebuia heptaphylla* and *Xylopia brasiliensis*. The hydromorphic sheets of *Copernicia alba* developed on clay-rich soils, very structured, hard when dry and floodable, in which the dominant species is the *Copernicia alba* palm accompanied by very few woody species in the case of modified environments. The herbaceous tapestry is rich in marsh and aquatic species and the floristic composition varies according to the time of flooding in the palm grove. Some characteristic species are *Aeschynomene rudis, A. sensitiva, Cleome spinosa, Commelina erecta, Diodia kuntzei, Discolobium pulchellum, Eleocharis elegans,*

E. montana, Fimbristylis sp, *Justicia laevilinguis, Mikania cordifolia, Panicum hiritcaule, P. laxum, Pfaffia glomerata, Phyla reptans, Polygonum punctatum, Rhynchospora scutellata, Ruellia tweediana, Setaria geniculata, Solanum spinosum, Vernonia rubircaulis*, among others.

Pérez de Molas & Céspedes (2009) conducted a study of the vegetation and flora for the technical justification of the Guyratî Nature Reserve, in the city of Villeta. They recorded 362 species in non-systematic surveys, within four natural communities corresponding to islands of sub-humid forest that form small islands of arboreal vegetation, with well-defined strata, islands of forest on hills developed on higher ground, hydromorphic savannahs of *Copernicia alba* and estuaries, in which aquatic-palustrine herbaceous vegetation predominates. In the forests described, the predominant species are *Achatocarpus praecox, Astronium balansae, Rollinia salicifolia, Tabernaemontana catharinensis, Tabebuia heptaphylla, Patagonula americana, Cecropia pachystachya, Terminalia triflora, Sapium haemathospermum, Sebastiania brasiliensis, Acacia bonariensis, Albizia inundata, Copaifera langsdorffii, Enterolobium contortisiliquum, Gleditsia amorphoides, Holocalyx balansae, Parapiptadenia rigida, Peltophorum dubium, Casearia sylvestris, Ocotea diospyrifolia, Trichilia catigua, Trichilia mollis, Pisonia zapallo, Ruprechtia laxiflora, Calycophyllum multiflorum, Cupania vernalis, Melicoccus lepidopetalus, Chrysophyllum gonocarpum, Guazuma tomentosa, Trema micrantha, Urera* sp., *Vitex montevidensis*, among others.

In the *Copernicia alba* savannah, the flora is mainly composed of *Justicia laevilinguis, Mollugo verticillata, Acacia caven, Desmodium incanum, Sesbania virgata, Heimia salicifolia, Cienfuegosia drummondii, Sida spinosa, Cissampelos pareira, Andropogon laterales, Panicum prionitis, Polygonum acuminatum, Portulaca fluvialis, Paullinia pinnata, Angelonia sp, Scoparia dulcis, Scoparia montevidensis, Solanum glaucophyllum, Turnera grandiflora, Turnera melochioides, Verbena aristigera, Cissus verticillata, Acalypha communis, Killinga odorata, Momordica charantia, Evolvulus sericeus, Commelina erecta, Tillandsia recurvifolia, Tillandsia streptocarpa* and *Bromelia balansae*. In areas where small water bodies were recorded, the most common were *Echinodorus grandiflorus, Croton urucurana, Hydrolea spinosa, Ludwigia helmintorrhiza, Ludwigia rigida, Eleocharis filiculmis, Cyperus laxus, Cyperus esculentus, Ipomoea carnea* subsp. *fistulosa* and *Commelina platyphylla.*

The vegetation of the estuaries consists of aquatic and marsh species such as *Rhabdadenia pohlii, Enydra radicans, Gymnocoronis spilanthoides, Mikania* sp., *Croton urucurana, Senna pendula, Juncus* sp, *Hydrocleys nymphoides, Limnocharis* aff. *flava, Paullinia elegans, Salvinia auriculata, Pistia stratiotes, Eupatorium candolleanum, Canna glauca, Eleocharis elegans, Oxycrium cubense, Rhynchospora corymbosa, Aeschynomene* sp, *Nymphoides indica, Nymphaea* sp., *Ludwigia* sp., *Hymenachne amplexicaulis, Paspalum* sp, *Eichhornia azurea, Heteranthera reniformis, Hetherantera limosa, Pontederia cordata, Pontederia rotundifolia* and *Neptunia plena*; there are also areas dominated by *Cyperus giganteus* and *Thalia geniculata*, known as Pirizales and Peguahozales, respectively.

Vogt & Mereles (2005) studied the vegetation of the Ñeembucú Ecoregion, resulting in 11 types: *Copernicia alba* savanna, *Copernicia alba* and *Acrocomia aculeata* savanna, Flooded savanna, Grassland savanna, Marginal or riparian hygrophilous forests, Bamboo forests, Floodable scrub, Espartillares savanna, Estuary vegetation, Lagoon vegetation and Embalsados. Each of these was described, along with its floristic composition and conservation status at the time of the study.

De Egea *et al*. (2012) recorded 676 taxa (including subspecies and varieties) in 100 families and 374 genera in the vegetation of the Ñeembucú wetlands.

Vegetation characterisation

The characterisation of the vegetation in the IIA of the project was based on the Annual Land Cover and Land Use Maps in Chaco produced by the MapBiomas Chaco Project - Collection 3.0[2] , from the year 2021, to determine the land cover types in the area. The "Annual Land Cover and Land Use Mapping of the Gran Chaco Americano" project is an initiative involving a collaborative network of specialists from Argentina, Bolivia, Brazil and Paraguay. It uses cloud processing and automated classifiers to generate a historical series of annual land cover and land use maps of the Gran Chaco Americano[3] .

For the characterisation of the natural vegetation, and its correspondence with the cartographic classes of the Mapbiomas, the study by Mereles (2007) was used as a basis.

According to the 2021 MapBiomas map, the following land cover classes are present in the project IIA: natural woody vegetation (including forests and savannahs); natural non-woody vegetation, including natural grasslands, floodable or not, and wetlands; anthropogenic areas (mainly built-up areas) and water bodies. **Table 5.3.1.1.a** presents the descriptions of each class, based on the categories used by the MapBiomas Project.

Table 5.3.1.1.a
Land use and land cover classes in the Area of Indirect Influence, based on the map of the Mapbiomas Chaco Project.

Class	Description
Natural woody vegetation	**Includes forest vegetation, mainly sub-humid and semi-deciduous forests, hygrophilous forests and hydromorphic savannahs.**
closed woody	Areas with natural vegetation consisting of trees, shrubs or a mixture of both, with a cover of 65% or more.
flood-prone woody	Transition zones between purely terrestrial and aquatic systems, where the water table is at or near the surface (waterlogged areas). The natural vegetation cover, consisting of trees, shrubs or a mixture of both, is strongly influenced by water and/or dependent on flooding.
sparse woody	Areas with natural vegetation consisting of trees, shrubs or a mixture of both, with a cover of 5% or more and less than 20%.
Natural non-woody vegetation	**Includes natural grasslands, flooded and non-flooded, and wetlands.**
closed grassland	Areas with natural vegetation consisting of herbaceous plants with a cover of 65% or more. Woody plants are allowed in this category, but must have a cover between 1-5 and 20%.
open grassland	Areas with natural vegetation consisting of herbaceous plants with a cover of 20% or more and less than 65%. Woody plants are allowed in this category, but must have a cover between 1-5 and 20%.
flooded grassland	Transition areas between purely terrestrial and aquatic systems, where the water table is at or near the surface (waterlogged areas). Natural herbaceous vegetation

2 Available here : MapBiomas Chaco

3 Mapbiomes Chaco

Table 5.3.1.1.a
Land use and land cover classes in the Area of Indirect Influence, based on the map of the Mapbiomas Chaco Project.

Class	Description
	cover is strongly influenced by water and/or dependent on flooding (e.g. estuaries, marshes, swamps and waterbeds).
Anthropic areas	**Includes crops, anthropogenic pastures and built-up areas.**
multiple cropping	Areas with two or more crops per season. They are usually developed on small properties.
single crops	Areas with only one crop per season. The main monoculture in the IIA is rice, which is widespread in the Chaco region, due to the favourable characteristics of this ecoregion for this type of crop.
pastures	Areas with cultivation of herbaceous species for fodder (animal production). However, it is also important to mention that the use of natural grasslands as pasture for livestock grazing is very common in the region.
non-vegetated areas	Areas with artificial cover resulting from human activities such as urban constructions, roads, etc. These areas are mainly located on the banks of the Paraguay River.
Water Bodies	Areas covered by water naturally (rivers, lakes, etc.) or artificially (reservoirs, canals, artificial lakes, etc.).

Source: Mapbiomas Chaco Project, Algorithm Theoretical Base Document & Results (ATBD_R), September 2022. Available here ATBD Collection 3.0.docx.pdf - Google Drive

Quantification of land use and occupation in the IIA

The quantification of land use and occupation in the IIA was based on the 2021 Map of Land Cover and Use in Chaco (Mapbiomas Chaco - Collection 3.0) and is shown in **Table 5.3.1.1.a**, where it is verified that natural non-woody vegetation represents 68.23% of the IIA, and woody vegetation 23.66%. However, as already mentioned, part of the natural grasslands are used for livestock, so the native vegetation in these natural habitats can be found in different levels of conservation.

Table 5.3.1.1.a
Quantification of land use and land cover in the project's Area of Indirect Influence

Class	Hectares	%
Natural woody vegetation	**8,515.45**	**23.66**
closed woody	2,444.99	6.79
flood-prone woody	6,067.92	16.86
sparse woody	2.54	0.01
Natural non-woody vegetation	**24,559.86**	**68.23**
closed grassland	6,418.24	17.83
open grassland	0.51	0.00
flooded grassland	18,141.11	50.40
Anthropic areas	**1,359.70**	**3.78**
multiple cropping	161.39	0.45
single crops	831.36	2.31
pastures	233.82	0.65
non-vegetated areas	133.13	0.37
Water Bodies	**1,560.80**	**4.34**
Total	**35,995.82**	**100.00**

Based on MapBiomas Chaco Project - Collection 3.0 of Annual Land Cover and Land Use Maps in Chaco, accessed March 2021, via link: MapBiomas Chaco.

5.3.1.2
Area of Direct Influence (AID)

Mapping and quantification of vegetation cover and land use in the AID

The land cover and land use map of the project's AID can be seen in **Map 5.3.1.2.a** and the quantification of the area of its mapping categories (in hectares) in **Table 5.3.1.2.a.** The mapping was done based on visual analysis of high resolution satellite images[4] , comparing the patterns of the images with what was observed in the field surveys.

Native vegetation cover is predominant in the IDA (65.25%) and is mainly represented by hydromorphic savannah, occupying 42.89% of the IDA. Semi-deciduous sub-humid forest corresponds to 22.26% of the AID.

Forests are mainly located in the northern portion of the IDA, both in large fragments and in smaller, isolated fragments. Savannah is distributed throughout the IDA.

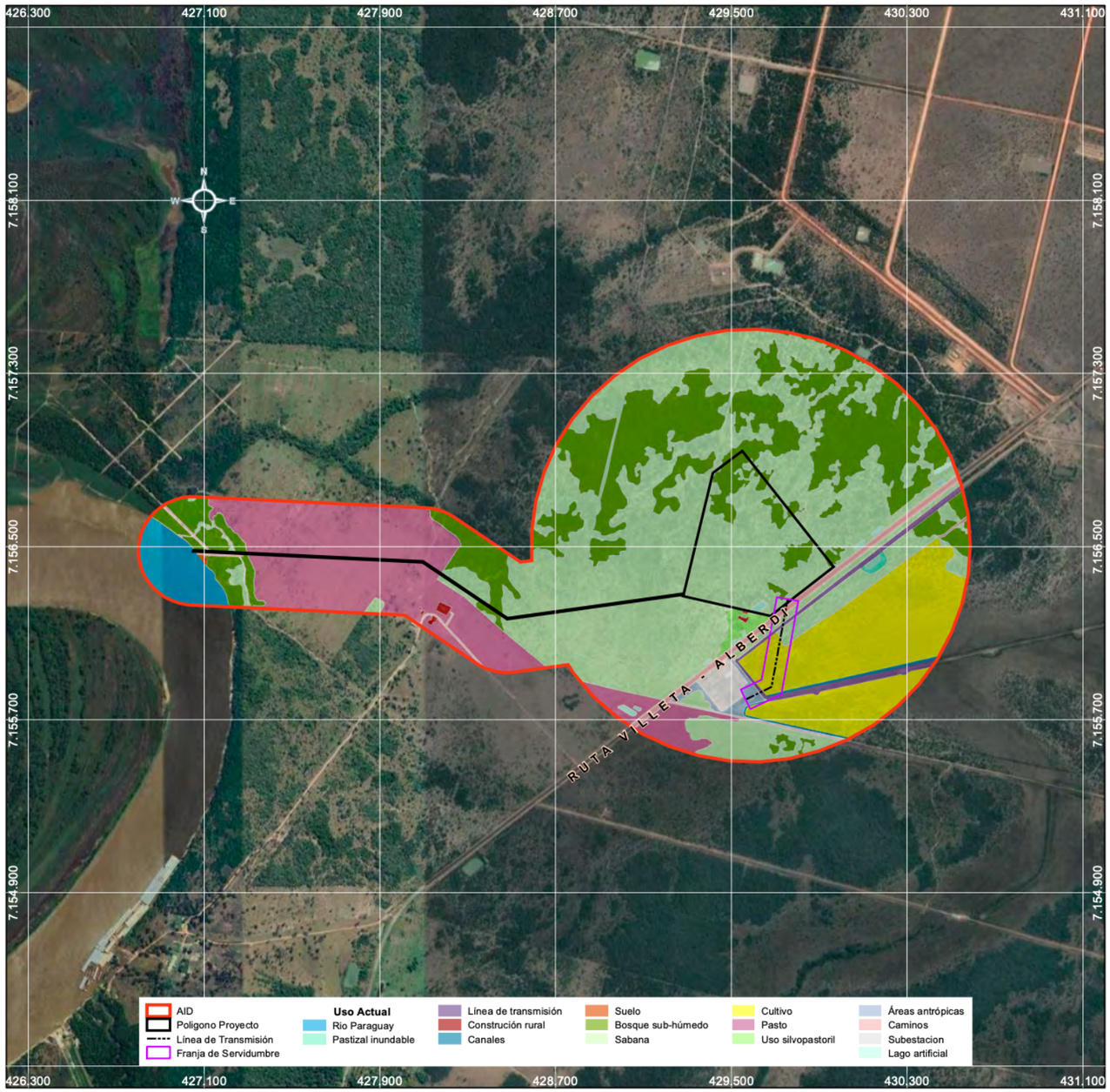
The hydromorphic savannah occurs on small, gentle hills, where the soil is more aerial and the development of the vegetation is more expressive, with a tangle of shrub and herbaceous species, as well as a large number of individuals of *Copernicia alba*, which is distributed throughout the region.

Anthropogenic land uses occupy 32.36% of the AID and include crop, pasture and silvopastoral use (a small property with multiple land uses), paved and unpaved roads, the power substation and transmission and distribution lines, and small artificial lakes.

4 Images from Google Earth, dated 25 November 2022.

Map 5.3.1.2.a - Land Cover and Land Use Map

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	5.3.1.2.a - MAPA DE COBERTURA VEGETAL Y USO DEL SUELO





Carátula Juridica Legal

Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	25/10/2023

Fuente Cartográfica

Proponente, DGEEC 2012
2023

Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:10.00

Table 5.3.1.2.a
Land cover and land use in the Area of Direct Influence (AID)

Class	Hectares	%
Native vegetation	**265.42**	**65.25**
Sub-humid semi-deciduous forests	90.55	22.26
Hydromorphic savannas	174.45	42.89
Flooded grassland	0.43	0.10
Anthropised areas	**131.64**	**32.36**
Anthropic area without defined use	2.39	0.59
Grass	62.54	15.37
Silvopastoral use	2.15	0.53
Single crops	46.24	11.37
Pathways	6.87	1.69
Rural construction	0.45	0.11
Artificial lake	1.29	0.32
Irrigation canal	1.37	0.34
Transmission line	5.18	1.27
Substation	3.08	0.76
Soil	0.09	0.02
Other	**9.70**	**2.39**
Paraguay River	9.70	2.39
Total	**406.77**	**100.00**

5.3.1.3
Directly Affected Area (DAA)

The working method for the study of the vegetation and flora in the Project's ADA was developed in four stages: a pre-field analysis to identify the site's natural communities, select the sampling points and review the study background. The second and third stages were the field work, which was carried out at two different times, and the fourth stage was the subsequent desk work, which included the systematisation and analysis of data.

The study of vegetation can be carried out through qualitative and quantitative methods. Qualitative methods offer as a main result the listing of the flora and characterisation of the vegetation. Quantitative methods, on the other hand, are more time-consuming as they involve measurements of individuals as well as their identification; they result in structural data on vegetation formations that can be used to estimate diversity and monitor population development.

In March 2023, a preliminary study of the Rapid Ecological Assessment type was carried out to determine the diversity of flora groups, and to describe the types of plant formations and the description of the Ecoregion. The second sampling was carried out from 19 to 23 June 2023, corresponding to a quantitative study within the forest area and another qualitative study within the savannah.

The objective was to describe the forest structure, identify the species of greatest ecological weight, threatened species, conservation status and estimate diversity; for the savannah the object of study was to intensify the sampling of species richness and conservation status.

5.3.1.3.1
Methodology

Data were recorded on pre-established forms, containing information such as sampling location, date, time, natural community, description and species present. The geographical coordinates of all the plots were taken with a GPS and recorded in the field sheets, and the plots were described with their physical and biological characteristics (**Annex 7**).

The taxa corresponding to botanical family, genus and species were indicated in the processed data sheet. The database of the Darwinion Institute[5] was used to update the scientific names. All possible individuals were identified, in a few cases it was only possible to arrive at the genus level due to lack of morphological characters necessary for their determination, in other cases, also scarce, it was not possible to conclude the identity of the species, it was only possible to differentiate at the dendrological level (tree architecture and bark) that they consisted of species other than the one determined, mainly due to the absence of leaves, and they were named using the code "indet" (indeterminate).

The nomenclature adopted for vegetation classification is that of Mereles (2005), as it is more in line with local floristic composition and soil components.

First survey

The method of the first field sampling was the one recommended by Keel *et al*. (1992), which suggests the establishment of an order of priorities for the selection of sites and sampling techniques. Based on the above, the following were considered: number of vegetation types preliminarily identified, accessibility, budget and time. Regarding the type of sampling, this method mentions that, if the area is large and time limited and the vegetation types are common and known, it is more efficient and productive to make direct observations at several points rather than establishing plots at a few locations, and that a sampling point with a range of 20 metres around is equivalent to a sampling area of 1,256 square metres and is adequate to characterise a forest of 50 hectares. Consequently, five sampling points were selected, three in the sub-humid forest area and two in the hydromorphic *Copernicia alba* savanna. Sampling consisted of establishing transects of 2 × 100 metres each (see **Figure 5.3.1.3.1.1.a**), in which the natural communities were verified and all the species within them were recorded, in addition ecological observations and casual records were made along the routes in order to record as many species as possible.

[5] Darwinion Institute of Botany.

Figure 5.3.1.1.3.1.a
Location of flora transects of the first field survey



Green lines: flora transects / Orange polygon: land where the Project is planned to be carried out.
Source: Google Earth, date 25/11/2022.

Transects were surveyed over two days and walks for casual observations over 5 days (**Table 5.3.1.1.3.1.a**). Some time intervals were interrupted by rainfall.

Table 5.3.1.3.3.1.a
Sampling dates and times

Date	Timetable	Sampling	Vegetation
04/03/2023	9:50 - 10:40	Transect 1	Forest
04/03/2023	16:27 - 17:13	Transect 2	Forest
04/03/2023	17:20 - 18:02	Transect 3	Forest
04/03/2023	18:10 - 19:05	Transect 4	Savannah
05/03/2023	9:10 - 10:14	Transect 5	Savannah
3 to 7/03/2023	8:00 - 11:00 y 15:00 - 18:00	Casual observation	-

Source: own elaboration.

Second survey

For the forest formation, 20 × 20 metre transects were used (DALLMEIER, 1992). Installation was carried out systematically in the lower and higher areas of the plot to obtain a profile of the forest vegetation and variation in these areas. All individuals with a diameter at breast height (DBH) ≥ 10 cm were measured. For the savannah, 10 × 10 m transects (DALLMEIER, 1992) were used, the percentage cover of individual species was measured, the species present in the sample and the richness was calculated. Then, data on number of individuals, botanical family, species, common name, DBH, height, phenology, phytosanitary status and ecological observations were collected. A floristic survey of tree and non-tree species present in all transect plots was also carried out.

Transect observations were made over 5 days (**Table 5.3.1.1.3.1.b**).

Table 5.3.1.1.3.1.b
Sampling dates and times

Date	Timetable	Sampling	Vegetation
19/06/2023	Tomorrow	Transect 1 and 2	Forest
19/06/2023	Afternoon	Transect 1	Savannah
20/06/2023	Tomorrow	Transect 3	Forest
21/06/2023	Tomorrow	Transect 2 and 3	Savannah
22/06/2023	Tomorrow	Transect 5	Savannah
22/06/2023	Afternoon	Transect 4	Forest
23/03/2023	Tomorrow	Transect 4	Forest

Source: own elaboration.

Figure 5.3.1.1.3.1.b
Location of the second survey plots in the field

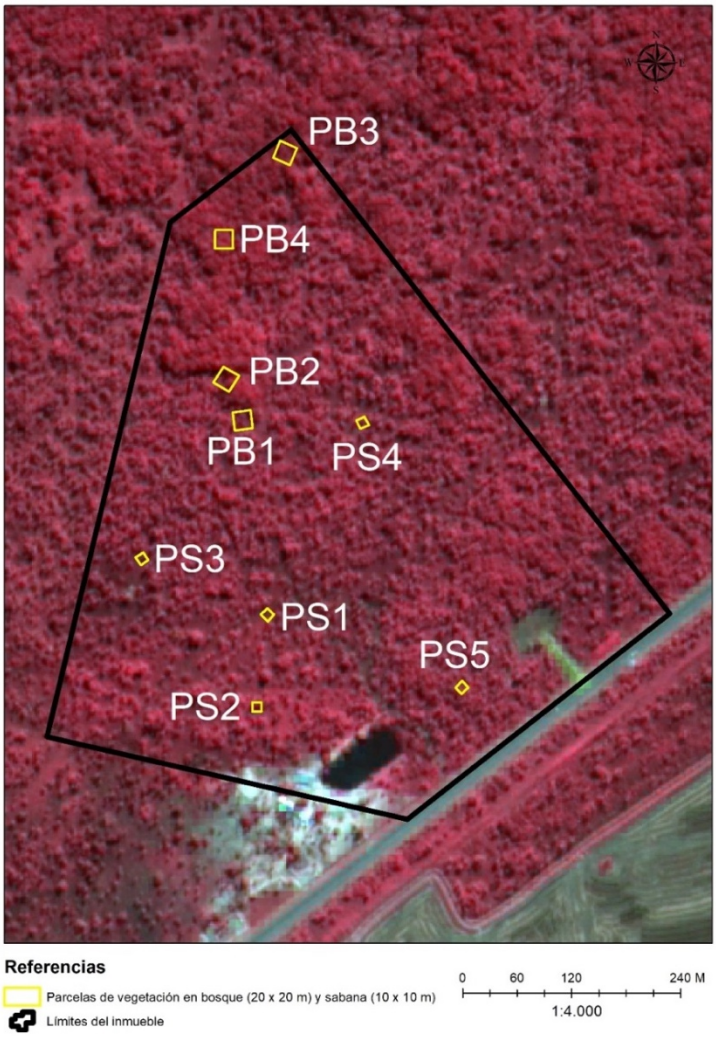




Photo 01: Measurement and installation of plots.



Photo 02: Measurement of trees.



Photo 03: Data recording.

Data analysis

Forest

Wealth and diversity

Richness was determined according to the recorded floristic composition or number of species within botanical families. Diversity was analysed using the Shannon-Wiener index, which is one of the most widely used indexes to determine the diversity of plant species (BOLFOR, 2000), using BiodiversityPro software (MCALEECE *et al*., 1997).

Vertical structure

For the study of vertical structure, individuals were grouped according to their heights (LAMPRECH, 1990). The upper stratum included all those whose heights were in the range > 2/3 of the upper height, the middle stratum included individuals between 2/3 and 1/3 of the upper height and the lower stratum included all individuals with heights < 1/3 of the upper height.

Horizontal structure

For the analysis of the horizontal structure, the abundance, frequency and dominance parameters were considered according to Matteucci & Colma (1982) and Soler *et al*. (2012), with these values the species importance value index (IVI) was calculated to obtain the hierarchy of the species in the site through the formula:

$$IVI = ARi + FRi + DRi = \text{community species, } 1...n$$

Where abundance (A) is the number of individuals per species (i) found in the community and is calculated by the formula: Ai = Ni / S, where Ni = number of individuals of species i and S = area (ha).

Relative abundance = relative abundance of species i (RA) relative to total abundance: RAi = (Ai / Σ Ai) * 100 i = 1...n, where i = community species, 1...n.

Frequency is the number of times a species occurs in the number of plots, subplots or sampling points. Relative frequency (RF) is calculated through the formula: FRi = ni / Σni * 100; where: FRi = centesimal frequency of species i, ni = number of plots where species i is found and Σni = sum of the number of plots where species i is found.

Dominance (D) is the condition in which one species strongly influences the composition and form of the community. Dominant species are relatively abundant and ecologically successful in the community. It is calculated as follows: Di = Abi / S; where Abi = basal area of the stem section of the species at 1.30 m height (m^2) and S = area (ha).

The relative dominance (RD) of species i with respect to the total community dominance is calculated as: DRi = (Di / Σ Di) * 100 i = 1 n.

Savannah

Data systematisation and analysis consisted of organising data in an Excel spreadsheet. To determine the richness of the floristic composition, the number of species was calculated. Diversity was analysed using the Shannon-Wiener index (BOLFOR, 2000). A species accumulation curve was also elaborated to estimate the minimum sampling area in this vegetation type.

State of conservation

For the Savannah study, the presence/absence of threatened species, physical characteristics of the soil and species richness were considered.

For the forest, diameter class, phytosanitary status, ecological observations and presence/absence of threatened or rare species were considered. Diametric class was considered because it reflects the interaction of species and their strategy to maintain themselves over time, as diameter allows determining the regeneration capacity of forests.

The presence of threatened species is a good indicator of the conservation status of an ecosystem where they grow naturally, as it indicates little anthropogenic intervention at the site, since the common threats to these species are extraction for their use or commercialisation and the degradation of their habitats. The conservation categories were obtained from Resolution N° 470/2019 of the Ministry of Environment and Sustainable Development and from the red list of the International Union for Conservation of Nature (IUCN).

The phytosanitary state of the species is a very important data to know the degree of conservation of an ecosystem. Healthy individuals develop in environments with little pollution, with the necessary nutrients, free of diseases and contamination of the substrate or water.

5.3.1.3.2
Results

Description of the natural communities present on the site

Hydromorphic savannah of *Copernicia alba* (Photo 04): developed on mostly clayey, floodable soils, located in the lower areas of the terrain. This savannah is dominated by the *Copernicia alba* palm, accompanied by some woody tree and shrub species such as *Annona emarginata, Guazuma ulmifolia, Neltuma affinis, Randa armata, Salvia cardiophylla, Sesbania virgata, Syagrus romanzoffiana, Tabebuia nodosa, Vachellia caven* and *Xylosma venosum*. There are also herbaceous shrub and sub-shrub species such as *Ipomoea carnea* subsp. *fistulosa*, *Senna obtusifolia* and *Solanum glaucophyllum*.

The herbaceous stratum is composed of *Aeschynomene montevidensis, Alternanthera* sp, *Angelonia salicariifolia, Aspilia* sp, *Borreria verticillata, Bromelia balansae, Caperonia palustris, Cenchrus* sp, *Coleataenia prionitis, Commelina diffusa, C. erecta, Coniza* sp, *Croton argenteus, Croton bonplandianus, Cuphea lysimachioides, C. racemosa* ssp. *racemosa, Cuphea* sp, *Cyperus aggregatus, C. brevifolius, C. entrerianus, C. odoratus, Desmodium sp, Dysphania ambrosioides*, *Eclipta prostata, Eleocharis* spp, *Eryngium* sp, *Eupatorium* sp, *Evolvulus nummularius*, *Fimbristylis* aff. *complanata*, *Gamochaeta* sp, *Gomphrena celosioides, G. perennis, Heimia salicifolia, Heliotropium* sp, *Hydrolea spinosa, Hymenachne amplexicaulis, Hyptis* sp, *Jaborosa integrifolia, Justicia* sp, *Leersia hexandra, Lepidium bonariense, Ludwigia* sp, *Mecardonia procumbens* var. *flagellaris, Mimosa balansae, M. debilis* var. *debilis, Neptunia* sp, *Nicotiana longiflora*, *Nymphoides indica, Oxalis paludosa, Panicum* sp, *Pfaffia glomerata, Pluchea sagittalis, Polygonum punctatum, Portulaca* sp, *Pterocaulon* spp, *Rhynchospora* spp, *Richardia brasiliensis, Ruellia* sp, *Scleria* sp, *Sida rhombifolia, S. spinosa, Sidastrum paniculatum, Solanum sp, Stachytarpheta cayennensis, Steinchisma hians, Stemodia* aff. *palustris*, *Tarenaya aculeata*, *Tradescantia fluminensis* and *Verbena litoralis*.

Some climbers, lianas and epiphytes are also present, mainly on tree species, such as *Cissampelos pareira*, *Cissus palmata, C. verticillata, Dolichandra unguis-cati, Ipomoea* spp, *Macroptilium erythroloma, Mikania* sp, *Oxypetalum* sp, *Phoradendron dipterum*, *Serjania* sp, *Smilax* sp, *Tillandsia recurvata* and *T. recurvifolia.*



Photo 04: Hydromorphic savanna of *Copernicia alba.*

Semi-deciduous sub-humid forest: developed on clay-loam soils, in higher areas of the terrain and subject to periodic flooding. Most of the species are of a marshy nature, typical of the humid Chaco. There are three well-defined strata. The upper one with a canopy that reaches up to 15 metres in height, in which 13% of the inventoried individuals were found, where the tree species that compose it are *Libidibia paraguariensis, Parapiptadenia rigida, Peltophorum dubium, Schinopsis balansae, Sideroxylon obtusifolium, Ruprechtia laxiflora,* and *Sorocea saxicola*.

The middle stratum is made up of species between 5 and 10 metres high, with 74% of the individuals, whose most common representatives are *Casearia* sp, *Chrysophyllum marginatum* ssp., *Eugenia* sp, *Eugenia uniflora, Gleditsia amorphoides, Plinia rivularis, Syagrus romanzoffiana, Tabebuia nodosa* and *Zanthoxylum fagara* ssp. *fagara.*

The lower stratum has mainly herbaceous species, some sub-shrubs and regenerations of tree species, where the maximum height was 4 metres. Among the most common species are *Aeschynomene montevidensis, Angelonia salicariifolia, Anthurium paraguayense, Bacopa salzmanii, Bromelia balansae, Caperonia castaneifolia, Commelina diffusa, C. erecta, Croton bonplandianus, Cyclopogon* sp, *Cyperus entrerianus, C. odoratus, Echinodorus grandiflorus, Eclipta prostata, Eleocharis* spp, *Eupatorium* spp, *Hemionitis tomentosa, Glandularia peruviana, Harrisia* sp, *Indigofera asperifolia, Justicia brasiliana, Justicia* sp, *Lasiasis* sp, *Leersia hexandra, Panicum* sp, *Paspalum* sp, *Peperomia* sp, *Petiveria alliacea, Pfaffia glomerata, Phyla nodiflora, Polygonum punctatum, Ruellia* sp, *Salvia cardiophylla, Scleria* sp, *Sida rhombifolia, Sidastrum paniculatum, Sisyrinchium* sp, *Solanum americanum, Solanum glaucophyllum, Solanum* sp, *Stachytarpheta cayennensis, Tarenaya aculeata, Vernonanthura* sp, *Viguiera* sp and *Wissadula* sp. Among the epiphytes, *Campylocentrum neglectum, Cohniella jonesiana, Microgramma* aff. *squamulosa, Microgramma vacciniifolia, Tillandsia recurvata*, *T. recurvifolia, T. streptocarpa, T. usneoides* and *Trichocentrum pumilum* were observed.

In addition, abundant herbaceous lianas and climbers of the families Apocynaceae, Bignoniaceae, Cactaceae, Convolvulaceae, Euphorbiaceae, Fabaceae, Malpighiaceae, Menispermaceae, Passifloraceae, Rubiaceae, Sapindaceae, Smilacaceae and Vitaceae were observed; among the others that could be identified were *Cissus verticillata, Dolichandra unguis-cati, Forsteronia* sp, *Ipomoea* spp, *Janusia* sp, *Macroptilium erythroloma, Manettia* sp, *Passiflora giberti, Paullinia* sp, *Rhipsalis baccifera, Serjania* spp, *Smilax* sp and *Tragia* sp.

An interesting observation is the presence of *Rivinia humilis* at the forest edge, an ornamental, feral or naturalised exotic species.



Photo 05: Forest and Savannah Mosaic.

Semi-deciduous Sub-humid Forest

The forest plots were installed in the larger wooded area to obtain a better represented structure. They started at the edge of the forest island and continued to the core of the fragment to obtain a vegetation profile. A total of 104 individuals were measured in four plots, thus meeting the minimum representativeness (100 stems).

General description of forest plots

Plot N° 1 (**Photos 06 and 07**): sparse forest adjacent to the palm savannah, saturated soil in some depressions, sparse undergrowth with abundant leaf litter, regeneration of tree species such as *Plinia rivularis, Parapiptadenia rigida, Syagrus romanzoffiana* and *Pisonia zapallo* was observed, herbaceous species in patches, dominated by *Anthurium paraguayense* and *Ocellochloa stolonifera*, accompanied by *Bromelia* sp, *Cyperus* sp, *Dichondra microcalyx, Eupatorium* sp and at the edges *Commelina erecta, Heimia salicifolia* and *Pfaffia glomerata*. Some epiphytes such as *Campylocentrum neglectum, Rhipsalis baccifera* and *Microgramma vacciniifolia*, as well as climbers such as *Smilax* sp and lianas such as *Serjania* sp.



Photos 06 and 07: Exterior view of plot 1 and undergrowth with abundant leaf litter and *Anthurium paraguayense.*

Plot N° 2 (**Photos 08 and 09**): forest interior, sparse, dense undergrowth dominated by regeneration mainly of Myrtaceae and in less dense areas by *Ocellochloa stolonifera*, accompanied by *Anthurium paraguayense*, *Cyperus* sp and *Monteverdia ilicifolia*. Abundant lianas were observed forming poorly accessible areas. Epiphytes of the species *Microgramma vacciniifolia* and *Campylocentrum neglectum.*



Photos 08 and 09: View of plot 2. It can be seen the difficulty of access due to vines and sparse undergrowth.

Plot N° 3 (**Photos 10 and 11**): forest interior, sparse, flooded area over most of the surface, abundant leaf litter and lianas, only a few herbaceous plants in the undergrowth, mostly regenerations of tree species; among the herbaceous plants co-dominating *Anthurium paraguayense* and *Hemionitis tomentosa*, few epiphytes of *Peperomia aceroana* and abundant lichens on the bark of the trees.



Photos 10 and 11: View of plot 3. Flooded undergrowth, with *Hemionitis tomentosa.*

Plot N° 4 (**Photo 12**): forest interior, saturated, dark soil, abundant leaf litter and seeds, with water accumulated in the lower areas. Regeneration of *Allophylus edulis, Genipa americana, Guazuma ulmifolia, Parapiptadenia rigida, Plinia rivularis, Randia armata, Sorocea saxicola, Syagrus romanzoffiana* and *Zanthoxylum fagara* ssp. *fagara* was observed. Among the herbaceous plants, *Anthurium paraguayense, Bromelia* sp, *Lithachne* sp and *Ocellochloa stolonifera* were recorded. Among the epiphytes *Campylocentrum neglectum, Microgramma vacciniifolia, Peperomia aceroana* and *Trichocentrum pumilum were* recorded.



Photo 12: General view of plot 4. There is abundant regeneration of tree species in the undergrowth.

Forest richness and diversity of the Sub-humid Semi-deciduous Forest

In the second survey campaign, carried out using the transect methodology, 26 tree, shrub and palm species were recorded within 14 botanical families (see **Table 5.3.1.3.2.a** in **Annex 8**). The family with the highest number of representatives was Fabaceae with 7 species, followed by Myrtaceae with 3 species and Arecaceae, Polygonaceae and Sapotaceae with 2 species each; the others with only one representative.

Three species could not be identified due to the absence of morphological characters necessary for their determination and one individual was impossible to determine even at the botanical family level, because it was leafless and the dendrological characters were insufficient for its recognition. The absence of leaves at this time of year is a common event in this type of vegetation.

The resulting diversity index was 0.93. This value indicates that the samples show low diversity, on a scale of values from 1 to 5. This can be seen in the distribution of the species, as there are aggregate areas with several individuals, corroborated by the distribution analysis (**Table 5.3.1.3.2.2.b** in **Annex 8**), as in the case of *Sorocea saxicola* and *Ruprechtia laxiflora*.

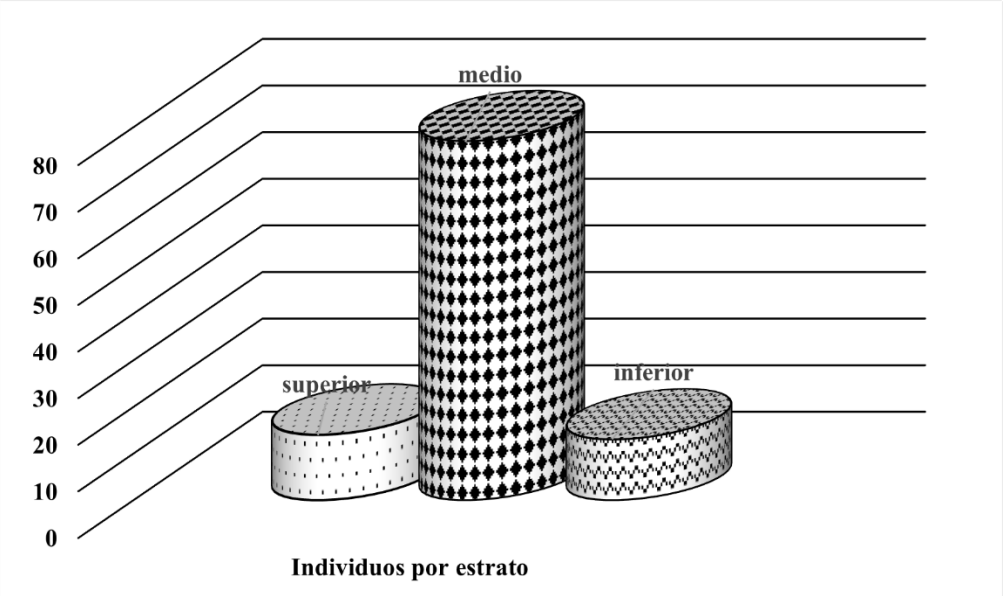
Vertical structure

The forest grows on clay loam soils, on higher ground and in areas subject to periodic flooding. Four well-defined strata were observed, the upper one in which 13% of the inventoried individuals were found and the species reached up to 15 metres in height. *Libidibia paraguariensis*, *Parapiptadenia rigida, Peltophorum dubium, Pisonia zapallo, Ruprechtia laxiflora, Schinopsis balansae, Sideroxylon obtusifolium* and *Sorocea saxicola* were recorded.

In the middle stratum the range was from 5 to 10 metres in height and 74% of the individuals (**Figure 5.3.1.3.2.c**) inventoried were included, some of those present corresponded to the upper stratum species still developing, but the most representative in the middle stratum were *Casearia* sp, *Chrysophyllum marginatum* ssp. *marginatum*, *Coccoloba* aff. *cordata, Copernicia alba, Cordia americana, Eugenia uniflora, Gleditsia amorphoides, Guazuma ulmifolia, Machaerium* sp, *Plinia rivularis, Syagrus romanzoffiana, Tabebuia nodosa* and *Zanthoxylum fagara* ssp. *fagara*.

The lower stratum, comprising the remaining 13% of the individuals inventoried, characterised by smaller species, including trees and shrubs, where the maximum height was 4 metres, comprised the lowest diversity of plants typical of this stratum, although abundant regeneration of species from the upper strata was observed. The representatives of this were *Eugenia uniflora, Plinia rivularis, Randa armata* and *Vachellia caven*. It is important to highlight the abundance of lianas on the site, mainly from the families Bignoniaceae, Sapindaceae, Apocynaceae, Euphorbiaceae and Fabaceae, which also share this space, but whose dimensions do not allow them to be quantified with this method.

Figure 5.3.1.3.2.c
Representation of number of individuals in strata



The undergrowth, made up of herbaceous species, did not show great diversity; on the contrary, dominant species were observed forming patches, some areas without herbaceous cover with abundant leaf litter and others completely covered with water, with no vegetation. The species recorded in this stratum were *Anthurium paraguayense, Bromelia* sp, *Commelina erecta, Cyperus* sp, *Dichondra microcalyx, Eupatorium* sp *Heimia salicifolia, Hemionitis tomentosa, Lithachne* sp, *Monteverdia ilicifolia, Ocellochloa stolonifera* and *Pfaffia glomerata.*

Among the most abundant epiphytes observed were *Campylocentrum neglectum, Microgramma vacciniifolia*, *Peperomia aceroana, Rhipsalis baccifera, Rhipsalis lumbricoides* and *Trichocentrum pumilum*.

Horizontal structure

According to the species importance value index (IVI), the most important, or species with the highest weight, characterising this forest were *Sorocea saxicola, Parapiptadenia rigida, Syagrus romanzoffiana, Pisonia zapallo, Ruprechtia laxiflora, Eugenia uniflora, Sideroxylon obtusifolium, Chrysophyllum marginatum* ssp. *marginatum* and *Schinopsis balansae* (**Table 5.3.1.3.2.c** in **Annex 8**).

The most abundant species were *Sorocea saxicola, Syagrus romanzoffiana* and *Ruprechtia laxiflora*. The most frequent were *Parapiptadenia rigida* and *Syagrus romanzoffiana,* followed by *Chrysophyllum marginatum* ssp. *marginatum*, *Eugenia uniflora, Sideroxylon obtusifolium* and *Sorocea saxicola. Sorocea saxicola* and *Parapiptadenia rigida* were the dominant species*,* followed by *Pisonia zapallo, Ruprechtia laxiflora* and *Tabebuia nodosa.*

Vegetation profile

The forest clearly shows a gradient from the most saturated zone or edges, adjacent to the *Copernica alba* sheets, where shrub and edge species such as *Guazuma ulmifolia are found, Parapiptadenia rigida, Peltophorum dubium, Randia armata* and *Vachellia caven*, as well as herbaceous species such as *Commelina erecta*, *Cyperus entreriensis, Glandularia tenera, Pfaffia glomerata, Polygonum punctatum* and *Verbena litoralis.* A few metres into the forest the soil becomes less clayey, the vegetation becomes denser and herbaceous species appear less frequently, replaced by abundant leaf litter. Some species such as *Anthurium paraguariense* and *Bromelia* sp form small patches of approximately 2 to 6 m^2 . The woody species are arranged in strata, as described above, in which the largest species are *Schinopsis balansae*, *Parapiptadenia rigida* and *Peltophorum dubium*. The spatial arrangement of the species varies along the island, in the areas closest to the palm grove and towards the south of the block *Sorocea saxicola* forms patches of almost pure populations, this condition changes a few metres further inland towards the north, where another species, *Ruprechtia laxiflora*, also forms patches and replaces the previous one; The other species are arranged randomly and always depending on the level of the ground, so the *Copernicia alba* palm is found in the lower areas and in the slightly higher areas it is replaced by *Syagrus romanzoffiana*.

To graphically represent this profile we adopted the figure of Mereles (2005) where he describes the forests of the humid Chaco with *Schinopsis balansae*. **Figure 5.3.1.3.2.d** shows how the forest is positioned in the higher areas of the terrain, surrounded by the palm savannah of *Copernicia alba*. **Photo 13 shows** a view of the forest/palm savannah mosaic on the site.

Figure 5.3.1.3.2.d
Vegetation profile of the forest with *Schinopsis balansae*. Adopted from Mereles (2005)





Photo 13: Actual view of the forest/palm savanna mosaic.

State of conservation

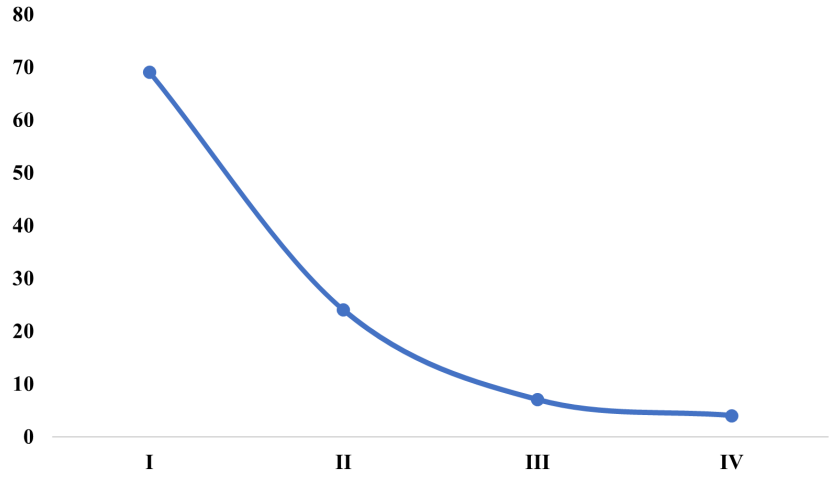
Phytosanitary status: of the 104 individuals, 55 showed no signs of deterioration and were recorded as healthy. The rest showed unfavourable phytosanitary conditions, such as infestation by lianas and termites, leaves eaten by insects, broken branches, cuts in the stems, hollows and the presence of the hemiparasite *Phoradendron dipterum*.

Threatened species: two threatened species were recorded in the sample: *Libidibia paraguariensis* and *Monteverdia ilicifolia*. Both have a category of threat at national level according to Resolution N° 470/2019 of the Ministry of Environment and Sustainable Development, at global level *Libidibia paraguariensis* is considered Vulnerable (VU). In the previous study, *Cohniella jonesiana* and *Prosopis nigra* were also recorded as threatened at the national level.

Diametric class: the diametric classes were grouped in ranges of 10 to 11 cm, forming four diametric classes: I - with individuals of DBH ≥ 10 to 20 cm; II - with individuals between 21 to 30 cm DBH; III - with individuals in a range of 31 to 40 cm DBH; IV - with individuals of DBH ≥ 41 cm.

Most of the individuals recorded were in the first diameter class, resulting in a decreasing curve graph (**Figure 5.3.1.3.2.e**). In this type of graph, an inverted J figure is normally visualised, which indicates abundant individuals in the first classes, marking a decrease in the middle classes and again rising slightly in the larger classes, which represents how the large trees in the larger classes die and are replaced by young trees located in the smaller diameter classes (QUIRÓS, 2002).

Figure 5.3.1.3.3.2.e
Representation of number of individuals in diameter classes



Disturbance: some signs of people entering the forest could be seen through some branches and trunks clearly cut with axes and machetes. Another disturbance recorded was the entry of livestock into the forest, which could be verified by footprints and compaction from trampling and droppings.

However, it is important to highlight the presence of the two threatened species, *Libidibia paraguariensis* and *Monteverdia ilicifolia* (**Photos 14 and 15**), whose main threats are the extraction and loss of habitat and the abundant regeneration of tree species.



Photos 14 and 15: Threatened species present in the sample: *Libidibia paraguariensis* and *Monteverdia ilicifolia.*

Total richness considering the two field campaigns

To better understand the total species richness in the site's forests, a combined list was compiled with data from the surveys carried out in March and June 2023, resulting in 121 species (**Table 5.3.1.3.2.2.d** in **Annex 8**).

Hydromorphic savanna of Copernicia *alba*

General description of the savannah plots surveyed

Plot N° 1 (**Photo 16**)**:** very saturated soil, with waterlogged areas, very difficult access due to the slope. Predominance of herbaceous species, mainly *Eleocharis elegans*. Most of the species present are of a marshy nature and some aquatic species such as *Eleocharis filiculmis, Hymenachne amplexicaulis* and *Pontederia cordata*. In the woody stratum the dominant species is *Copernicia alba*.



Photo 16: View of plot 1, with *Eleocharis elegans* dominating, in full bloom.

Plot N° 2 (**Photo 17**): saturated, waterlogged soil. The co-dominant species were *Eleocharis elegans, Panicum* sp and *Setaria* sp. All the species recorded are of a marsh and/or aquatic nature, with the exception of those present in slightly higher areas of the slope, of a ruderal nature, such as *Commelina erecta, Mimosa balansae, Sidastrum paniculatum*, *Sida spinosa* and *Cuphea racemosa* ssp. racemosa.



Photo 17: View of plot 2, co-dominance of *Eleocharis elegans, Panicum* sp and *Setaria* sp.

Plot N° 3 (**Photo 18**): soil completely covered by abundant water, in some areas forming apparently semi-permanent puddles, where aquatic plants such as *Hymenachne amplexicaulis Nymphoides indica* and *Pontederia cordata* predominate. The upper stratum was dominated by Copernicia alba and to a lesser extent *Vachellia caven*, and the epiphyte *Tillandsia recurvifolia* was also present in full bloom.



Photo 18: View of plot 3, the water level can be seen in most of the plot.

Plot N° 4 (**Photo 19**): less saturated palm grove area, with less diversity than the previous samples, dominated in the upper or woody layer by *Copernicia alba* and shared with some woody species such as *Xylosma venosum* and others that did not fall within the plot, but were found on the site, such as *Tabebuia nodosa* and *Vachellia caven.* The herbaceous tapestry was co-dominated by *Cyperus entrerianus* var. *entrerianus, Eleocharis elegans, Hydrocotyle ranunculoides, Hymenachne amplexicaulis, Ludwigia decurrens* and *Panicum* sp.



Photo 19: View of plot 4, less saturated than the previous samples.

Plot N° 5 (**Photo 20**): area with a greater diversity of shrubs and trees than the other samples; *Copernicia alba was* recorded as dominant, accompanied by *Eupatorium* sp, *Ipomoea carnea* subsp. *fistulosa*, *Senna pendula* var. *paludicola*, *Tabebuia nodosa* and *Vachellia caven*. The herbaceous stratum was co-dominated by *Cyperus entrerianus* var. *entrerianus*, *Cyperus* aff. *digitatus, Eleocharis elegans, Paspalum* sp and *Setaria* sp.



Photo 20: View of plot 5. A greater diversity of woody plants can be seen than in the previous plots.

Floristic richness in the hydromorphic savannah of *Copernicia alba*

In the second field campaign, 72 species belonging to 29 botanical families were recorded in the second sampling carried out in the Savannah (**Table 5.3.1.3.2.e** in **Annex 8**). The most represented family was Asteraceae with 10 species, although not all of them were determined to that level because some were sterile, others with dried fruits and others needed to be collected for their determination, which meant that a collection permit had to be requested and their subsequent processing in the herbarium with the corresponding time for this purpose. Other families with diverse representatives were Fabaceae and Poaceae with 8 species, Cyperaceae with 7 species, Malvaceae with 5, Lythraceae with 4 and the others with 3 to 1 species.

To better estimate diversity, a combined species list (**Table 5.3.1.3.2.f** in **Annex 8**) was also produced for the two campaigns. This combined list contains all the data recorded in this plant formation including casuals, but for this analysis only the species recorded in the samples were used, resulting in 125 species, corresponding to two transects of the first sampling considered as samples 1 and 2 in the curve, with 200 m^2 each and the 5 plots of this sampling considered as samples 3 to 7 in the curve and with 100 m^2 each, totalling 900 m^2 .

The species accumulation curve (**Figure 5.3.1.3.2.f**) stabilises between samples 4 and 5, at 700 m^2 , then increases slightly in the plots, this is due to the fact that the latter have a higher density of woody plants and some climbers, which contribute to increasing diversity, but the herbaceous stratum has already stabilised. Another similar study carried out in Ñeembucú at the same time of the year, between May and June (Piris da Motta et al., 2021), reported 55 species in the palm grove of *Copernicia alba*, included in 23 botanical families, in an area of 43 m^2 . Compared to our data, we can observe that there is no significant increase as the sampling area increases (**Figure 5.3.1.3.2.g**).

Figure 5.3.1.3.2.f
Species accumulation curve in the savannah (N° species/ N° samples)

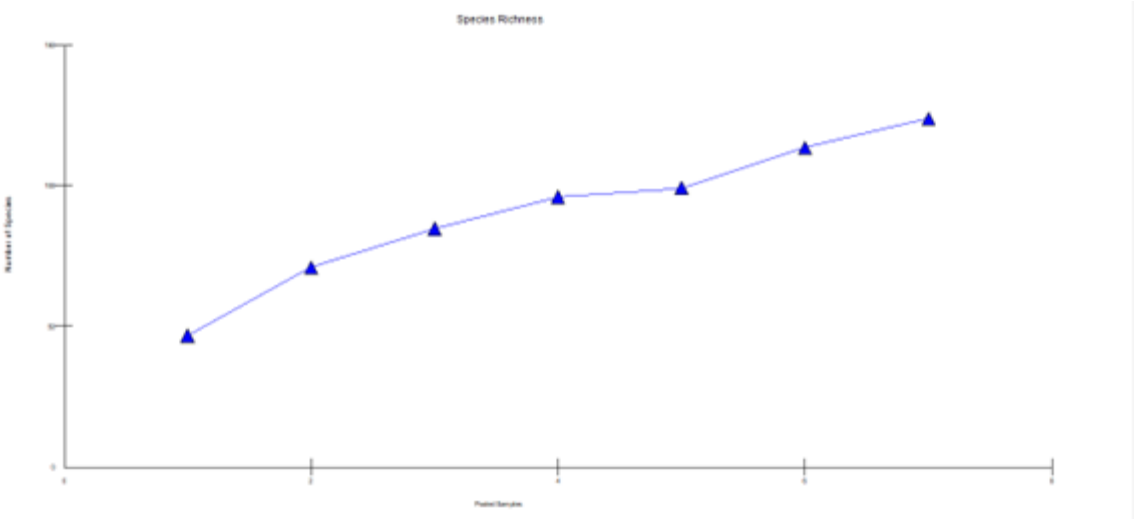
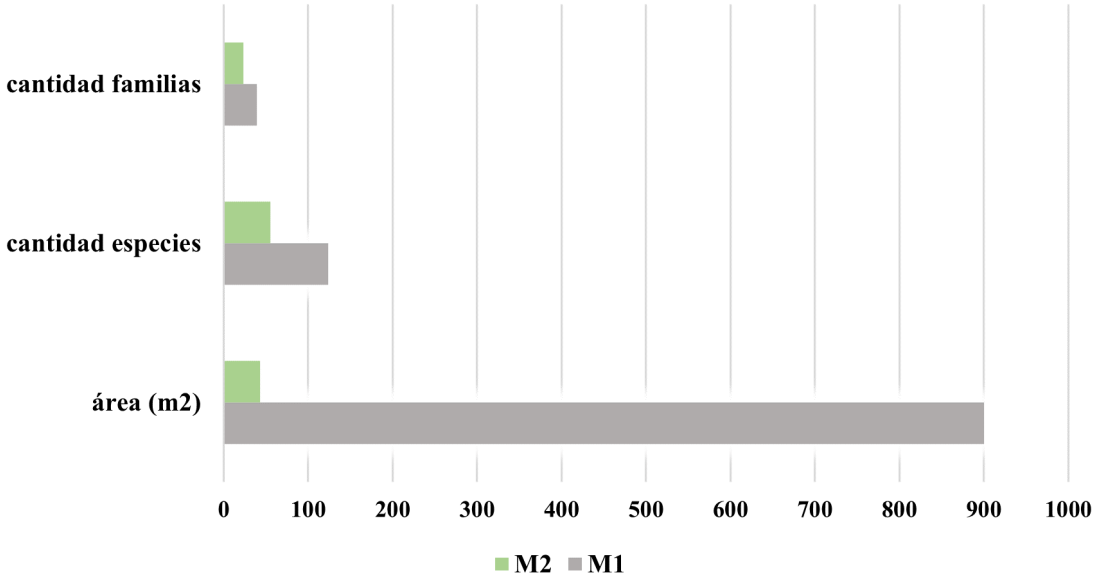


Figure 5.3.1.3.3.2.g
Comparison of species diversity and botanical families reported in this study (M1) and by Piris da Motta *et al.* (M2)



Casual registrations

Two species were observed that had not been recorded in the March 2023 study and were not found within the sampling units on this occasion, but are considered important to enrich the floristic list of the site. The species mentioned are *Dolichandra cynanchoides* Cham (**Photo 21**) and *Utricularia foliosa* L (**Photo 22**).



Photo 21: *Dolichandra cynanchoides.*



Photo 22: *Utricularia foliosa.*

State of conservation

The current species richness is 72 in 0.05 ha, corresponding mostly to marsh and aquatic species, due to the large amount of water that remains stagnant. There is little data on species richness in the *Copernicia alba* palm groves; some studies mention species present at a certain time of the year, but it should always be borne in mind that the herbaceous vegetation of the palm grove is very changeable and depends on the months of flooding, as the palustrine and aquatic species are those that predominate when the water level remains high, while others may appear in dry periods (MERELES, 2005).

To assess the conservation status, more consideration was given to substrate characteristics and presence/absence of threatened species. The soil was very uneven, with small pits due to cattle trampling, resulting in very compacted areas when dry and deep when saturated with water.

No endangered or rare species have been recorded in the savanna, although they are not reported in other studies either, so we cannot know with certainty whether this criterion would apply to this vegetation type. We can only infer that the savanna vegetation is in a degraded state due to cattle trampling.

Conclusions

Four species are present in the study site with threat category according to Resolution N° 470/2019 of the Ministry of Environment and Sustainable Development/MADES, (**Table 5.3.1.3.2.g**). In the IUCN red list[1] , the following species are found: *Libidibia paraguariensis*, which is considered *Vulnerable (VU)* and *Cynophalla retusa,* which is considered *Near Threatened (*NT).

All species recorded are mentioned as common in this type of forest and savannah according to Peña-Chocarro *et al*. (2006) and Mereles (2005; 2007; 2015; 2018).

Despite showing signs of degradation, the forest showed abundant regeneration and is home to endangered species. The savannah shows signs of cattle trampling, although this does not prevent the development of native species typical of this type of ecosystem.

Abundant flowering and fruiting of species was observed, which clearly demonstrates the presence of pollinators and necessary dispersal agents, so that the vegetation develops without difficulty.

Table 5.3.1.3.2.g
Threatened species present on the site

Species	Common name	State of conservation (MADES)	Conservation status (IUCN)
Cohniella jonesiana (Rchb. f.) Christenson	Orchid	Endangered	-
Cynophalla retusa (Griseb.) X. Cornejo & H.H. Iltis	Shrub	-	Near Threatened (NT)
Libidibia paraguariensis (D. Parodi) G.P. Lewis	Guayacán	Endangered	Vulnerable (VU)
Monteverdia ilicifolia (Mart. ex Reissek) Biral	Kangorosa	Endangered	-
Prosopis nigra (Griseb.) Hieron	Black locust	Threatened with extinction	Data Deficient (DD)

Source: own elaboration.

Cohniella jonesiana (Rchb. f.) Christenson is an epiphytic orchid, its main threat is habitat loss and fragmentation.

Cynophalla retusa (Griseb.) X. Cornejo & H.H. Iltis is a terrestrial shrub, distributed in Latin America, mainly in Argentina, Paraguay and Brazil. Its main threat is habitat loss and fragmentation.

Libidibia paraguariensis (D. Parodi) G.P. Lewis is a tree whose wood is used in the construction of poles and outdoor structures, as well as for making musical instruments. Its bark is highly valued in folk medicine, with astringent properties. Its main threat is the loss of habitat.

Monteverdia ilicifolia (Mart. ex Reissek) Biral is a shrub frequently used in folk medicine. The leaves and roots of the plant are consumed for the treatment of infections and wounds, and as an anticarcinogen. Root extraction of this species and habitat loss are the main threats to its populations.

[1] International Union for Conservation of Nature: IUCN Red List of Threatened Species.

Prosopis nigra (Griseb.) Hieron is a tree used for the production of firewood, charcoal and flour. Its populations are threatened by habitat loss, and although it is not categorised as "Endangered", it is listed as "Threatened with Extinction".



Photo 23: *Monteverdia ilicifolia*, endangered.



Photo 24: *Haemionitis tomentosa.*



Photo 25: *Hydrolea spinosa.*



Photo 26: *Stemodia aff. palustris.*



Photo 27: *Solanum glaucophyllum.*



Photo 28: *Evolvulus nummularius.*



Photo 29: *Gleditsia amorphoides.*



Photo 30: *Schinopsis balansae.*



Photo 31: *Verbena litoralis.*



Photo 32: *Nymphoides indica.*

5.3.1.3.3.3
Mapping and Quantification of Land Cover and Land Use on the Ground

Similar to the AID, the Plant ADA is mostly covered by native vegetation (99.19%), consisting mainly of hydromorphic Savannah (78.78%) and Forests (20.41%) (**Table 5.3.1.3.3.3.a**).

Table 5.3.1.3.3.3.a
Vegetation cover and land use on the plant site, according to the Vegetation Clearance Zones as defined in Figure 2.7.2.1.a.

Class	Zones			Total	
	A	B	C		
	hectares			hectares	%
Native vegetation	**20,66**	**4,08**	**5,10**	**29,85**	**99,18**
Sub-humid semi-deciduous forests	2.65	0.11	3.38	6.14	20.41
Hydromorphic savannas	18.01	3.98	1.72	23.70	78.77
Anthropised areas	**0.25**	**-**	**-**	**0.25**	**0.82**
Silvopastoral use	0.03	-	-	0.03	0.11

Class	Zones			Total	
	A	B	C		
	hectares			hectares	%
Rural construction	0.01	-	-	0.01	0.02
Artificial lake	0.21	-	-	0.21	0.69
Total	**20.91**	**4.08**	**5.10**	**30.09**	**100.00**

Source: own elaboration.

The intervention is estimated to cover an area of 24.99 ha (83% of the ADA), corresponding to Zones A and B shown in **Figure 2.7.2.1.a** of **Section 2.7.2.1**, where the plant facilities will be built. Of these 24.99 ha, 24.75 ha correspond to areas with native vegetation, being 2.76 ha of sub-humid forest and 21.99 ha of savannah. In the future it may be necessary to intervene in Zone C to expand the plant. In this Zone C, with an area of 5.1 ha, there is 3.38 ha of sub-humid forest and 1.72 ha of savannah. If intervention in Zone C were necessary in the future, the total area of native vegetation affected would be 29.85 ha, 24.85 ha corresponding to Zones A + B and 5.1 ha to Zone C.

The transmission line easement strip (50 m, 25 m on each side of the axis) is also mainly occupied by anthropogenic land uses (76.27%), mainly agricultural cultivation. The native vegetation is mainly characterised by hydromorphic savannah (1.27 ha, or 23.36%), only 0.02 hectares correspond to forest (0.38%) (**Table 5.3.1.3.3.3.b**).

Table 5.3.1.3.3.3.b
Vegetation cover and land use in the transmission line easement strip (50 m wide)

Class	Hectares	%
Native vegetation	**1.29**	**23.73**
Sub-humid semi-deciduous forests	0.02	0.38
Hydromorphic savannas	1.27	23.36
Anthropised areas	**4.16**	**76.27**
Anthropic areas	0.57	10.53
Pathways	0.37	6.83
Irrigation canal	0.11	2.05
Cultivation	2.64	48.42
Transmission line	0.46	8.44
Total	**5.45**	**100.00**

Although **Table 5.3.1.3.3.3.b** shows the amount of vegetation cover in the total LT easement strip, to show its degree of anthropisation and the positive impact of the layout study carried out, it must be taken into account that the removal of vegetation for the construction of the LT will not be carried out in the entire easement, as indicated in action A.2.03 of Section 6.1.2 and impact 4.01 of Section 6.1.3.2..03 of **Section 6.1.2** and impact 4.01 of **Section 6.1.3.2.** The removal of vegetation will only be necessary in the 6 m wide service strip and in the area of the towers, which will reduce the impact on vegetation to only 0.07 ha of savannahs.

The pipeline easement strip (5 m, 2.5 m on each side of the axis) is mainly occupied by native vegetation, which represents 60% of the area, but 47.8% is savannah and only 12.2% is forest. Areas with anthropic use, represented mainly by pasture, occupy 40% of the easement strip (**Table 5.3.1.3.3.3.c**).

Table 5.3.1.3.3.3.c
Vegetation cover and land use in the water and effluent pipeline easement strip (5 m wide)

Class	Hectares	%
Native vegetation	**0.69**	**60.0**
Sub-humid semi-deciduous forests	0.14	12.2
Hydromorphic savannas	0.55	47.8
Anthropised areas	**0.46**	**40.0**
Anthropic areas	0.46	40.0
Total	**1.15**	**100.00**

5.3.2
Terrestrial Fauna

This report presents the results of the fauna survey in the area of influence corresponding to the "Free Trade Zone and Green Hydrogen and Ammonia Production Plant" of ATOME Paraguay S.A.

The method applied for wildlife diagnosis is the "Rapid Ecological Assessment (REA)", a methodology that has been developed and refined by *The Nature Conservancy* (TNC). The basic publication is called "Un enfoque en la Naturaleza" TNC (2000) in Spanish language[2] .

The work consisted of generating valid and formal scientific information on the existing biodiversity on the fraction of land, over a period of 15 days, seven days in March 2023 and seven days in June 2023. All the information, both primary and secondary, was systematised by the multidisciplinary technical team that participated in the survey.
Each specialist consulted existing scientific reports, published or unpublished, that refer to the biodiversity of the area. The lists of official institutions such as the Ministry of Environment and Sustainable Development, National Museum of Natural History of Paraguay - MNHNP, Faculty of Chemical Sciences - FCQ, National Institute of Development and Land - INDERT, National Institute of Statistics - INE, Ministry of Agriculture and Livestock - MAG, National Forestry Institute - INFONA, among others, were used.

[2] The Nature Conservancy. 2002. A Focus on Nature: Rapid Ecological Assessments, 202 p. Arlington, Virginia, USA.

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Specific equipment was used for each taxa and field notebooks were used with information such as plant community, plant inventory sampling location, animal inventory sampling location, plant observations and some special characteristics such as degree of threat or use, and animals with high conservation value recorded. It should be noted that no invasive methods requiring the handling, capture or transport of wild animals were applied.
The desk and field reports were compared to produce the lists of items, the analysis and the final result.

5.3.2.1
Objectives

Draw up species lists from secondary and primary data for the groups of birds, reptiles, amphibians and terrestrial mammals (medium, large and flying). From these lists, verify the existence of species and/or habitats with high conservation value.

5.3.2.2
Study Area

Typical humid Chaco habitat with karanda'y palm groves and islets of forest with pindó palms, with lots of fruit. The ground was dry but very uneven due to heavy cattle trampling when waterlogged/waterlogged. The cattle had been removed a month before the first campaign (**Photos 01 to 03**). No permanent water bodies except for the borrow area next to the house and another one in front of the road (**Photo 04**). In the second season, due to rainy periods, the entire study area was flooded (**Photos 05 to 08**). The whole area of the field was walked to take wildlife samples.

Figure 5.3.2.2.a
Location of the wildlife sampling area in the field



Source: Google Earth (2022).

The first fauna survey campaign was carried out from 4 to 8 March 2023. The second field campaign took place from 20 to 24 June 2023.



Photo 01: Detail of the environment sampled by the fauna team.



Photo 02: Detail of the environment sampled by the fauna team.



Photo 03: Isolated palms and small trees recorded in the vicinity of the Project.



Photo 04: Lake located partly on Project land and partly on a neighbouring property.



Photo 05: Flooded environments with the presence of palm trees and isolated small trees recorded in the vicinity of the Project.



Photo 06: Flooded environments with the presence of palm trees and isolated small trees recorded in the vicinity of the Project.



Photo 07: Flooded environments with the presence of palm trees and isolated small trees recorded in the vicinity of the Project.



Photo 08: Vegetation island with water bodies.

5.3.2.3
Survey Methods

Secondary data

The following references have been used for the study of secondary data on the regional fauna:

- Birds - Lesterhuis (2009); Lesterhuis and Méndez (2016) and in addition records of Rebeca Irala were found in eBird for the region of interest.

- Amphibians and Reptiles - Brusquetti & Lavilla (2006); Weiler & collaborators (2013) and Cacciali & Buongermini (2021).

- Terrestrial mammals - Fox & Martim (1996); Lopez-Gonzalez (2004) and Rumbo (2010).

All full citations are given in the bibliographical references.

Primary data

For the active search for terrestrial fauna, no fixed transects were defined. The whole area was covered in a random search for two reasons: the sampling area is small and could therefore be covered completely, and also efforts could be concentrated in the environments with the highest potential for detection of focal groups. Nevertheless, all sampling effort was counted per hour/expert or team, which allowed for estimation of effort and statistical analysis. The effort per focus group and/or specific method is presented below.

It is important to mention that, during the first sampling campaign, active search methods were carried out with time-limited effort, and only for the herpetofauna group there was no quantification of the species recorded. In the second campaign, quali-quantitative methods were used for herpetofauna and the complementary methods of Mackinnon's Lists and Listening Points for avifauna.

5.3.2.3.1
Avifauna

Fieldwork consisted of walks and observations, both opportunistic along the route, as well as searching to record as many species as possible, from fixed points and in different habitat types.

Bird species were classified according to the taxonomy of Remsen *et al*. (2023), common names according to Del Castillo and Clay (2004, 2005). They have been categorised according to their global and national conservation status, their inclusion in an international convention, their migratory status, their affinity to a particular habitat, whether they are waterfowl or grassland birds, whether they are exotic, invasive or invasive native species, and their degree of endemism to the ecoregion. Two methodologies were applied: Fixed Points and Mackinnon Lists.

Mackinnon Lists

For this methodology, the observer continuously recorded all species seen and/or heard along the trails. Once the first 10 different species on each list were recorded, a new list of 10 species was started, and so on (RIBBON, 2010). The use of Mackinnon's lists allows the frequency of occurrence of species in a given area (Frequency Index - or FFI) to be calculated, basically by dividing the total number of lists in which a given species appeared by the total number of lists obtained in the area (RIBBON, 2010). It is assumed that the more common a species is, the more lists it will appear in, and the higher its FFI should be (RIBBON, 2010).

The responsible observer carried out three hours of sampling on routes along the field, in two sampling periods (morning and afternoon). Thus, the effort was 1,800 minutes or 30 hours per sampling campaign (180 minutes X 02 periods X 05 days).

Fixed Listening Point Sampling

To carry out the sampling by listening and observation points, seven (07) observation points were established, arranged uniformly throughout the Project area, at a minimum distance of 200 m between them, to prevent the same individual from being recorded at more than one listening point (VIELLIARD *et al*., 2010). Each point was treated as a sample, and was defined so as to cover the maximum of physiognomic forms and microhabitats present in the sampled environments, as uniformly as possible (VIELLIARD *et al*., 2010). Sampling focused on the periods of greatest bird activity, early in the morning, when the professional remained at each point for 10 minutes, recording all birds seen and/or heard, as well as the number of individuals.

Through the tapping points set it is possible to calculate the relative abundance of species in a given area (Point Abundance Index - or PAI), basically by dividing the total number of contacts obtained for a given species by the total number of samples (tapping points) taken in the area. As this methodology generates relative abundance data, it is also possible to calculate Diversity Indices (e.g. Shannon's Index - H') and Indices of Evenness (Pielou's Index) for the sampled areas. Thus, the sampling effort was 350 minutes during sampling (08 points X 10min X 01 period X 05 days).

The records were made by direct observation, with the naked eye or with Swarovski 8x32 binoculars, the auditory records by playback technique and by comparison with recordings of the voices of the species with a Nokia C3-00 player. The most interesting records were documented by photography with a Nikon Coolpix B 600 camera with 60X optical and 120X digital zoom. The coordinates and bearings were obtained with a Garmin nüvi 40LM GPS (**Photos 09 and 10**).



Photo 09: Survey of birdlife with binoculars.



Photo 10: Survey of avifauna with auditory records.

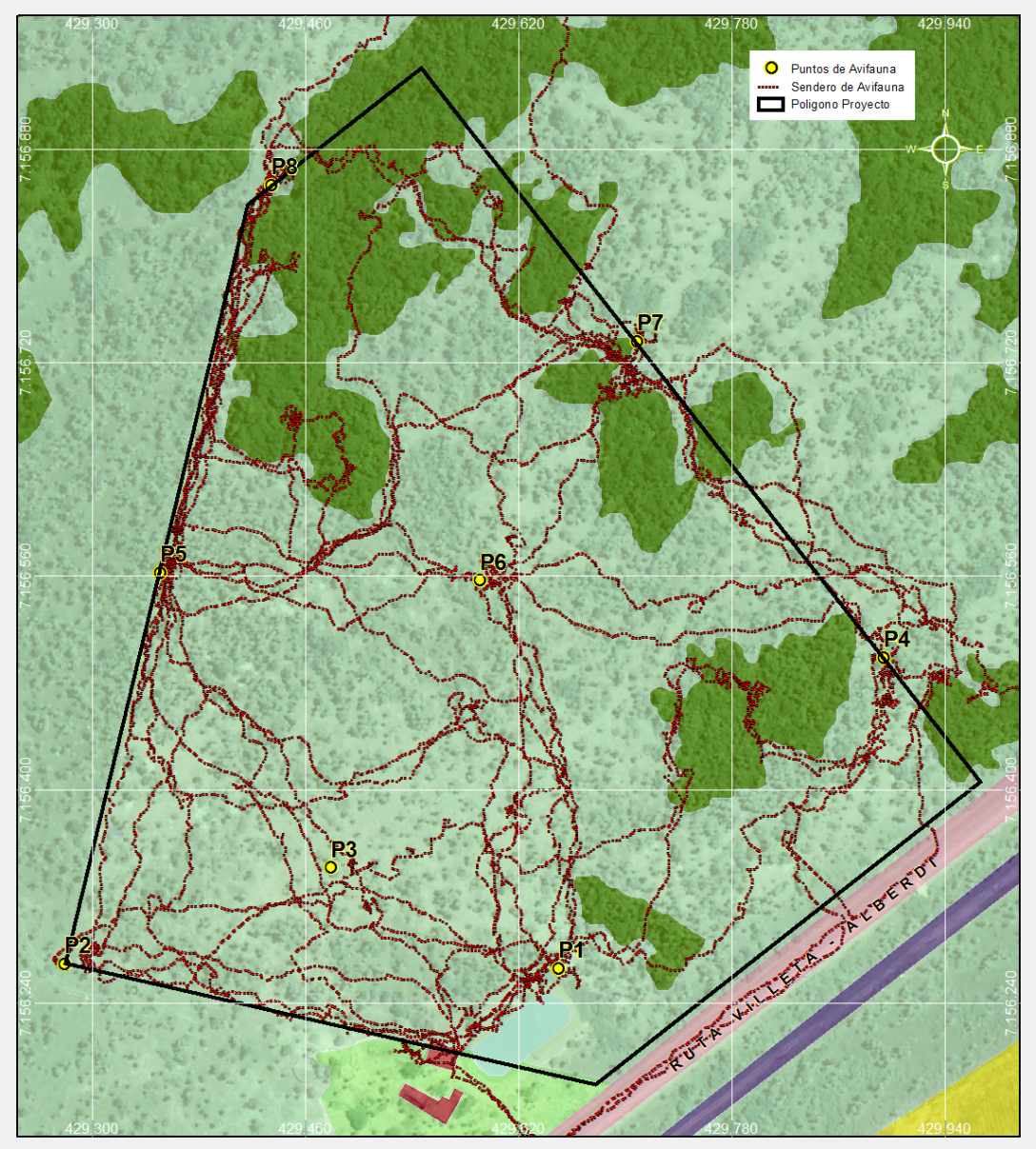
Species determinations were made from experience and familiarity with birds perched and in flight, with their voices, songs and calls, with their nests and downed feathers. The book by Narosky *et al*. (2022) was used as a field guide, which the bird specialist collaborated to adapt for application in Paraguay. For the identification of nests, the guide by De la Peña (2010) was used, which the author collaborated with for its edition and adaptation to the country. The recordings of bird voices used as reference were those stored in a voice bank of various authors such as those that appear on the xeno-canto website (http://www.xeno-canto.org/).

To attract birds and obtain a response in forest habitats, we used a technique that is very common in the region called "kavure'i" (*Glaucidium brasilianum*), a small, mostly nocturnal but also diurnal bird of prey that preys on the nests and chicks of other birds, so that when they hear its voice they are

attracted to the place to see what is happening. To attract species of conservation importance and be able to detect them, the corresponding voices are used.

Figure 5.3.2.2.3.1.1 below shows the bird field surveys carried out using the *Mackinnon List method*, as well as the 7 points corresponding to the *Fixed Listening Points* methodology.

Figure 5.3.2.3.3.1.a
Trails and fixed points for avifauna sampling



5.3.2.3.2
Herpetofauna

For the herpetofauna, random and stratified walking tours were carried out, in which the different strata/environments found in the sampling sites were selected, and within these sites random searches were carried out, which involved an active search for amphibians and reptiles, examining all types of potential refuges such as leaf litter, stones, logs, holes, etc. During the work, a camera with GPS was used to geo-reference and photograph the records whenever possible. In addition, leather

gloves and hooks were used, as well as other equipment necessary for the proper handling of snakes to avoid injury to the person or animal (**Photos 11 and 12**).

These surveys were carried out at different times (daytime, twilight and night-time) to ensure that the different time periods of activity of the different species were monitored. In addition, an evaluation of the acoustic signals emitted by amphibian males during the breeding season was carried out to identify species that might not have been detected by direct observation. Amphibian songs were recorded and compared with on-line sonogram databases and repositories, in addition to published guides for the identification of amphibian voices in the region (STRANECK *et al*., 1993; DE LA RIVA *et al*., 2000; HADDAD *et al.,* 2005).

The sampling effort was 6 hours of search per day in the entire sampling area, during five consecutive days, totalling 30 hours of search/day. This effort was concentrated between 15.00 hs and 20.00 hs, covering the diurnal, twilight and nocturnal periods, when this group has its activity peaks throughout the day.

Species identification was carried out using the work of Cacciali & Buongermini (2021). The presence of threatened species among those found was assessed using the MADES Resolutions on threatened amphibians and reptiles (SEAM Resolutions N° 433/19 and N° 206/2020 respectively) with the analysis of the threat justification of Motte *et al*. (2019) for amphibians and Martínez *et al*. (2020) for reptiles.



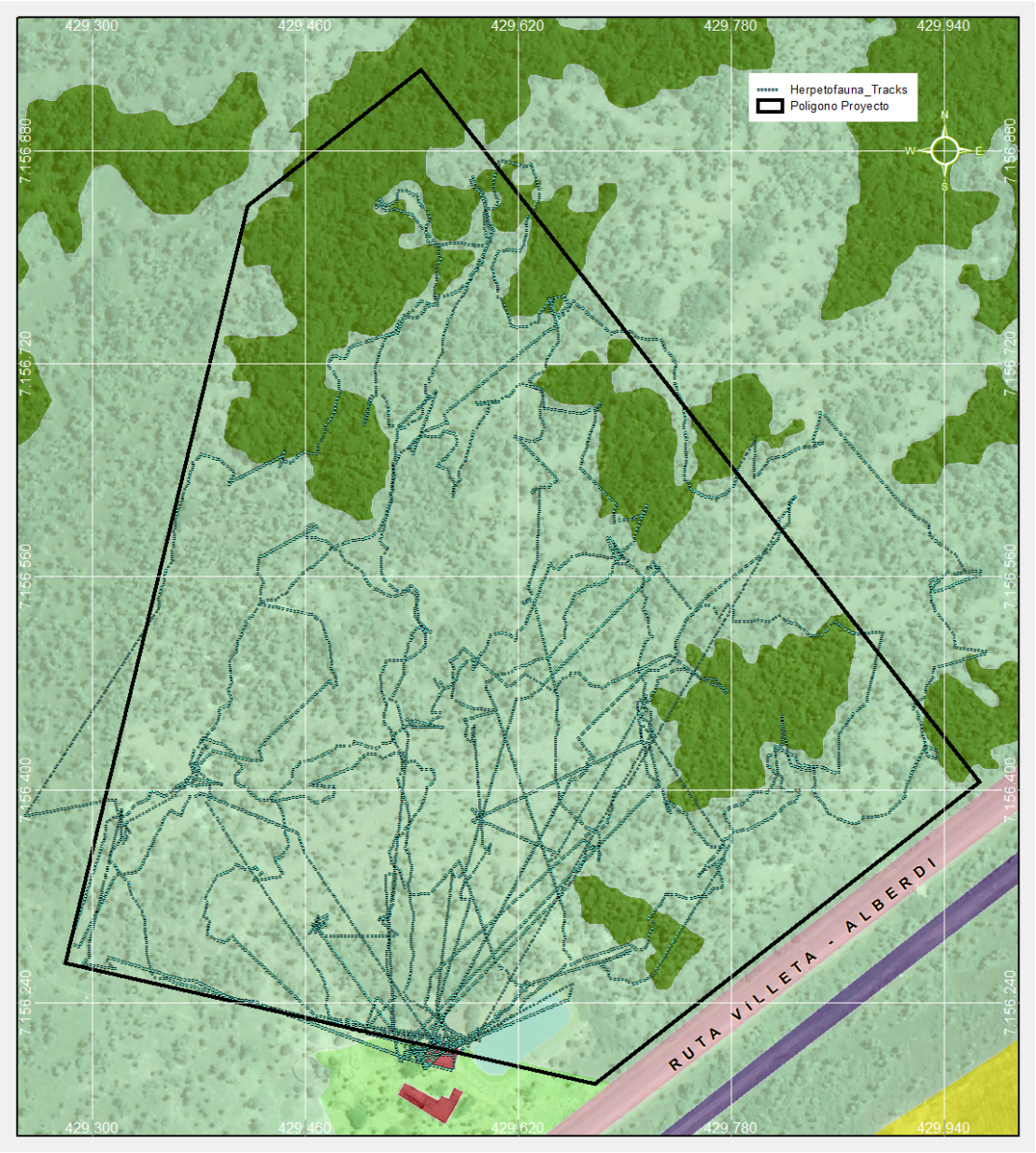
Photo 11: Active search for reptiles and amphibians.



Photo 12: Nocturnal census of amphibians with auditory recordings.

Figure 5.3.2.2.3.2.a shows the field walks carried out for herpetofauna sampling.

Figure 5.3.2.2.3.2.a
Herpetofauna sampling trails



5.3.2.2.3.3
Terrestrial Mammals

Medium and large mammals

As most medium and large mammal species can be identified in the field, sampling was carried out through time-limited direct and indirect observation methods, camera trap monitoring and interviews with local residents.
Direct and indirect observation

Direct observation methods included visual recording (including photographs), vocalisation and finding carcasses, while indirect observation methods included recording tracks, burrows, signs and marks, as well as faeces.

Specialists in this group walked all existing access points in each sampling area to obtain direct and indirect records. Observations were also made in the surrounding area and casual records were considered during movements.

The results obtained in these searches were limited by time in order to generate an index of relative abundance of the species recorded. These searches were conducted with the aid of field guides, binoculars and GPS (**Photos 13 to 16**).

In cases of sighting and/or vocalisation, the location, species, number of individuals sighted and time were recorded. For all records of medium and large mammals, the source data (habitat, point of observation, date) and the form of the record were recorded.

The proposed sampling effort was 6 hours of search per day in the entire sampling area, during five consecutive days, totalling 30 hours of search/day. This effort was concentrated in the early morning, twilight and night time periods, taking into account the characteristic activity pattern of the different species in this group.

At this point, the area of the transmission line was also sampled, using both direct and indirect observation methodologies.



Photo 13: Active daytime search for mammals.



Photo 14: Nocturnal mammal census.



Photo 15: Indirect records of mammals.



Photo 16: Indirect records of mammals.

Camera traps

Camera traps are an efficient technique for the detection of medium and large mammals, as they allow the species to be photographed in the wild, without them being aware of the presence of the equipment.

The camera trap works by means of a motion sensor, even allowing to record the species (video mode) (CHEIDA & RODRIGUES, 2010). For the sampling, a total of 5 camera traps were installed in the sampling area, in a place considered relevant by the researcher for the recording of focal species (**Photos 17 and 18**). The traps remained active for 5 consecutive days.

Camera trap sites were selected taking into account the environments and traces of medium and large mammals. To this end, priority was given to trails and natural paths used by the target species, fruit trees, active burrows and places with water availability and/or barriers to maximise the results of photographic captures of large mammals. Sampling effort was 25 hours/day for large mammals (5 camera traps x 5 days x 1 sampling area).



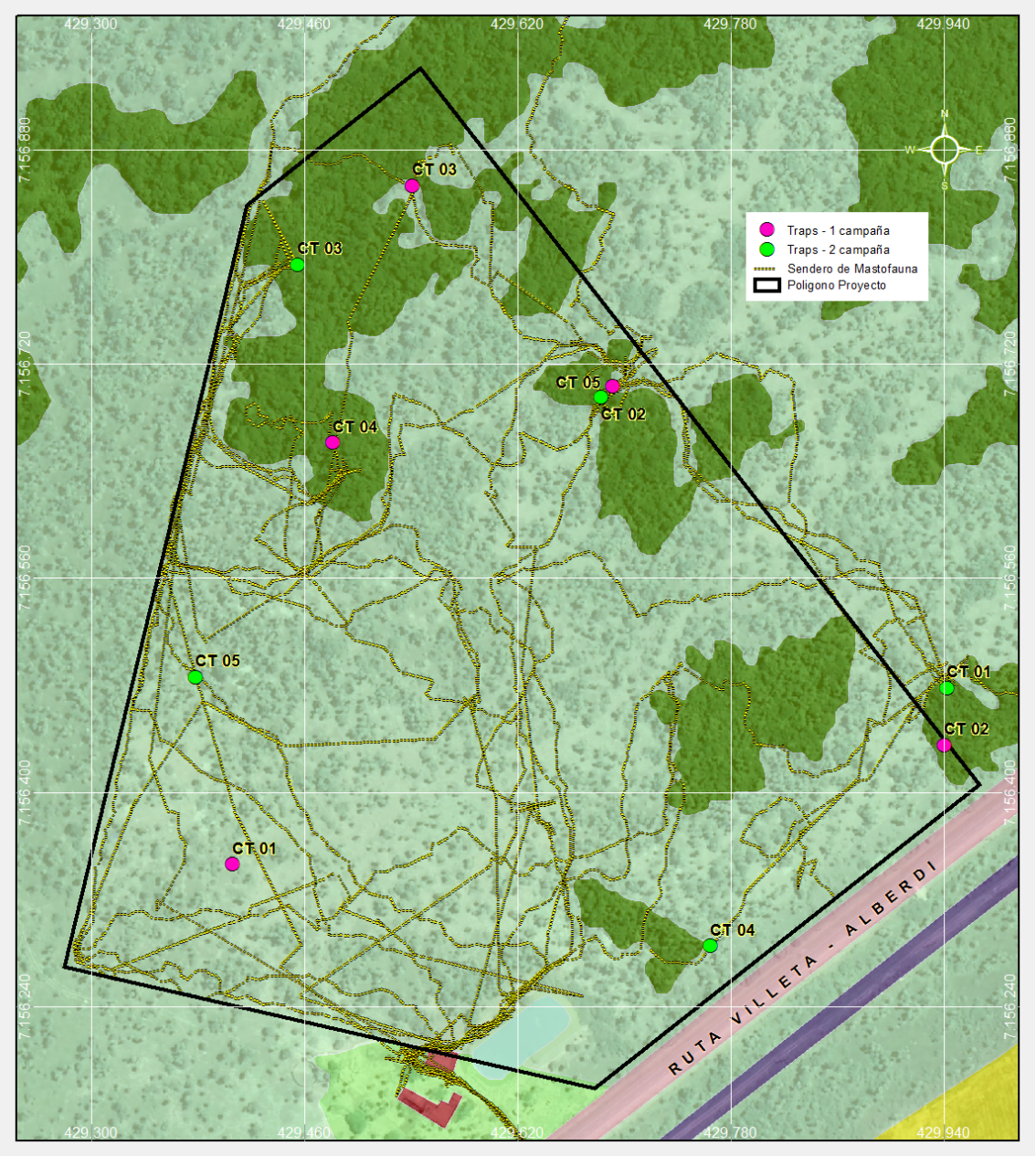
Photo 17: Camera trap installation.



Photo 18: Detail of the camera trap installed.

Figure 5.3.2.3.3.3.a shows the routes taken in the mastofauna fieldwork and the location of camera traps used in the two sampling campaigns.

Figure 5.3.2.3.3.3.a
Mastofauna sampling and camera-trap locations



5.3.2.2.3.4
Aerial Insectivorous Bats

Increasingly, researchers in different countries are using echolocation to acoustically identify bat species. Of the 93 species of aerial insectivorous bats susceptible to acoustic identification, 65 have formally described sonotypes and for 28 no information is available (ARIAS-AGUILAR *et al*., 2018). With the method, patterns of richness and activity (bat passes) are obtained and for some groups it is already possible to arrive at identifications at specific levels with some ease (ARIAS-AGUILAR *et al*., 2018). The great advantage of this method is that it is non-invasive, efficiently sampling the bat families sub-sampled by the mist net method and with the possibility of

obtaining a number of records (bat passes) that allow more robust detailed analyses in a shorter study time compared to mist net sampling.

The sampling method is considered passive, with the equipment installed during the night at strategic locations within the sampling area. During the analysis, the number of bat passes, defined as a sequence of three or more echolocation calls per unit of time (e.g. passes/15 seconds), is recorded (BARROS *et al*., 2017).

The equipment used is the Song Meter SM4 BAT FS, with the following configuration: 400 kHz sampling frequency, 3s pre-triggering and 15s after triggering. The identifications have been performed automatically and manually, the former serving to separate files with noise from files with bat calls using the software Kaleidoscope version 3.1.1 (www.wildlifeacoustics.com) and after this evaluation all files with bat calls were evaluated manually using the program CallViewer18 (SKOWRONSKI & FETON, 2008), using the automatic detection function of the Hamming window, FFT=1024, window length of 1 ms and background threshold of 10 dB. The parameters were extracted from the best calls of each vocalisation sequence.

The equipment was programmed to record for 12 hours at night and the records of the first 10 minutes of each hour of recording were analysed.

The sampling effort was 720 minutes per night for five consecutive nights per recording sampling area, totalling 3,600 minutes of recording during the study. The first 10 minutes of each hour per night were analysed, for a total of 600 minutes of recordings analysed. This method is indicated to avoid duplication of recordings obtained through bioacoustics (**Photos 19 and 20**).



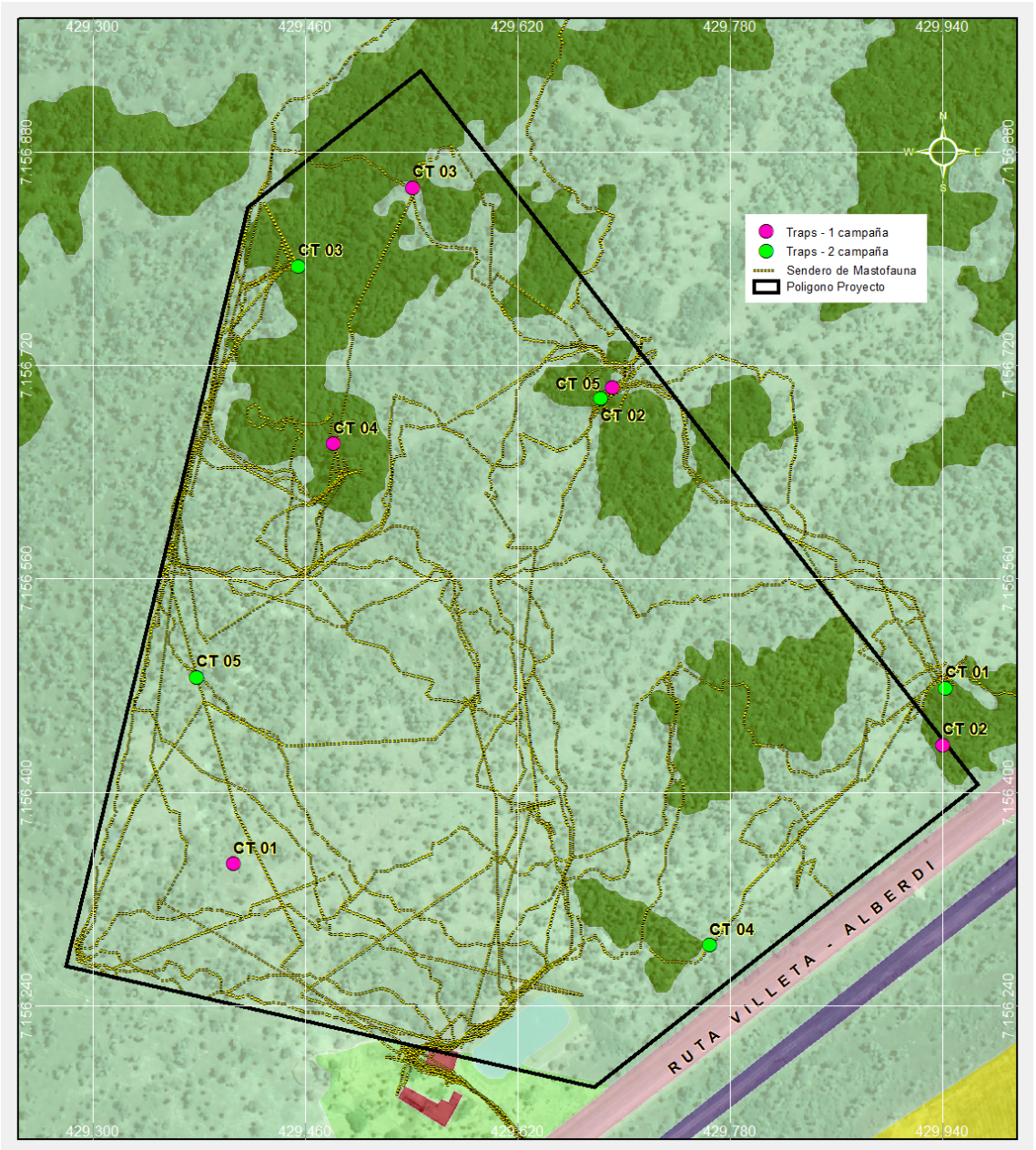
Photo 19: Programming of the bioacoustic Songmeter device.



Photo 20: Detail of the Songmeter bioacoustic device installed for bat detection.

Figure 5.3.2.3.3.4.a shows the routes carried out in the mastofaunal fieldwork, including the positions where the Songmeter was installed on each sampling night during the two field campaigns.

Figure 5.3.2.3.3.4.a
Songmeter installation locations



5.3.2.3.3.5
Data analysis

The Shannon diversity index (H') was used to assess species diversity. This index weights the distribution of each species by its relative abundance, so that rarer species have a lower weight than more common species. This index is used to measure diversity in categorical data, treating species as symbols and the respective population size as a probability. The advantage of this index is that it takes into account the number of species and the dominant species. The index is calculated by:

$H' = - \sum pi \ln pi$

Where:

pi = (ni/N) probability that a sampled individual belongs to species i; ni = the total number of individuals of species i;
N = total number of individuals sampled in the area.

Fisher's Alpha diversity index, which is less related to the total number of records for each locality, has also been used, allowing for less biased comparisons between areas with very different numbers of records. F i s h e r ' s Alpha index is implicitly defined by:

$S = \alpha . \ln(1+n/\alpha)$

Where:

S = number of species
n = total number of individuals recorded; α = diversity index.

The Jacknife 1 and Chao2 estimators have been used for richness. The Jacknife 1 method estimates total richness using the number of species present in a single sample. The Chao2 method estimates total richness using the number of species represented in only one sample and the number of species in only two samples.

These wealth estimates are calculated using the equations:

$Jacknife\ 1 = s + Q1(n-1/n)$

Where:

s = observed wealth;
Q1 = number of species occurring exactly in the sample; N = number of samples.

$Chao2 = s+(Q1^2/2Q2)$

Where:
s = observed wealth;
Qj = number of species present in j samples.
In addition, Pielou's fairness index (J') has been applied, using the following formula:

J' = H'/ln(S)

Where:

S = number of species.

Finally, the accumulation curve was constructed to evaluate the effectiveness of the survey campaign (sufficiency of sampling), comprising the sum of records of species catalogued daily in the observations (qualitative and quantitative), using the rarefaction curve by the *Mao Tao* index.

5.3.2.4
Results

The following sections present the results obtained in the two terrestrial fauna baseline field survey campaigns. The photographic record of these surveys is presented in **Annex 9** and the lists of species resulting from the surveys are presented in **Annex 10.**

5.3.2.4.1
Avifauna

First campaign

With the first bird survey campaign, which took place from 04 to 08 March 2023, 1,037 bird records were obtained, belonging to 121 species, distributed in 22 orders and 42 families (**Table 5.3.2.4.1.a** in **Annex 10**).

With the richness obtained during this campaign, among the orders, the Passeriformes (birds or songbirds) was the most representative, with 58 species recorded, representing approximately 48% of the total. In sequence are the orders Pelecaniformes (herons, egrets, egrets, boobies and the like) and Psittaciformes (macaws, macaws, cockatoos, parrots and the like), both with eight species, representing approximately 7% of the recorded bird assemblage each (**Table 5.3.2.4.1.a**).

In terms of families, the most representative families were Tyrannidae (phiophytes, lice, doraditos, pitogüés and similar), with 15 species (12%), followed by Furnariidae (honeros, honeritos, pijuís and similar) and Icteridae (boyeros, tordos, boyeritos and similar), both families with nine species recorded, representing around 7% of the total obtained, each (**Table 5.3.2.4.1.a**).

State of conservation

Regarding the conservation status of the species recorded, according to the national list of protected species of wild fauna of the class Birds (MADES - Resolution N° 254/19), none of them has a threat classification. For the international classifications of the IUCN (2022), which establishes threat categories according to well-defined criteria based on population reduction, number of breeding individuals, area of distribution, among other criteria, only one species has a degree of threat, being the Talking Parrot (*Amazona aestiva*), which is classified as "Near

Threatened - NT" of extinction (**Table 5.3.2.4.1.a**).

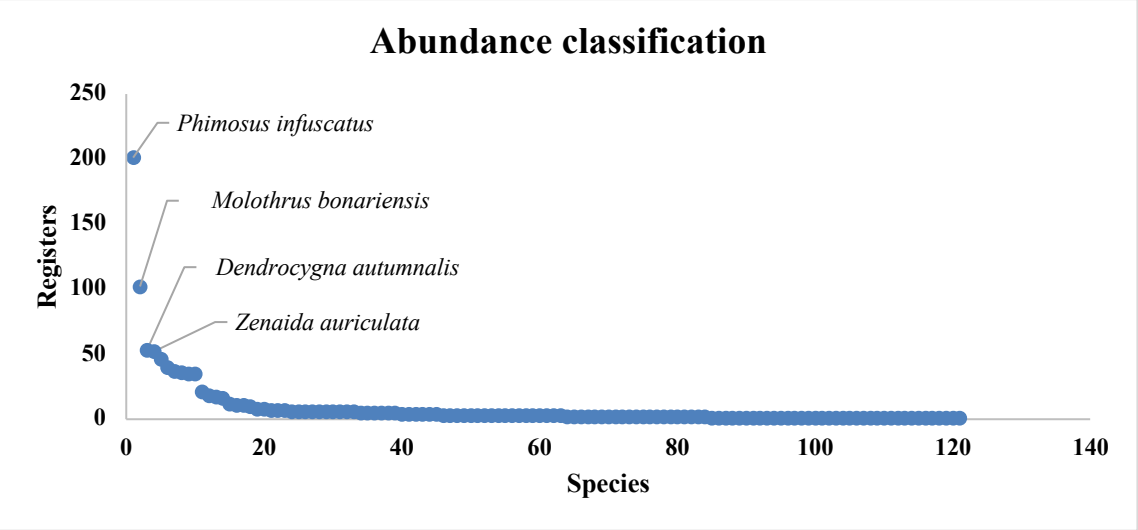
While for the international CITES list (2023), only the yabiru (*Jabiru mycteria*) is included in Appendix I, which includes species threatened with extinction (**Table 5.3.2.4.1.a**). On the other hand, 19 species recorded are included in Appendix II of the same list, which includes species that are not threatened with extinction, but which could become so without rigorous inspection: *Amazona aestiva* (*Amazona aestiva*), Nanday (*Aratinga nenday), Brotogeris* chiriri (*Brotogeris chiriri),* Caracara *plancus (Caracara plancus*), *Chlorostilbon lucidus (Chlorostilbon lucidus*), *Falco femoralis (Falco femoralis*), chinstrap hummingbird (*Heliomaster furcifer),* bronzed hummingbird (*Hylocharis chrysura*), barn owl (*Megascops choliba*), chimachima (*Milvago chimachima*), little parrot (*Myiopsitta monachus*), the cardinal (*Paroaria capitata*), the cardinal (*Paroaria coronata*), the choclero parrot (*Pionus maximiliani*), the blue-headed maracana (*Psittacara acuticaudatus*), Red-winged Parrot (*Psittacara leucophthalmus*), Green-headed Parakeet *(Pyrrhura frontalis)*, Snail Parrot (*Rostrhamus sociabilis)* and Great Crested Petrel (*Rupornis magnirostris*) (CITES, 2023) (**Table 5.).3.2.4.1.a**).

Abundance classification

The abundance ranking of the birds recorded during the first survey campaign is presented below (**Figure 5.3.2.4.1.a**). Looking at the graph below, it can be seen that one species stood out in relation to the others, namely, the smooth-faced crow (*Phimosus infuscatus*), which had a total of 201 records, corresponding to around 19% of the total records obtained during this first survey campaign. This was followed by the black-throated thrush (*Molothrus bonariensis)* with 102 records (10%), followed by the white-winged wigeon (*Dendrocygna autumnalis*) with 53 records (5%) and the black-winged guillemot (*Zenaida auriculata)* with 52 records (5%) (**Figure 5.3.2.4.1.a**).

And for the plots in the lower part of the figure, following the entire X-axis, the majority of species are found, most of which had values of less than 10 records, being represented by 103 species, corresponding to 85% of the total richness recorded (**Figure 5.3.2.4.1.a**). It is worth noting that in 37 cases, the species had only one record, as is the case of the blue heron *(Butorides striata*), red-legged saria (*Cariama cristata)*, yellow-headed crow *(Cathartes burrovianus*), green woodpecker *(Chlorostilbon lucidus)*, congo wader (*Chrysomus ruficapillus*) and American stork (*Ciconia maguari*), White-faced Whistling Duck (*Dendrocygna viduata*), Great Phiophiophio *(Elaenia spectabilis*), Chinstrap Hummingbird (*Heliomaster furcifer),* Chestnut-bellied Sandpiper (*Lurocalis semitorquatus*), Great Kingfisher *(Megaceryle torquata*), Barn Owl (*Megascops choliba)*, and other species (**Table 5.3.2.4.1.a**).

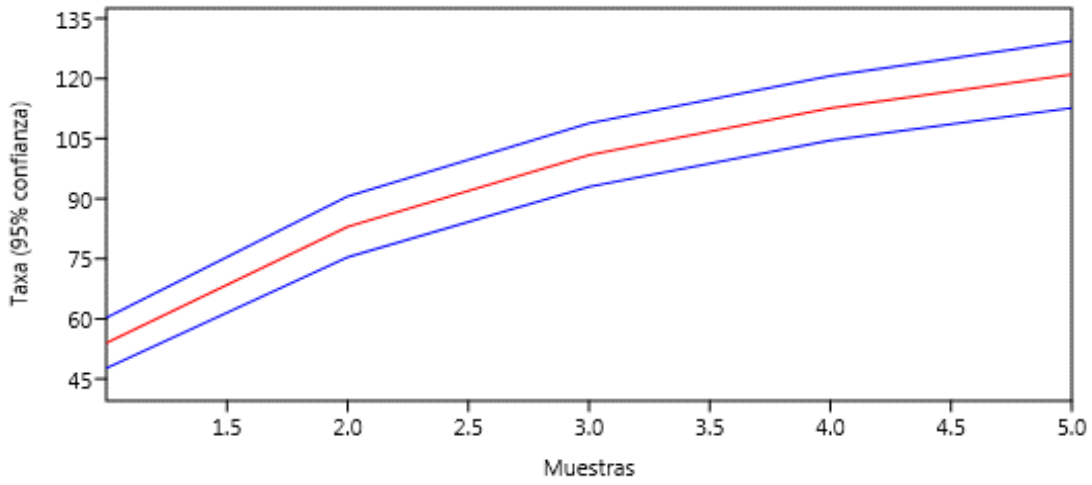
Figure 5.3.2.4.4.1.a
Ranking of the abundance of birds recorded in the first campaign



Adequacy of the sample

In this first campaign, five days of sampling effort were devoted to bird surveys in the project's area of influence. The species rarefaction curve generated shows an upward trend, with no signs of stabilisation, indicating that the actual richness was not reached and that a higher number of species is expected for the areas sampled (**Figure 5.3.2.4.1.b**).

Figure 5.3.2.4.4.1.b
Rarefaction curve of the first campaign



<u>Second campaign</u>

In the second bird survey campaign, carried out from 20 to 24 June 2023 , 1,103 records were obtained belonging to 99 bird species, distributed in 16 orders and 34 families (**Table 5.3.2.4.1.b** in **Annex 10**).
With the richness obtained during this second campaign, among the orders Passeriformes (birds

or songbirds) was the most representative, with 43 species recorded, representing approximately 43% of the total. Next came the Psittaciformes orders (macaws, macaws, macaws, cockatoos, parrots and similar), with nine species (9%), followed by the Pelecaniformes (herons, egrets, egrets, herons and similar) and Piciformes (woodpeckers and woodpeckers), both with eight species, representing approximately 8% of the recorded bird assemblage each (**Table 5.3.2.4.1.b**).

In terms of families, the most representative are Psittacidae (macaws, macaws, maracanas, cockatoos, parrots and the like), with nine species (9%), followed by Picidae (woodpeckers and woodpeckers) and Tyrannidae (phiophytes, lice, doraditos, pitogüés and the like), both with eight species (8%). In sequence are the Thraupidae (canaries, fruiteaters, chogüis, cardinals and the like) and Furnariidae (honeros, honeritos, pijuís and the like) with seven species recorded each (7%) (**Table 5.3.2.4.1.b**).

State of conservation

As for the conservation status of the species recorded in the second campaign, according to the national list of protected species of wild fauna in the Birds class (MADES - Resolution N° 254/19), none of them are classified as endangered. For the international classifications of the IUCN (2022), only one species is classified as endangered, that is, the *Amazona aestiva* parrot (*Amazona aestiva*), which is classified as "Near Threatened - NT" of extinction (**Table 5.3.2.4.1.b**).

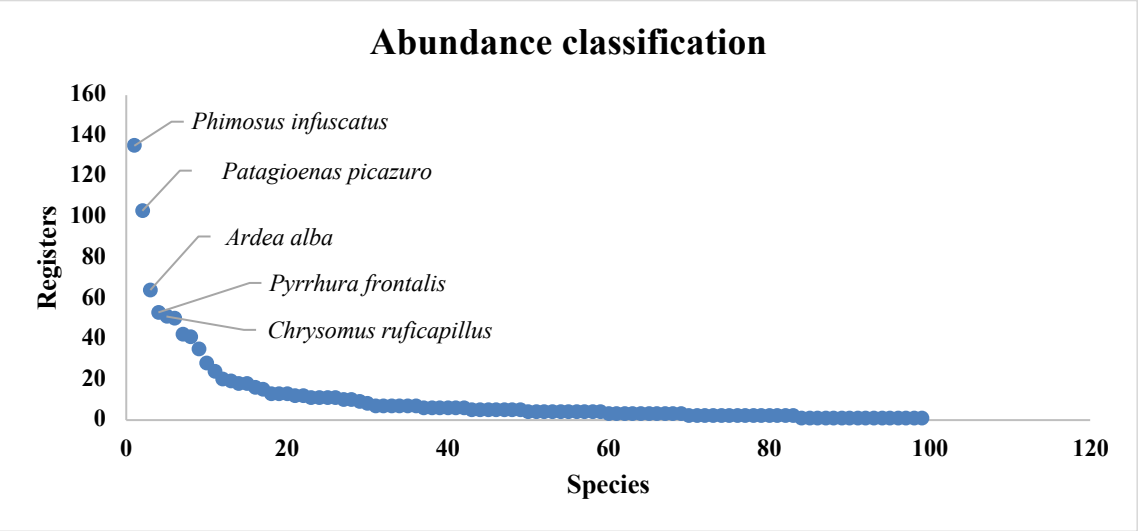
While for the international CITES list (2023), no species is included in Appendix I, which includes species threatened with extinction (**Table 5.3.2.4.1.a**). On the other hand, 20 species are included in Appendix II of the same list, which includes species that are not threatened with extinction, but could become so if there is no strict application of the law. Among these species are the Talking Parrot (*Amazona aestiva*), the Nanday (*Aratinga nenday*), the Chiriri's Warbler (*Brotogeris chiriri*), the Caracara *(Caracara plancus*), the Green-winged Hummingbird *(Chlorostilbon lucidus*), the Red-breasted Falcon (*Falco sparverius*), the Widow's Warbler *(Forpus xanthopterygius)*, the Chinstrap Hummingbird (*Heliomaster furcifer*), the Bronze-winged Hummingbird (*Heliomaster furcifer*), the Black-winged Woodpecker (*Heliomaster furcifer*), the Black-winged Woodpecker (*Heliomaster furcifer*), and the Black-winged Woodpecker (Heliomaster *furcifer),* bronzed grosbeak (*Hylocharis chrysura*), mountain hawk (*Micrastur semitorquatus*), chimachima (*Milvago chimachima*), parakeet (*Myiopsitta monachus)*, cardinal (*Paroaria capitata*), cardinal (*Paroaria coronata*), choclero parrot (*Pionus maximiliani),* and others (CITES, 2023) (**Table 5.3.2.4.1.b**).

Abundance classification

The abundance ranking of the birds recorded during the second sampling campaign is presented below (**Figure 5.3.2.4.1.c**). Looking at the graph below, it can be seen that one species stood out in relation to the others, being the Buff-faced Crow *(Phimosus infuscatus*), which had a total of 135 records, corresponding to about 12% of the total number of records obtained during this second survey campaign. In the sequence is the turtle dove (*Patagioenas picazuro*) with 103 records (9%), followed by the white heron (*Ardea alba*) with 64 records (6%), the green-headed warbler *(Pyrrhura frontalis*) with 53 (5%) and the congo wader (*Chrysomus ruficapillus*) (**Figure 5.3.2.4.1.c**).

And for the plots in the lower portion of the figure, following the entire X axis, the majority of species presented values of less than 10 records, being represented by 71 species, corresponding to 71% of the total richness recorded (**Figure 5.3.2.4.1.c**). It is worth noting that in 16 cases, the species had only one record, as is the case of the water rail (*Aramides ypecaha*), the carau (*Aramus guarauna*), the green hummingbird (*Chlorostilbon lucidus*), the chinstrap hummingbird (*Chlorostilbon lucidus*) and the chinstrap hummingbird (Aramus *guarauna)*, chinstrap hummingbird (*Heliomaster furcifer),* golden-eyed flycatcher (*Hemitriccus margaritaceiventer*), chestnut-coloured woodpecker (*Lurocalis semitorquatus)*, mountain hawk (*Micrastur semitorquatus*), Great Hawthorn *(Phacellodomus ruber*), Golden Woodpecker (*Piculus chrysochloros*), *Sociable* Snailcreeper (*Rostrhamus sociabilis*), Paraguayan Canary (*Sicalis flaveola*), Coloured Tit *(Tigrisoma lineatum*), the Yellow-winged Thrush (*Turdus leucomelas*), the Olive-crowned Woodpecker *(Veniliornis passerinus*), the Black-winged Woodpecker (*Zenaida auriculata)* and the Blessed Sea-bluebird *(Zonotrichia capensis*) (**Table 5).3.2.4.1.b**).

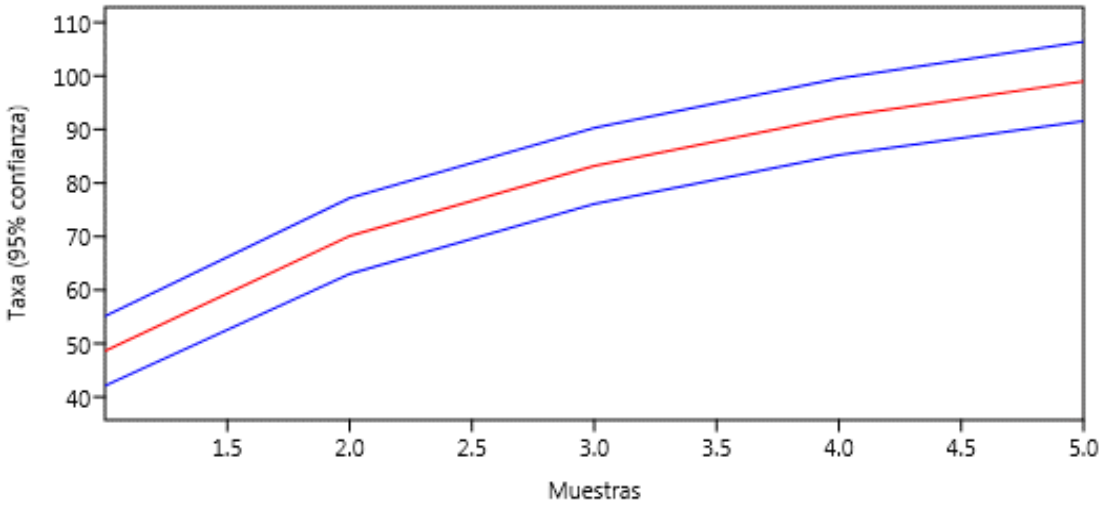
Figure 5.3.2.4.1.c
Ranking of the abundance of birds recorded in the second campaign



Adequacy of the sample

In this second campaign, five days of sampling effort were also devoted to the study of birds in the project's area of influence. The species rarefaction curve generated shows an upward trend, with no signs of stabilisation, indicating that the actual richness was not reached and that a higher number of species is expected for the areas sampled (**Figure 5.3.2.4.1.d**).

Figure 5.3.2.4.1.d
Sample of the rarefaction curve of the Second Campaign



Consolidation of sampling campaigns

Considering the results obtained during the two campaigns, a total of 2,140 records have been made belonging to 138 bird species, distributed in 22 orders and 43 families (**Table 5.3.2.4.1.c** in **Annex 10**).

Comparison of primary and secondary data

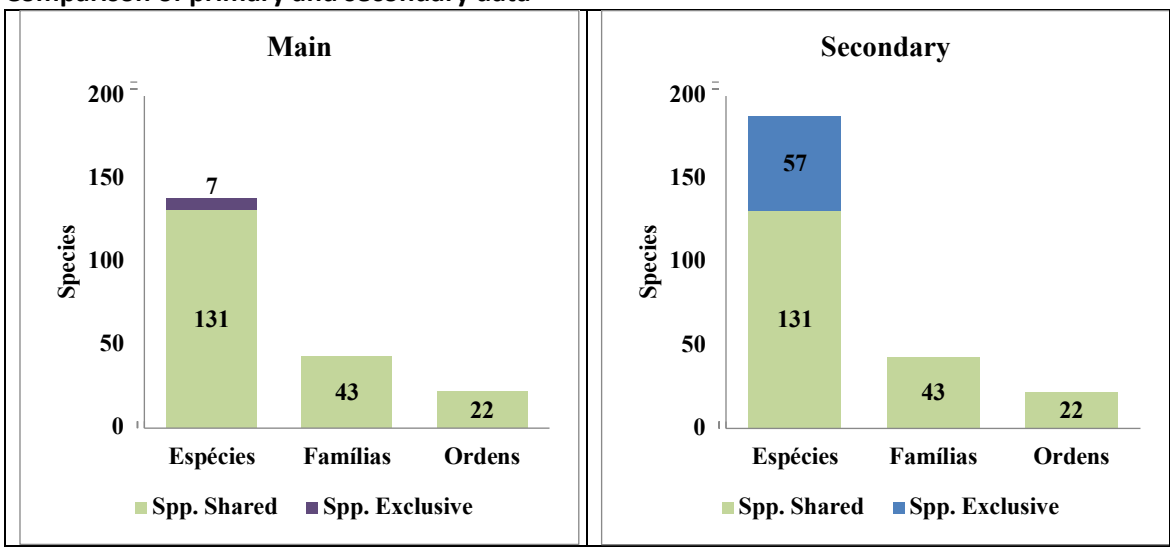
The list of expected species for the development based on secondary data compiled 188 bird species, distributed in 23 orders and 51 families (**Table 5.3.2.4.1.c**). References such as Lesterhuis (2009) and Lesterhuis and Méndez (2016) were used for this survey, and Rebeca Irala's records through the eBird platform (EBIRD, 2023) for the region of interest were also considered.

Thus, considering both the primary and secondary surveys, there are a total of 195 bird species, distributed in 23 orders and 52 families **(Table 5.3.2.4.1.c**). Of this total, 131 species are common to both surveys, meaning that they were recorded during the sampling campaigns, but are also on the list of species expected to be present in the project region (**Figure 5.3.3.2.4.1.e**).

In terms of exclusivity, i.e. species that are only present in one of the two studies carried out, the field surveys obtained records of seven species whose presence in the region is not indicated in the list of birds of probable occurrence based on secondary data. These species are: the Chiricoe (*Aramides cajaneus*), the Royal Tero *(Himantopus himantopus*), the White-fronted Woodpecker (*Melanerpes candidus*), the Black-winged Hawk (*Micrastur semitorquatus), the* Golden-fronted Woodpecker (*Piculus chrysochloros*), the Roseate Spoonbill (*Platalea ajaja)* and the Ravine Crow (*Plegadis chihi*). For these species, although no records were obtained through secondary data specifically in the project region, based on the known distribution (BIRDLIFE INTERNATIONAL, 2023; IUCN, 2023) it is possible to state that their presence in the project areas is not unexpected.
The number of birds recorded in the field and included in the list of expected species for the region according to secondary data (131 species, excluding the seven species not included in the

list of probable occurrence but recorded in the field) represents approximately 73% of the expected richness for the project area. Furthermore, considering the 195 species with potential occurrence in the area, the seven species recorded only during the survey campaigns represent an increase of 4% of the already known richness.

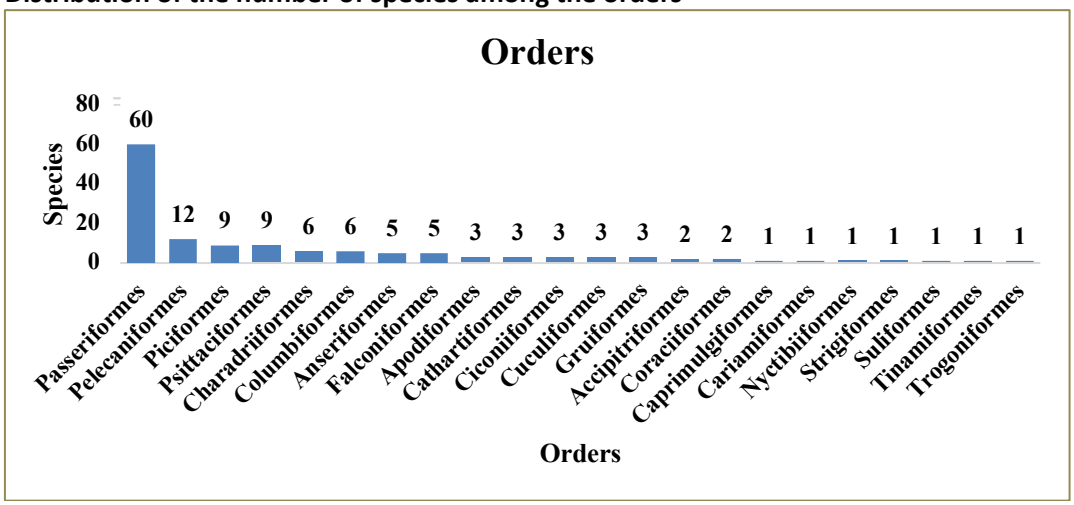
Figure 5.3.2.4.4.1.e
Comparison of primary and secondary data



It is important to mention that, in order to increase the comparability of the results, only the records obtained by the standardised methodologies carried out in the two bird survey campaigns will be used for all the following analyses.

Thus, with the richness obtained over the two campaigns, among the orders, Passeriformes (birds or songbirds) was the most representative, with 60 species recorded, representing approximately 43% of the total. This was followed in order by the Pelecaniformes (herons, egrets, egrets, boobies and the like) with 12 species (9%), the Piciformes (woodpeckers and woodpeckers) and the Psittaciformes (macaws, macaws, maracanas, cockatoos, parrots and the like), both with nine species recorded, representing about 7% of the total number of birds recorded (**Figure 5.3.2.4.1.g** and **Table 5.3.2.4.1.c**). The order Passeriformes is usually the most representative in bird survey studies, as it is the most diverse order worldwide, accounting for more than half of all bird species, and for Paraguay it represents 50% of the total number of catalogued birds (REMSEN *et al*., 2023).

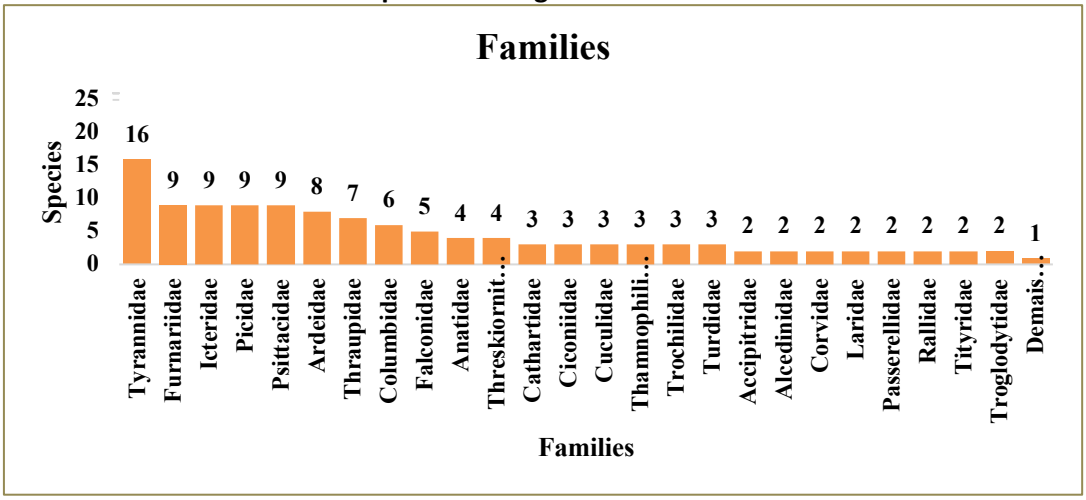
Figure 5.3.2.4.1.f
Distribution of the number of species among the orders



In terms of families, the most representative were Tyrannidae (phiophytes, lice, doraditos, pitogues and similar) with 16 species (12%), followed by Furnariidae (honeros, honeritos, pijuís and similar), Icteridae (boyeros, tordos, boyeritos and similar), Picidae (carpenters and woodpeckers) and Psittacidae (macaws, maracanás, catites, parrots and similar), boyeritos and similar), Picidae (woodpeckers and woodpeckers) and Psittacidae (macaws, macaws, maracanas, cockatoos, parrots and similar), both with nine species recorded, representing around 7% of the total number of birds recorded (**Figure 5.3.2.2.4.1.g** and **Table 5.3.2.4.1.c**).

The family Tyrannidae is one of the most representative families, accounting for approximately 18% of the passerines of South America, and the great representativeness of this family is related to the insectivorous habit of most of its representatives, these birds have obtained greater success due to the great diversity of ecological niches and neotropical entomofauna, which, in some way, has ensured their adaptation to different environments and the ease in obtaining food, since insects are available throughout most of the year (SICK, 1997; FAXINA & SCHELEMMERMEYER, 2010; BISSOLI *et al*., 2014).

Figure 5.3.2.4.1.g
Distribution of the number of species among families

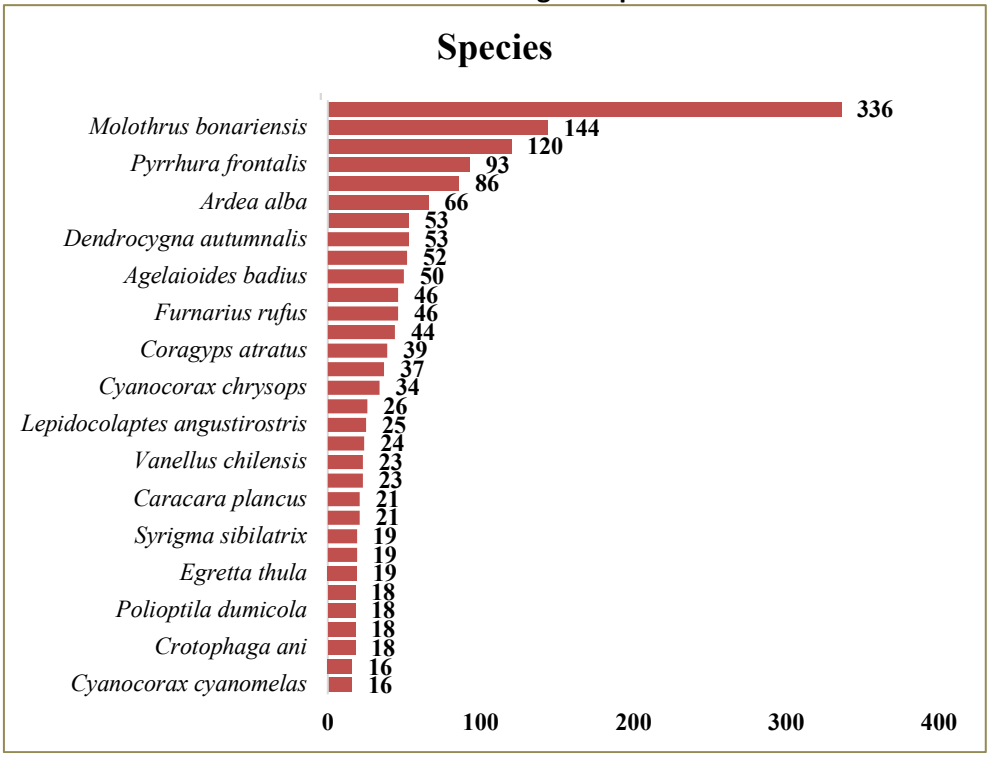


As for the most abundant species, looking at the graph below (**Figure 5.3.2.4.1.h**), it can be seen that for the consolidated results one species stood out from the others, namely the white-headed cormorant (*Phimosus infuscatus*), which made a total of 336 records, corresponding to around 16% of the total number of records obtained during the survey campaigns. This was followed by the Black-crowned Thrush (*Molothrus bonariensis)* with 144 records (7%), followed by the Rock Pigeon (*Patagioenas picazuro*) with 120 records (6%) and the Green-headed Warbler (*Pyrrhura frontalis*) with 93 records (4%) (**Figure 5.3.2.4.1.h**).

It is worth noting that, in addition to the species shown in the graph, another 106 species had values of less than 16 records, which corresponds to 77% of the total richness recorded (**Table 5.3.2.4.1.c**). It is also worth noting that, of the 106 species with less than 16 records, 24 had only a single record, such as the trinator louse (*Serpophaga griseicapilla*), the white-bellied suiriri (*Suiriri suiriri*), the striped batará (*Thamnophilus doliatus*), the coloured hocó *(Tigrisoma lineatum*), the surucuá aurora (*Trogon curucui), the* little white monjita (*Xolmis irupero*), the coloured curutié (*Certhiaxis cinnamomeus*), the green hummingbird *(Chlorostilbon lucidus*), the red-breasted falcon *(Falco sparverius*), the chinstrap hummingbird (*Heliomaster furcifer), the* chestnut-coloured añapero (*Lurocalis semitorquatus*), the ñei ñei (*Megarynchus pitangua*), the green anambé *(Pachyramphus viridis*), the churrinche (*Pyrocephalus rubinus*), the snailcatcher (*Rostrhamus sociabilis*), among other species (**Table 5).3.2.4.1.c**).

Although some species showed high abundance, overall the results were similar, with subtle variation in the number of individuals per species, although species with few records predominated in relation to the more abundant species, indicating homogeneity of abundance.

Figure 5.3.2.4.1.h
Distribution of the number of records among the Species



State of conservation

To verify the conservation status of the species recorded, lists of species threatened with extinction at national and international level were consulted. For the national criteria, according to the MADES resolutions (Resolution Nº 254/19), which lists threatened and endangered native bird species, none of the species recorded in the field present a degree of threat (**Table 5.3.2.4.1.c**).

For the IUCN (2022), only the Lesser Spotted Parrot (*Amazona aestiva*) is classified as "Near Threatened - NT" of extinction (**Table 5.3.2.4.1.c**).

This species is found in the interior of South America, from northeastern Brazil, eastern Bolivia, Paraguay, to northern Argentina, where it inhabits humid and dry forests, with the presence of palm groves and along riverbanks. Justifications for the degree of threat to this species are varied, but are mainly based on the decline in its population that it has suffered in recent years due to deforestation of native forests, in addition to the susceptibility of the species to hunting, especially for cage breeding, as a domestic animal (IUCN, 2019). According to Sick (1997), this species is the most sought after of the psittaciformes to serve as a xerimbabo (a species captured and/or traded as a pet), with a reputation for being the best "talker". A total of 14 records of this species were made in the project area, and in many of these cases, individuals were sighted flying over the site, but were not recorded foraging in the study area (**Table 5.3.2.4.1.c**).

According to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2023), the organisation that regulates international trade in species. Among the registered species, only the yabiru (*Jabiru* mycteria) is listed in Appendix I, which included

species "*threatened with extinction and which are or may be affected by trade, such that trade in them may only be authorised by the Management Authority through the issuance of a Licence or Certificate*" (**Table 5.3.2.4.1.c**).

On the other hand, 22 recorded species are included in Appendix II of the same list, which includes species that "*are not threatened with extinction, but whose trade and transport must be regulated to avoid uses incompatible with their survival, as well as species considered similar to species threatened because of their commercial use*" (CITES, 2023) (**Table 5.3.2.4.1.c**). These species include: the widow warbler (*Forpus xanthopterygius*), the chinstrap hummingbird (*Heliomaster furcifer*), the bronzed hummingbird (*Hylocharis chrysura*), the barn owl (*Megascops choliba)*, the mountain hawk (*Micrastur semitorquatus*), chimachima (*Milvago chimachima*), parakeet (*Myiopsitta monachus*), cardinal (*Paroaria capitata*), cardinal (*Paroaria coronata),* choclero parrot (*Pionus maximiliani*) (**Table 5.3.2.4.1.c**).

Finally, taking into account the Convention on Migratory Species (CMS, 2022), which classifies species into: Appendix I: Endangered migratory species (migratory species in danger of extinction); Appendix II: Migratory species in an unfavourable conservation status and in need of international agreements. Only two species were recorded as listed in CMS category II, namely the solitary pitotoy (*Tringa solitaria*) and the snailbird (*Rostrhamus sociabilis*) (**Table 5.3.2.4.1.c**).

The solitary pitotoy (*Tringa solitaria*) is a small species belonging to the family Scolopacidae. Individuals of this species make annual long-distance migrations, moving between breeding regions in the northern hemisphere and wintering areas in the southern hemisphere. Migratory routes used by this species include those passing through the Arctic and Subarctic region to South America, and may include flights over the Atlantic Ocean, including passage through several sites along the way, such as coastal regions and estuaries in South America, including countries such as Paraguay, Brazil, Argentina, Uruguay and Chile (HAYES *et al*., 1990; LESTERHUIS & CARTES, 2008; CEMAVE, 2019). Only five records were obtained for this species in the study area, and on all these occasions only one individual was sighted (**Table 5.3.2.4.1.c**).

The snail-eater (*Rostrhamus sociabilis*), on the other hand, is a medium-sized raptor species belonging to the family Accipitridae, having been recorded on only two occasions during the field surveys, one record in each season (**Table 5.3.2.4.1.c**). This species is widely distributed in Central and South America, including Paraguay. Although it does not perform large-scale migrations, it has seasonal and regional migratory behaviours, which are carried out in response to seasonal changes and availability of food resources (CEMAVE, 2019; JAHN *et al*., 2021).

Migration

In a broad sense, the term migration is most often used to designate the massive directional movements of many individuals of a given species from one locality to another (BEGON *et al*., 1990). Strictly speaking, migration is characterised by the annually recurring, seasonally recurring movement of a given animal population from its breeding area to feeding and resting areas at a certain time of the year, returning to its original breeding area (ALERSTAM & HENDENSTRÖM 1998).

This repeating cycle is caused by seasonal food supply (SICK, 1983). In latitudes further away

from the equator, or colder regions, daily light intensity has been indicated as a factor that stimulates the reproductive organs, with a consequent increase in fat accumulation, which serves as a reserve for long-distance movements (ROWAN, 1930). In tropical regions, where there is little variation in photoperiod compared to temperate regions, other factors, such as rainfall and, consequently, flowering and fruiting, may serve as a stimulus for migrations (SICK, 1983).

SICK (1983) summarised the knowledge of migratory birds in South America. In summary, this author divides the movements that occur in this continent as follows: Nearctic migrations (birds coming from the northern hemisphere); austral migrations (birds that move northwards from the southern hemisphere, with several migrations from the southern part of the continent to the north); movements in response to the seasonality of water and trophic resources (such as flowering and fruiting), which include regional, local or partial movements.

Thus, according to the classifications of Castillo & Clay (2005), in the two survey campaigns, 12 species were recorded as exhibiting some form of migratory behaviour.

The solitary pitotoy (*Tringa solitaria*) is classified as a "Nearctic migrant - N", migrating from North America outside the breeding season **(Table 5.3.2.4.1.c**).

The brown añapero (*Lurocalis semitorquatus*), the brown swallow (*Progne tapera), the* black anambé *(Pachyramphus polychopterus*), the great phoebe *(Elaenia spectabilis)*, the cinnamon-billed burlist *(Myiarchus swainsoni*), the striped pitogoue (*Myiodynastes maculatus*) and the red-crowned redstart *(Tyrannus melancholicus*) are classified as "Northern Southern Migrant - NA", nesting and migrating northwards. The first species, *L. semitorquatus,* is classified as "Resident - R", but with the status "Unknown - ?" (**Table 5.3.2.4.1.c**).

The Snailbird (*Rostrhamus sociabilis*), the Turtle Dove (*Patagioenas picazuro*) and the Red Knot (*Pyrocephalus rubinus)*, on the *other hand,* are classified as "Southern Migrant Nesting - AS". And the trinator louse (*Serpophaga griseicapilla)* is classified as "Wintering visitor, non-nesting - AV" (**Table 5.3.2.2.4.1.c**).

Endemism

Endemic species are those that are confined to a specific ecoregion, ecosystem or biome and develop their entire life cycle there, depending on the resources they obtain there, so that, in the extreme case, if this environment disappears, the species will also disappear. In ornithology, near-endemic or restricted species are also considered to be those that, although they have most of their population in a particular ecosystem, also occur marginally outside it. Thus, geographic distribution patterns of endemic species have been used to identify priority conservation areas worldwide (KERR, 1997; STATTERSFIELD *et al*., 1998).

Thus, considering the classifications of Del Castillo & Clay (2004, 2005), which provides a list of species associated with the habitats present in the country, two species recorded in the bird survey campaigns are classified as endemic to the Chaco: the white-backed woodpecker (*Campephilus leucopogon)* and the giant nuthatch (*Xiphocolaptes major*). In addition to these, the green-headed warbler *(Pyrrhura frontalis*) is classified as endemic to the Atlantic Forest biome domains (**Table 5.3.2.4.1.c**). However, in all cases, despite the endemicity classifications,

these species are widely distributed, occurring in other habitat types, including neighbouring countries such as Argentina, Bolivia and Brazil (IUCN, 2023). Therefore, they are not strictly endemic to Paraguay, and consequently do not represent a conservation concern.

Species of important economic or food value to local populations

Field surveys indicated the presence of some bird species that can be considered huntable, i.e. under illegal hunting pressure, which may be for food and/or commercialisation as pet birds, which are trapped in cages. These species vary according to region and local legislation, but common examples are: partridges, quails, ducks, wild turkeys and pigeons (FERREIRA-FERNANDES, 2014). Hunting and forest fragmentation represent the two main factors that put avifauna communities at risk, reducing their populations and inducing species at risk of extinction, especially those with low population densities. Both hunting for food and the illegal trade in caged songbird species are activities that are passed down from generation to generation and over the years are responsible for the decline in populations of some species and the near extinction of others (FERREIRA-FERNANDES, 2014).

In this study, game species were recorded that are hunted mainly for food, such as the Brazilian wigeon (*Amazonetta brasiliensis)*, the white-winged pintail (*Cairina moschata*), the white-winged widgeon (*Dendrocygna autumnalis*), the white-faced widgeon (*Dendrocygna viduata*), the white-faced widgeon (*Chauna torquata*), the Picuí lovebird (*Columbina picui*), the Scaled dove *(Columbina squammata*), the Coloured lovebird *(Columbina talpacoti*), the Common yeruthi (*Leptotila verreauxi)*, the Turquoise pigeon *(Patagioenas picazuro), the* Pigeon (*Zenaida auriculata)* and the Common tataupa (*Crypturellus tataupa*) (**Table 5).3.2.4.1.c**).

Species recorded as being mainly destined for illegal trade for ornamental and/or pet purposes include: the musical thrush (*Agelaioides badius*), the black wader *(Agelasticus cyanopus*), the yellow-winged booby (*Cacicus chrysopterus*), the black booby *(Cacicus solitarius*), the congo wader (*Chrysomus ruficapillus*), the cardinal (*Paroaria capitata*), the cardinal (*Paroaria coronata*), the grey cuckoo *(Saltator coerulescens*), the Paraguayan canary (*Sicalis flaveola*), the cassowary thrush *(Turdus amaurochalinus)*, the red-winged thrush *(Turdus leucomelas*), the rufous-winged thrush (*Turdus rufiventris*), the *Amazona aestiva* (*Amazona aestiva*), the rhea (*Aratinga nenday*), the chiriri warbler (*Brotogeris chiriri*), the widowed catitra (*Forpus xanthopterygius*), the monk parrot (*Myiopsitta monachus*), the choclero parrot (*Pionus maximiliani*), the bluetheaded maracana (Psittacara *acuticaudatus*), the red-winged maracana (*Psittacara leucophthalmus),* and other species **(Table 5.).3.2.4.1.c**).

All these species, both those hunted for food and those destined for the cage bird trade, deserve attention, as they are important bio-indicators of the degree of environmental preservation, considering that they are the first to disappear due to poaching pressure (BEZERRA *et al*., 2011; BEZERRA *et al*., 2012; ALVES *et al*., 2012; BARBOSA *et al*., 2014; FERREIRA-FERNANDES, 2014).

Important Bird Areas (IBAs) and Endemic Bird Areas (EBAs)

IBAs are selected using quantitative ornithological criteria, based on knowledge of bird population sizes and trends, which should ensure that the selected areas are of real importance for the international conservation of bird populations (BIRDLIFE INTERNATIONAL, 2023a).

On the other hand, EBAs (*Endemic Birds Area*) are classified as endemic bird areas and are defined as areas encompassing overlapping bands of restricted occurrence species, such that these occurrence bands are fully included within the boundaries of EBAs. Restricted-range species are defined as all landbirds with an estimated global breeding range of less than 50,000 km². Species with estimated historical ranges above this limit, but which have been reduced to less than 50,000 km² due to habitat loss or other anthropogenic pressures, are not included in EBAs, as these areas should represent natural areas of endemism for birds (BIRDLIFE INTERNATIONAL, 2023a).

In this case, the polygon foreseen for the construction of the project does not fall within the boundaries of IBAs and EBAs. However, it is worth mentioning the proximity to an IBA called Valle Fluvial del Río Paraguay (AR070), located in the neighbouring country of Argentina. This IBA covers an area of approximately 250,000 ha, and is located in the extreme east of the province of Chaco, occupying a strip of up to 40 km wide from the coast of the Paraguay-Paraná axis to the town of Paralelo 28, on the border with the province of Santa Fe. The entire area occupied by this IBA is subject to a flood regime with flood peaks (BIRDLIFE INTERNATIONAL, 2023b).

The area has been little explored, but there is information on globally threatened species and also records without current confirmation for some threatened grassland species, such as the collared yetapa *(Alectrurus risora*), the tailed tachuri *(Culicivora caudacuta*) and the masked curlew *(Coryphaspiza melanotis*). Species of importance for this IBA are: rhea (*Rhea americana*), flamingo (*Phoenicopterus chilensis)*, black-winged curlew *(Eleothreptus anomalus*), crowned eagle *(Buteogallus coronatus*), dwarf sparrowhawk (*Spartonoica maluroides*), cinnamon tachuri (*Polystictus pectoralis*), collared yetapa *(Alectrurus risora*), brown-throated capuchin *(Sporophila ruficollis)* and chestnut-capped capuchin (*Sporophila hypochroma*) (BIRDLIFE INTERNATIONAL, 2023b). However, none of these species were recorded in the bird survey campaigns in the study region, with only the collared nightjar *(Alectrurus risora*) appearing in the list of species of probable occurrence based on secondary data (**Table 5.3.2.4.1.c**).

Invasive alien, introduced, invasive or native invasive species

Alien species are animal species that are non-indigenous or non-native to an area or country, have been introduced by man and have acclimatised and are able to survive and reproduce in the wild, forming wild populations. This definition does not include domestic species or escaped companion animals that cannot survive on their own.

Based on the above information, none of the species recorded in this study are classified as introduced. However, it is worth mentioning that the domestic pigeon (*Columba livia*) and the cobartita (*Passer domesticus)*, species present only in the secondary data list, i.e. which have not been recorded in the project area, but whose presence is expected for the study region, are classified as introduced (**Table 5.3.2.4.1.c**).

The domestic pigeon (*Columba livia*) is a bird native to Mediterranean countries, having been domesticated about 5,000 years ago and introduced in North, Central and South America and throughout Europe, and is now present in urbanised areas all over the world, coexisting with the human population. This can lead to public health problems, as pigeons can be a reservoir of pathogenic micro-organisms for humans, including *Salmonella* spp. as an agent responsible for food-borne infections. Although there are not many reports of food-borne infections in humans caused by pigeons, there are several records indicating the presence of *Salmonella spp.* in pigeon faeces, and the possibility of transmission of the pathogen to humans and other animals cannot be ruled out (ROCHA-E-SILVA *et al*., 2014).

The corbatita (*Passer domesticus*), a species originating in the Middle East, is a synanthropic species that expanded its distribution to occupy parts of Eurasia and North Africa along with the spread of agriculture. Through natural and ship dispersal, the species has occurred in most parts of the world since the mid-19th century, and continues to expand its distribution in some parts, and is now the most widely distributed bird on the planet. In South America, it was first introduced near Buenos Aires in 1870, and quickly spread across the continent. Sparrows are strongly associated with crops and human habitation, and are well adapted to life in anthropogenic environments, even breeding indoors, although they can also thrive in natural environments (SUMMER-SMITH, 1988; ANDERSON, 2006).

Invasive species are exotic species that reproduce uncontrollably and can invade native habitats and compete with native species. In this case, we highlight the presence of the cattle egret (*Bubulcus ibis*), a medium-sized bird of African origin, considered an invasive alien on the American continent, with historical records of its establishment in South America around the 1930s (CROSBY, 1972). Currently, the species occupies virtually all of sub-Saharan Africa and South America, and is also present in areas of Central and North America (DEVAULT *et al*., 2003; DELLA BELLA & AZEVEDO-JÚNIOR, 2004).

Invasive native species are those that show population oscillations with explosive reproduction under certain conditions that cause their numbers to increase exponentially and may endanger other native species, causing an environmental imbalance. In this case, groups of dozens of black-crowned thrushes (*Molothrhus bonariensis*) were observed flying over the study area and feeding on grain dropped from lorries, mainly rice, on the asphalt road (**Table 5.3.2.4.1.c**). The explosive increase of these birds may affect the populations of other native birds, as they are nest parasites (SICK, 1997).

Waterfowl

Waterbirds are birds that spend most or all of their life cycle associated with water. According to the Ramsar Convention, waterbirds are those that are ecologically dependent on wetlands and, more specifically, those belonging to the families Gaviidae, Podicipedidae, Pelecanidae, Phalacrocoracidae, Anhingidae, Ardeidae, Ciconiidae, Threskiornithidae, Phoenicopteridae, Anhimidae, Anatidae, Aramidae, Rallidae, Heliornithidae, Jacanidae, Rostratulidae, Recurvirostridae, Charadriidae, Scolopacidae, Laridae, Sternidae and Rynchopidae (to mention only the families occurring in Paraguay and in chronological order). There are 123 species of waterbirds present in the country according to Lesterhuis *et al*. 2018. Waterbird censuses are conducted both in the country and globally twice a year and are reported to Wetlands Intl. which maintains the global statistics.

According to the data obtained in the field, 30 species of birds associated with aquatic environments were recorded, corresponding to the flooded savannah habitat, in addition to the association with rice fields. For the type of environment present in the area of direct influence of the project, waterfowl represent a significant group in the composition of this ecosystem, precisely because they include migratory, threatened and other species of hunting interest (ELPHICK & ORING, 1998).

In addition, the presence of cyclical agricultural areas, in this case irrigated rice crops, can exert a strong influence on bird dynamics in the region. The rice agro-ecosystem behaves like a temporary wetland, alternating periods of flooding in summer and drought in winter. This type of environment provides feeding, shelter and breeding habitats for large populations of birds, especially those inhabiting wetlands, such as marshes, lakes, mudflats and wetlands (FASOLA & RUIZ 1996; MUGICA *et al*., 2006).

Species recorded as being associated with aquatic environments include: the dabbling *duck* (*Amazonetta brasiliensis*), the white-winged wigeon (*Cairina moschata*), the white-winged widgeon (*Dendrocygna autumnalis)*, the white-faced widgeon *(Dendrocygna viduata*), the chajá (*Chauna torquata*), the collared plover (*Charadrius collaris*), the tero tero (*Vanellus chilensis*), the jacana (*Jacana jacana*), the atí (*Phaetusa simplex*), the rayador (*Rynchops niger)*, the little tern *(Sternula superciliaris*), the great crested tit (*Himantopus himantopus*), the spotted sandpiper (*Actitis macularius*), the lesser black-backed godwit (*Gallinago paraguaiae*), the solitary pitotoy (*Tringa solitaria*), the American stork (*Ciconia maguari*), yabiru (*Jabiru mycteria*), tuyuyu (*Mycteria americana*), carau (*Aramus guarauna*), chiricoe (*Aramides cajaneus*), redfish *(Aramides ypecaha*), greater scaup (*Porzana albicollis*), and other species (**Table 5).3.2.4.1.c**).

Grassland birds

In the southern cone of South America there is a grassland bird conservation initiative of BirdLife International in which grassland species are classified according to their dependency, facultative and obligate, following the publication of (VICKERY *et al*., 1999), and according to grass height preference (low, high, wide, according to AZPIROZ *et al*., 2012) in Aldabe *et al*. 2020. Facultative species are those that use the grass only temporarily and obligate species all the time.

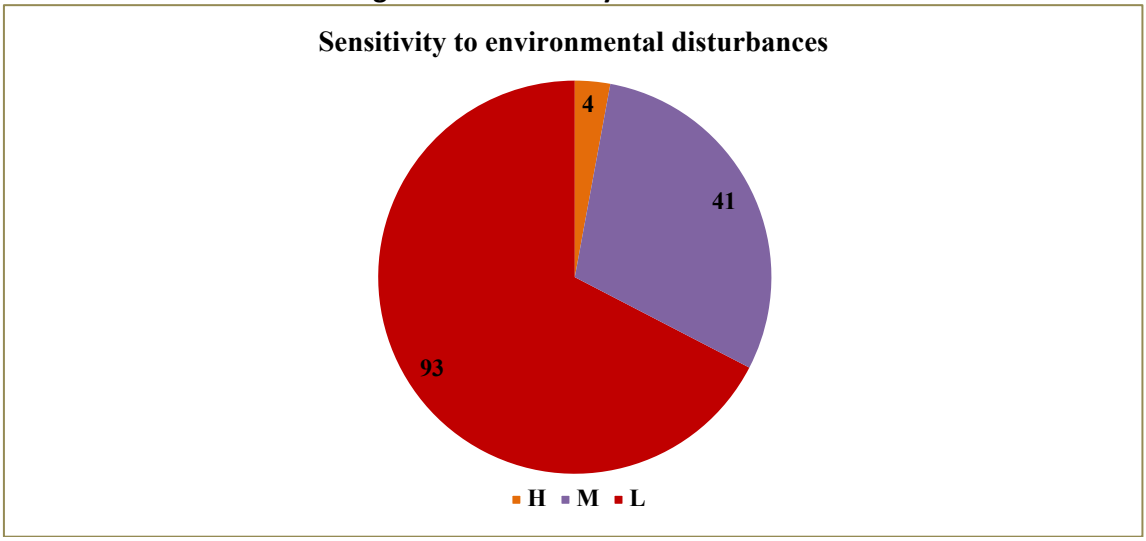
Among the species recorded in the field, only two are classified as "Obligate - O", these being: the Eurasian Tern (*Vanellus chilensis)* and the Lesser Black-backed Hawk (*Falco femoralis*) (**Table 5.3.2.4.1.c**). While 27 species are classified as "Optional - F", these include: Red-footed Sandpiper (*Cariama cristata*), Red-headed Crow *(Cathartes aura*), Turtle Dove *(Patagioenas picazuro*), Pigeon (*Zenaida auriculata*), *Guira guira (Guira guira*), Caracara (*Caracara plancus*), Red-breasted Falcon (*Falco sparverius*), *Rufous-breasted* Horned Owl (*Furnarius rufus*), Black-bellied Sandpiper (*Schoeniophylax phryganophilus*), Brown Swallow (*Progne tapera*), Wood Thrush (*Agelaioides badius)*, Black-bellied Warbler (*Gnorimopsar chopi*), Blackburnian Thrush (*Gnorimopsar chopi*), Black-bellied Thrush (*Molothrus bonariensis*), Short-billed Thrush *(Molothrus rufoaxillaris*), Blessed Beech (*Zonotrichia capensis*), Cardinal *(Paroaria coronata)*, Cassava Thrush (*Turdus amaurochalinus*), the common sandpiper (*Machetornis rixosa*), the common pitogüé (*Pitangus sulphuratus*), the churrinche (*Pyrocephalus rubinus*), the royal suiriri *(Tyrannus melancholicus), the* little white monjita (*Xolmis irupero),* and others (**Table 5.3.2.4.1.c**).

Sensitivity to environmental disturbances

The sensitivity of bird species to disturbances caused by human activities was also analysed, classifying them as follows: Low sensitivity "L" - species found in anthropogenic ecosystems, regardless of whether they are close to natural ecosystems; Medium sensitivity "M" - species found in anthropogenic ecosystems only if they are close to natural ecosystems or aquatic ecosystems; High sensitivity "H" - species found only in landscapes composed of intact or nearly undisturbed ecosystems (STOTZ *et* al., 1996).

Based on the Sensitivity classification of STOTZ *et al*. (1996), we observed the predominance of species with low sensitivity, with 93 species recorded, representing 67% of all birds recorded throughout the campaigns. This is followed by the medium sensitivity category, with 41 species recorded, representing 30% of the total, and finally, species with high sensitivity to environmental disturbances, with four species recorded, representing 3% of the community observed (**Figure 5.3.2.4.1.i**).

Figure 5.3.2.4.4.1.i
Classification of birds according to their sensitivity to environmental disturbances



The phytophysiognomies present in the study area are generally composed of herbaceous vegetation with few trees and shrubs, with the presence of small fragments of forest, predominantly open areas with a great variety of grasses. In addition, there are large expanses of pastures in the surrounding areas, as well as cyclical rice crops. These characteristics favour more generalist species that are not very sensitive to environmental changes. This fact may explain the 67% predominance of species with low sensitivity (high adaptability) to environmental disturbances. Species in this category, in general, show greater tolerance to the effects of fragmentation, as well as greater plasticity in the use of different environments (MENCATO & TRECO, 2016; RATON & GOMES, 2015; ROCHA *et al*., 2015; PADOVEZI *et al*., 2014).

Species with low sensitivity include: the Muscovy thrush (*Agelaioides badius*), the Black-crowned night heron (*Amazonetta brasiliensis*), the White heron (*Ardea alba*), the Purple heron (*Ardea cocoi*), the Cattle egret (*Bubulcus ibis)*, the Little blue heron *(Butorides striata), the* Yellow-winged cattle egret (*Cacicus chrysopterus), the* Whistling louse (*Camptostoma obsoletum*), the great buzzard (*Campylorhynchus turdinus*), the caracara *(Caracara plancus*), the red-headed crow *(Cathartes aura*), the chajá (*Chauna torquata*), the medium kingfisher *(Chloroceryle amazona*), the green hummingbird *(Chlorostilbon lucidus), the* congo wader (*Chrysomus ruficapillus),* among others (**Table 5).3.2.4.1.c**).

For the medium sensitivity category there are species such as: the black wagtail (*Agelasticus cyanopus*), the talking parrot (*Amazona aestiva*), the water rail (*Aramides ypecaha*), the carau (*Aramus guarauna*), the ñanday (*Aratinga nenday)*, the collared peccary (*Arremon flavirostris*), the chiriri catita (*Brotogeris chiriri*), the black cattle *(Cacicus solitarius*), the red-rumped woodpecker (*Cairina moschata*), the white-rumped woodpecker (*Campephilus leucopogon)*, Red-footed Sandpiper (*Cariama cristata*), Chestnut-crowned Dipper (*Casiornis rufus*), Yellow-headed Raven (*Cathartes burrovianus*), Red-crowned Curassow *(Certhiaxis cinnamomeus*), Chinstrap Hummingbird (*Heliomaster furcifer*), golden-eyed flycatcher (*Hemitriccus margaritaceiventer*), royal tero (*Himantopus himantopus*), bronze prickly pear (*Hylocharis chrysura)*, boyerito (*Icterus pyrrhopterus)* and yabiru (Jabiru mycteria) (**Table 5.3.2.4.1.c**).
Species with high sensitivity to anthropogenic disturbance are: Chiricoe (*Aramides cajaneus*),

Red-crested Woodpecker (*Campylorhamphus trochilirostris*), Aiti (*Phaetusa simplex*) and Little Tern (*Sternula superciliaris*) (**Table 5.3.2.4.1.c**). For the first two species, *A. cajaneus* and *C. trochilirostris,* five and eight records *were* obtained, respectively. Individuals were observed foraging in open and flooded areas of the study region. As for the latter two, *P. simplex* and *S. superciliaris,* only one and four individuals were recorded, in all cases individuals were seen foraging in a lake and in low overflights in the study area.

Comparison between the two Sampling Campaigns

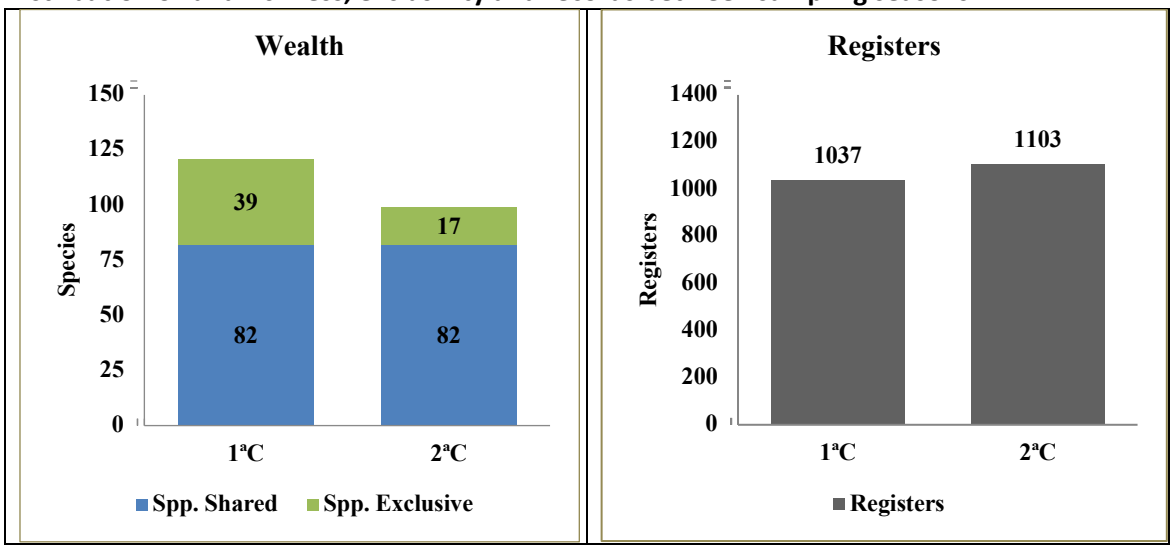
As mentioned, a total of 2,140 records were made in the two campaigns, belonging to 138 bird species, distributed in 22 orders and 43 families (**Table 5.3.2.2.4.1.c**).

For richness, the highest diversity value was obtained in the first sampling campaign, with 121 species, of which 39 were exclusive, i.e. they were recorded only in this first campaign. While in the second campaign a total of 99 species were obtained, 17 of which were exclusive, so the difference in richness between the campaigns was approximately 18% (**Figure 5.3.2.4.1.j**). And for the abundance values, despite the slight difference, the opposite is observed, with the second campaign having the highest value, presenting 1,103 records, while the first campaign presented a total of 1,037 records, representing a difference in value of only 6% between the sampling campaigns (**Figure 5.3.2.2.4.1.j**).

Species unique to the first campaign include: the aí (*Phaetusa simplex*), the trinator louse (*Serpophaga griseicapilla*), the white-bellied suiriri (*Suiriri suiriri), the* striped batará (*Thamnophilus doliatus*), surucuá aurora (*Trogon curucui*), monjita blanca (*Xolmis irupero),* curutié colorado (*Certhiaxis cinnamomeus*), ñei ñei (*Megarynchus pitangua*), green anambé (*Pachyramphus viridis*), guirí (*Sittasomus griseicapillus*), grey heron *(Ardea cocoi*), woodpecker *(Colaptes campestris*), striped pitogüé (*Myiodynastes maculatus*), picuí lovebird (*Columbina picui)*, plumbeous falcon (*Falco femoralis*) and other species (**Table 5).3.2.4.1.c**).

For the second season, the exclusives were: Red-breasted Hawk (*Micrastur semitorquatus*), Golden-headed Woodpecker (*Piculus chrysochloros)*, Red-breasted Siskin (*Tigrisoma lineatum*), Red-breasted Falcon (*Falco sparverius*), the red-crowned nightjar (*Pyrocephalus rubinus), the* black-bellied woodpecker (*Veniliornis mixtus*), the widow warbler (*Forpus xanthopterygius)*, the little tern (*Sternula superciliaris*), chochi (*Tapera naevia*), chiricoe (*Aramides cajaneus*), red-crowned crow (*Cathartes aura*), great tit *(Himantopus himantopus*), black fruitcreeper *(Tachyphonus rufus)*, white woodpecker (*Melanerpes candidus*), roseate spoonbill (*Platalea ajaja*), gully crow (*Plegadis chihi*) and white egret (*Egretta thula*) (**Table 5).3.2.4.1.c**).

Figure 5.3.2.4.1.j
Distribution of bird richness, exclusivity and records between sampling seasons

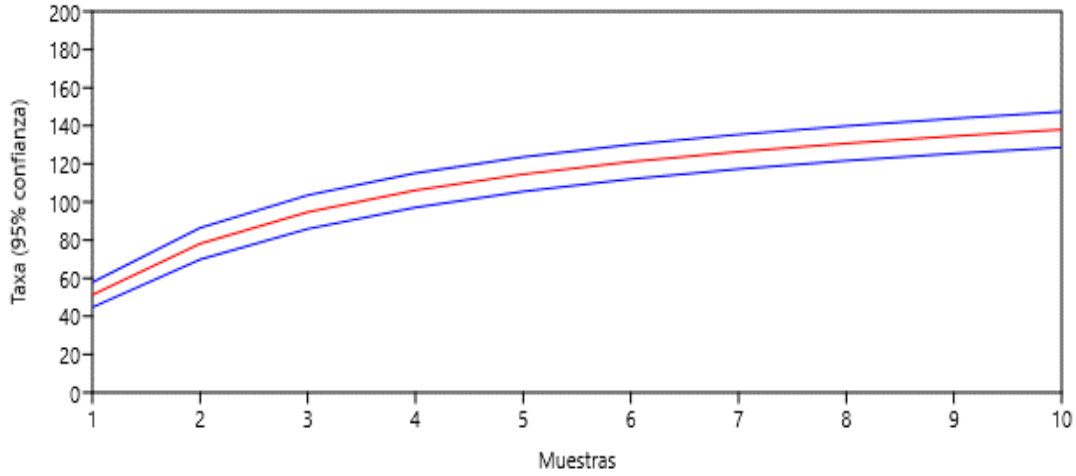


Adequacy of the sample

When compared to community structure, the number of species per number of individuals sampled is a very useful measure. However, comparisons between communities are often based on different sample sizes, which in turn makes conclusions difficult. A proposed solution to this problem is the adoption of the rarefaction curve technique, which consists of calculating the expected number of species in each sample for a standard sample size. Therefore, with the intention of checking the effectiveness of the efforts made during the avifauna survey campaigns, a rarefaction curve per sampling unit was plotted for the total observed (**Figure 5.3.2.4.1.k**).

The species rarefaction curve generated, even considering the two sampling campaigns (10 days), shows an upward trend, but with a slight tendency to stabilise, indicating that, although much of the expected richness has been obtained, more species are still expected for the total richness of the study area. These results were already expected, taking into account that studies with small sampling efforts are not enough to reach stability of the curves, which should only occur in the long term, especially when considering endemic and/or endangered species, which are naturally rare and have low population density, requiring much more time to be recorded in the field (COSTA-BRAGA *et al.*, 2014; STRAUBE *et al.*, 2010; VASCONCELOS, 2006). This result is corroborated by the richness estimators (Chao2 and Jacknife 1), which estimated more species for the species company region (see below).

Figure 5.3.2.4.1.k
Rarefaction curve per sample for total



Wealth, Diversity and Equity Estimators

Comparison of observed richness with richness estimators can be used as another analysis of sample adequacy. In short-term studies it is possible to consider richnesses equivalent to 90% or more of the estimated richness as indicators of representative sampling (e.g. HERZOG *et al*., 2002; CAVARZERE *et al*., 2012 for Mackinnon's checklists). These values are given for the present study, serving as a suggestion of the minimum additional effort needed to achieve representative sampling for the study region. **Table 5.3.2.2.4.1.d** shows richness, number of records, incidence-based richness estimators (Chao2 and Jackknife 1), as well as alpha diversity indices (Fisher's alpha and Shannon's exponential) and evenness.

The richness estimators generated (Chao 2 and Jacknife 1) corroborate the results shown by the species rarefaction curves (**Figure 5.3.2.4.1.k**), with estimates higher than those observed. For the Chao 2 estimator 163.24 species were estimated and for Jacknife 1 the estimate was 168.6 species, indicating that sampling sufficiency was 84.54 and 81.85%, when compared to the total number of species recorded (N=138), respectively. Thus, these values indicate that 15.46 (Chao 2) and 18.15 (Jacknife 1) species are still expected for the study area (**Table 5.3.2.4.1.1.d**).

The Shannon diversity index (also called Shannon-Wiener index (H')) is one of several indices used to measure diversity in categorical data. It is simply the entropic information of the distribution. This index measures the degree of uncertainty in predicting to which species a randomly chosen individual will belong in a sample of S species and N individuals. In addition, it allows the index values to be compared directly with the observed richness, and the higher the index value, the greater the diversity of the area considered (HILL, 1973; KEYLOCK, 2005; LUDWIG & REYNOLDS, 1988; TUOMISTO, 2010). For this index the value was 3.93 (**Table 5.3.2.4.1.d**), which can be considered high, as the values assumed by the Shannon-Wiener index are between 1.5 and 3.5 and only rarely exceed 4.5 (MAGURRAN, 1988).

Another index used is Fisher's Alpha, which has some advantages over other diversity indices because it is little influenced by sample size or by the abundance of the most common species (TAYLOR & FORSMAN, 1976). Fisher's Alpha index relates the number of species (S) to the number of individuals (N) in a community by the following equation: $S = \alpha \ln (1 + N/\alpha)$ (FISHER

et al. 1943). In the present study, the index was 32.94 (**Table 5.3.2.2.4.1.1.d**).

Evenness expresses how the number of individuals is distributed among the different species, i.e. it indicates whether the different species have similar or divergent abundance (number of individuals). It is proportional to diversity, i.e. the ratio between the actual diversity and the maximum existing diversity. Thus, Equitability ranges from 0 (zero) to 1 (one), with values close to one indicating a uniform distribution of abundance of records in the sampling universe (richness) (BROWER & ZAR, 1984). For the present study, the index was 0.79, indicating a greater homogeneity of abundance over species (**Table 5.3.2.4.1.1.d**).

Table 5.3.2.4.1.d
Richness, diversity and fairness estimators for birdwatching surveys

Indexes	Total
Observed wealth (S)	138
Number of records (N)	2140
Estimated wealth (Chao 2)	163,24
Estimated wealth (Jacknife 1)	168,6
Diversity (Shannon, eH)	3,93
Diversity (Fisher's alpha)	32,94
Equity_J	0,79

Concluding remarks

Comparison between the results of the field surveys and secondary data indicates that approximately 73% of the predicted richness for the study region was recorded in the field, a result that can be considered significant, especially considering the effort involved.

Regarding the sufficiency of the sample, although the estimators indicated more species for the project region, the field efforts were significant, with a high percentage of species obtained in relation to those estimated. In addition, it could be observed that the rarefaction curve showed a slight tendency to stabilise.

In general, a large part of the bird community uses open environments, and a large part is associated with aquatic environments, whether natural or anthropogenic (cyclical agriculture). Consequently, a high percentage of these species show a low sensitivity to environmental disturbances. Anthropisation processes exert a strong influence on the structure and composition (community) of the avifauna, especially when it occurs in large forest formations, and can lead to the reduction of species with high sensitivity to environmental disturbances. Species that are ecologically more demanding in relation to environmental conditions are gradually replaced by more tolerant species with high plasticity and adaptability and low sensitivity to environmental changes. The more intense the modifications imposed on the environment, the more severe the changes in the avifaunal community.

5.3.2.4.2
Herpetofauna

First campaign

During the first herpetofauna survey campaign, carried out from 04 to 08 March 2023, 19 species of amphibians and reptiles were recorded, belonging to three families of the order Anura and three of the order Squamata (**Table 5.3.2.2.3.2.a** in **Annex 10**).

Considering the richness obtained, the most representative family was Leptodactylidae, within the order Anura, which contains ten species, representing approximately 53% of the total. It is followed by the families Hylidae, with three species (15%); Bufonidae and Dipsadidae, with two species each (11%), and Colubridae and Teiidae, with one species, each representing approximately 5% of the total recorded assemblage (**Table 5.3.2.2.3.2.a**).

Second campaign

As for the second campaign, carried out from 20 to 24 June 2023, 30 records were obtained belonging to 15 species of amphibians and reptiles, distributed in two orders and five families (**Table 5.3.2.2.3.2.a**). The order Anura is represented by species distributed in four families, namely: Bufonidae (2 sp.), Hylidae (3 sp.), Leptodactylidae (6 sp.) and Odontophrynidae (1 sp.). In Squamata, diversity is represented by only one family, Dipsadidae (3 sp.), as presented in (**Table 5.3.3.2.3.2.2.a**).

In terms of proportion of family richness, Leptodactylidae is the most representative, with 40% of the observed diversity. Next, Dipsadidae and Hylidae cover 20% each, Bufonidae 13.3% and Odontophrynidae 6.67%, the latter being the least representative (**Table 5.3.2.3.2.2.a).**

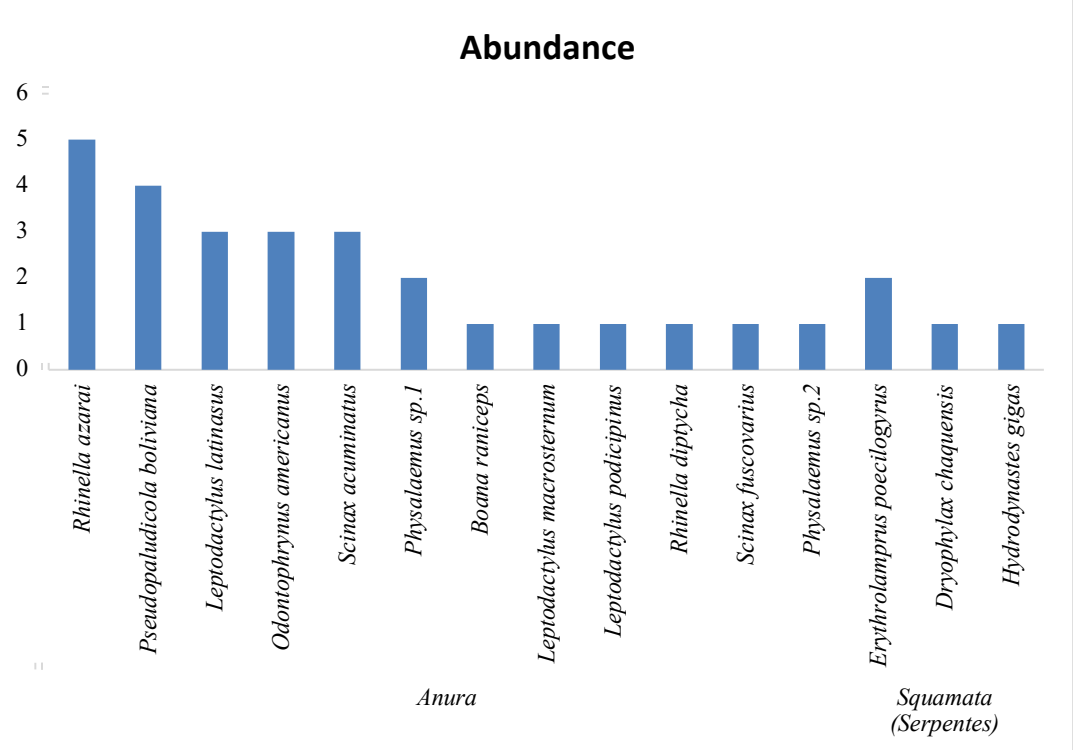
Abundance classification

For the herpetofauna, abundance data are only available for the second season. The abundance ranking of the herpetofauna recorded during the second sampling campaign is presented below for the orders Anura and Squamata (**Figure 5.3.2.2.3.2.a**).

The graph shows that the order Anura has the highest number of records compared to the order Squamata. Within this group, the kururu toad (*Rhinella azarai*) stood out in relation to the others, with a total of five specimens recorded, representing 16.67% of the total sampled. It was followed by the Bolivian frog *Pseudopaludicola*, with four specimens, representing 13.33%, while the frogs *Leptodactylus latinasus*, *Odontophrynus* americanos and the pileated frog *Scinax acuminatus*, represented 10%, with three individuals each (**Figure 5.3.2.2.3.2.a**). The frog *Physalaemus* sp.1, has two records (6.67%) and the other species are represented by only one individual, or 3.33%, each.

As for the order Squamata, of the three species recorded in the family Dipsadidae, the snake *Erythrolamprus poecilogyrus* has two records, representing 6.67% of the total sample, followed by *Dryophylax chaquensis* and *Hydrodynastes gigas*, each with one record, representing 3.33% of the total (**Figure 5.3.2.3.2.2.a**).

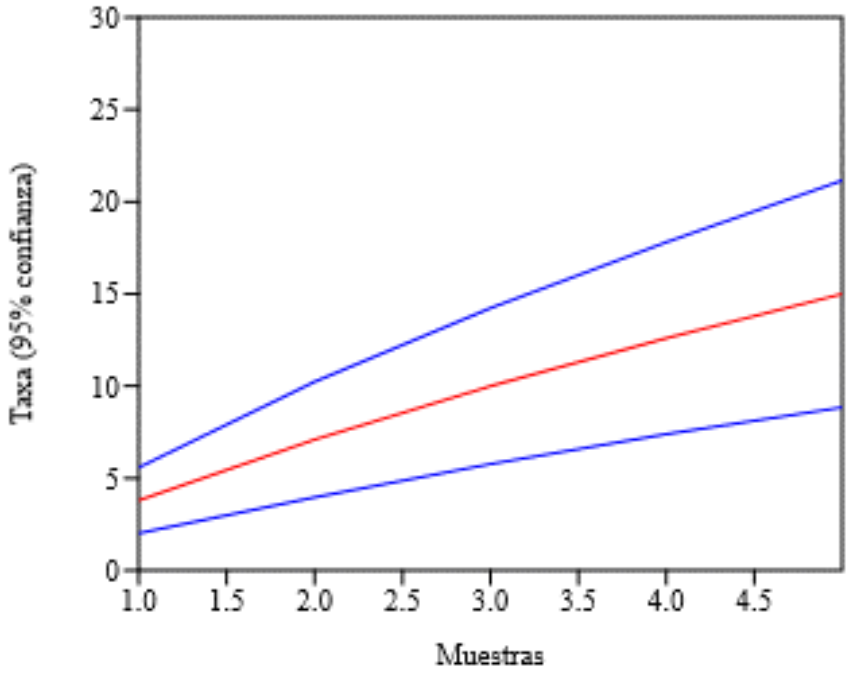
Figure 5.3.2.2.3.2.a
Abundance ranking of species recorded during the second herpetofauna survey campaign



Sampling adequacy

From the sampling effort obtained during the five days of prospecting in the area of influence of the project, the graph obtained through the species rarefaction curve generated shows an upward trend, with no signs of stabilisation, indicating that the actual richness was not reached, with a greater number of species expected for the area sampled (**Figure 5.3.2.2.3.2.b**). This result is consistent with short-term studies, especially in relation to the particularities of amphibian and reptile lifestyle and the likelihood of encounter in the wild.

Figure 5.3.2.2.3.2.b
Rarefaction curve per sample of the second herpetofauna survey campaign



Estimators of richness, diversity and homogeneity

Comparison of observed richness with richness estimators can be used as a further analysis of sampling adequacy. In short-term studies it is possible to consider richnesses equivalent to 90% or more of the estimated richness as indicators of representative sampling (e.g. HERZOG *et al.*, 2002). These values are given for the present study, serving as a suggestion of the minimum additional effort needed to achieve representative sampling for the study region. **Table 5.3.3.2.3.2.b** shows richness, number of records, incidence-based richness estimators (Chao2 and Jackknife 1), as well as alpha diversity indices (Fisher's alpha and Shannon's exponential) and evenness.

The richness estimators generated (Chao 2 and Jacknife 1) corroborate the results shown by the species rarefaction curves (**Figure 5.3.2.2.3.2.b**), with higher estimates than those observed. For the Chao 2 estimator 32.6 species were estimated and for Jacknife 1 the estimate was 24.6 species, indicating that sampling sufficiency was 46.01% and 60.97%, when compared to the total number of species recorded (N=59), respectively. Thus, these values indicate that 53.99% (Chao 2) and 39.02% (Jacknife 1) species are still expected for the study area.

The Shannon diversity index (also called Shannon-Wiener index (H') is one of several indices used to measure diversity in categorical data. This index measures the degree of uncertainty in predicting to which species a randomly chosen individual in a sample of S species and N individuals will belong. In addition, it allows the index values to be compared directly with the observed richness, and the higher the index value, the greater the diversity of the area considered (HILL,

1973; KEYLOCK, 2005; LUDWIG & REYNOLDS, 1988). For this index the value was 2.52 (**Table 5.3.2.2.3.2.b**), and can be considered average, as the values assumed by the Shannon-Wiener index are between 1.5 and 3.5 and only rarely exceed the value of 4.5 (MAGURRAN, 1988).

Another index used is Fisher's Alpha, which has some advantages over other diversity indices, as it is little influenced by sample size or the abundance of the most common species (TAYLOR & FORSMAN, 1976). Fisher's Alpha index relates the number of species (S) to the number of individuals (N) in a community by the following equation: $S = \alpha \ln (1 + N/\alpha)$ (FISHER *et al.*, 1943). In the present study, the index was 11.94 (**Table 5.3.2.2.3.2.b**).

Evenness expresses how the number of individuals is distributed among the different species, i.e. it indicates whether the different species have similar or divergent abundance (number of individuals). It is proportional to diversity, i.e. the ratio between the actual diversity and the maximum existing diversity. Thus, Equitability ranges from 0 (zero) to 1 (one), and for values close to one, it indicates a uniform distribution of abundance of records in the sampling universe (richness) (BROWER & ZAR, 1984). For the present study, the index was 0.93, indicating a greater homogeneity of abundance over species (**Table 5.3.3.2.3.2.2.b**).

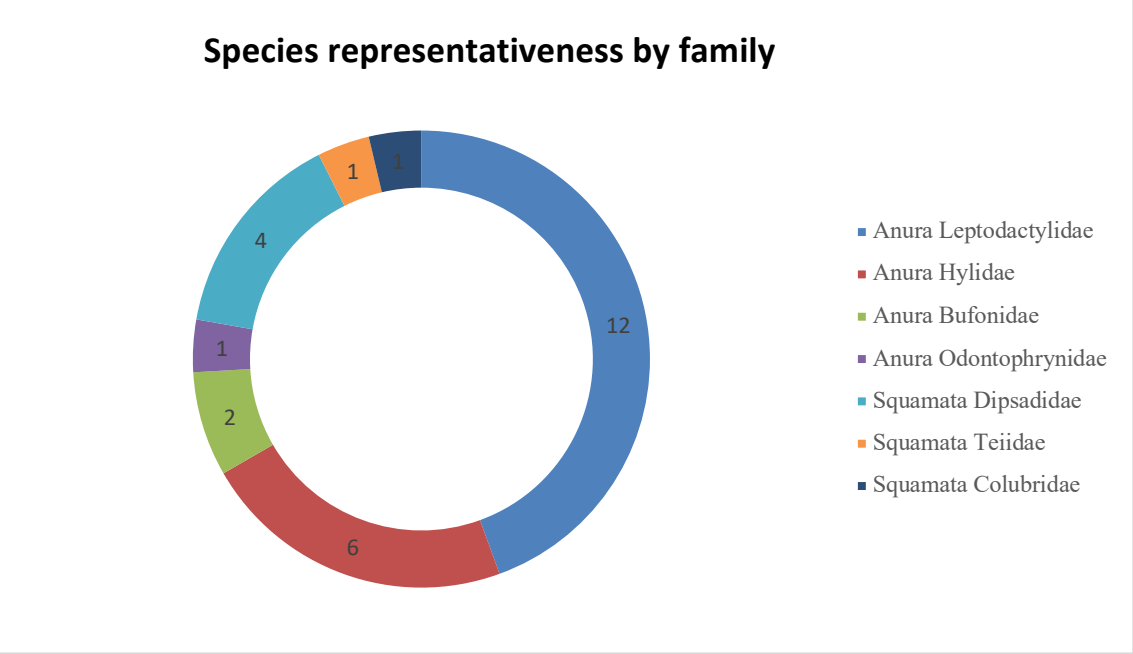
Table 5.3.2.2.3.2.b
Richness, diversity and homogeneity estimators for the second herpetofauna survey season

Indexes	Total
Observed Wealth (S)	15
Number of records (N)	30
Estimated Wealth (Chao 2)	32.6
Estimated Wealth (Jacknife 1)	24.6
Diversity (Shannon, eH)	2.52
Diversity (Fisher's Alpha)	11.94
Equity_J	0.93

Consolidation of campaigns

The diversity obtained by consolidating the results of both campaigns (1C and 2C), gives a total of 27 species, of which 21 represent the order Anura and six the order Squamata. In terms of family representativeness, Anura has four while Squamata has three (**Figure 5.3.2.2.3.2.2.c**).

Figure 5.3.2.2.3.2.c
Species representativeness by family, using data consolidated between the two herpetofauna survey campaigns.



The study of data from different seasonal periods is very effective in terms of complementary sampling. In the case of anuran amphibians, activity and vocalisation during warmer periods is higher compared to colder periods. During the first campaign, vocalising individuals were recorded near water bodies of species belonging to the dwarf species (*Dendropsophus minutus* and *D. nanus*) and to the family Leptodactylidae. These records were not made during the second season, due to the lower temperature, despite the fact that the entire Project site was flooded. Throughout the second season, the recorded individuals of frogs belonging to the genus Leptodactylus, as well as *Odontophrynus americanus* and *Pseudopaludicola boliviana* (**Table 5.3.3.2.3.2.b**), were found by active visual search. Only the two individuals of Weeping Frog (*Physalaemus* sp.1) were recorded by vocalisation. The three individuals of *Odontophrynus americana* were found in the water and with metamorphosis still incomplete, with the tail present. The individual of Physalaemus sp2. appears to be a juvenile, due to its body size, and was found in dry mud at the water's edge. The individuals of the kururu toad (*Rhinella azarai*) and the pouched frog (*Scinax acuminatus*) were sighted on small mud mounds in the middle of the water. The bramble frog (*Boana raniceps*) was rescued in one of the thickets of vegetation located in the middle of the flooded area, active on a dry trunk, but not vocalising. According to the records made, seasonality does not seem to have the same effect on snake activity, as the cats' eye snake (*Dryophylax chaquensis*) and snakes of the genus Erythrolamprus were sighted in both campaigns.

In general, the records made denote species that adapt quite well to environments with a certain degree of anthropisation, having an ecological plasticity that allows them to adapt to different environments. In the case of the water snake (*Hydrodynastes gigas*), it can be present in various types of marsh environments, and even in riverine environments. They are mostly common species with the exception of

Leptodactylus latinasus which, although not a rare species, is not very frequent. Most of the species found are generalists opting for any type of environment, some of them in extreme cases with high levels of anthropophilia (predilection for human dwellings) such as *Scinax fuscovarius* and *S. nasicus*.

Comparison between primary and secondary data

The following is a comparison between the primary data, collected during the two herpetofauna surveys, and the species likely to occur in the project area, made by consulting scientific articles (BRUSQUETTI & LAVILLA, 2006; WEILER *et al*.,2013; CACCIALI & BUONGERMINI, 2021) and official fauna lists (**Table 5.3.2.2.3.2.c** in **Annex 10**).

A total of 59 species belonging to 18 families, of which six belong to the order Anura and 12 to the order Squamata, were estimated to occur in the area where the company is located (**Table 5.3.2.2.3.2.c**).

Considering the total estimated richness, based on primary and secondary data, there are 63 species, distributed in six families of the order Anura and 12 of Squamata. The difference in the number of species studied from the primary data with respect to the secondary data is the fact that, in the latter, four taxa belonging to the family Leptodactylidae have not been counted, two assigned to the genus Leptodactylus (*L. latinasus* and *L. latrans*), and two to the genus Physalaemus, the latter two, however, unidentified (*Physalaemus* sp.1 and *Physalaemus* sp.2).

The taxonomy of the butter frogs, which are part of the *L. latrans* group, has been discussed (MAGALHÃES *et al*., 2020). The group includes at least seven species, of which *L. latrans*, *L. chaquensis*, *L. luctator* and L*. macrosternum* include in their distributions biomes present in Paraguay. In the project area, therefore, *L. latrans* or *L. aff. latrans*, *L. luctator* and *L.* macrosternon/L*. chaquensis* can be found.

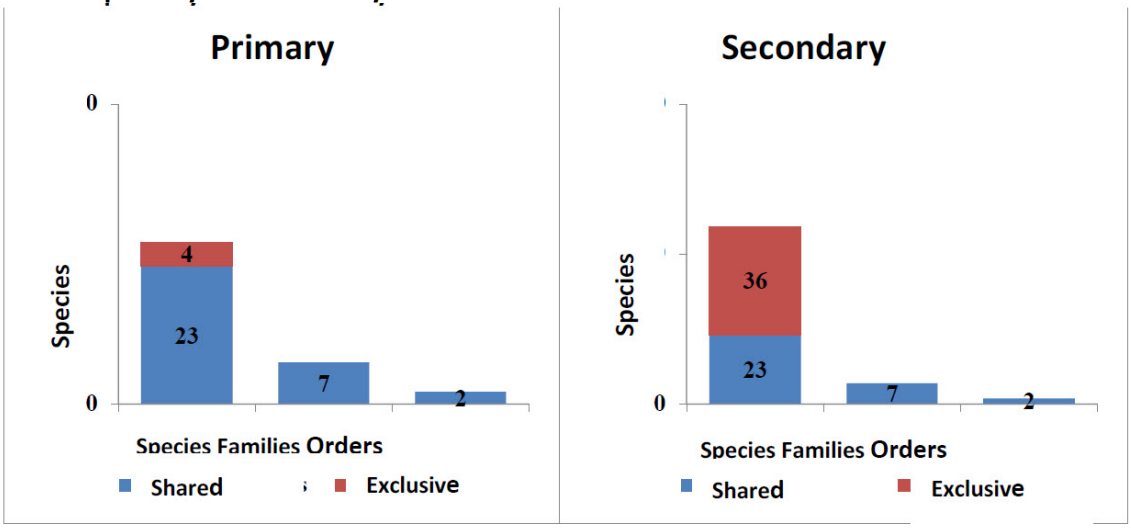
The records of the two individuals of *Physalaemus* sp.1, obtained by vocalisation during the second campaign, belong to the group of weeping frogs which, in the case of the project area, can be attributed to the species *Physalaemus albonotatus* and *Physalaemus biligonigerus*, and also to *P. gracilis*, a species recently recorded for Paraguay (PROCOSARA, 2008). The song of these anurans is quite peculiar in comparison with other Proyecto (**Table 5.3.3.2.3.2.c**). The visual record of *Physalaemus* sp.2 did not allow a correct identification at the specific level, although it shares some colouring characteristics with *Physalaemus cuvieri*.

When considering the primary and secondary surveys, 23 species are common to both surveys, meaning that they were recorded during the survey campaigns, but are also included in the list of species expected to occur in the Project region (**Figure 5.3.2.2.3.2.c**).

In terms of exclusivities, i.e. species that are only present in one of the two surveys conducted, four species were obtained throughout the primary data sampling whose presence in the region is not indicated in the list of probable occurrence based on secondary data, as mentioned above.

The number of amphibians and reptiles recorded in the field and included in the list of species predicted for the region based on secondary data (23 species) represents approximately 39% of the predicted richness for the Project area. Furthermore, considering the 59 species with potential occurrence for the area, the four species recorded during the primary data sampling campaigns alone represent an increase of approximately 7% of the already known richness.

Figure 5.3.2.2.3.2.d
Comparison of representativeness between shared/excluded species, families and orders between primary and secondary data



State of conservation

To verify the conservation status of the species recorded, lists of national and international threatened species were consulted. For national criteria, MADES resolutions (Resolution No. 254/19 and No. 206/2020), which lists threatened and endangered species of native reptiles and amphibians, were consulted. For international criteria, the IUCN (2022) and CITES (2023) classifications were consulted.

Among the reptile and amphibian species recorded, none are listed as endangered in the MADES and IUCN lists consulted. With regard to CITES, two species, the anaconda (*Eunectes notaeus*) and the Brazilian lizard (*Salvator merianae*) (**Table 5.3.2.2.3.2.**c), are included in Appendix II of the list, which includes species that "are not threatened with extinction, but whose trade and transport must be regulated to avoid uses incompatible with their survival, as well as species considered similar to species threatened by commercial utilisation" (CITES, 2023).

Endemism

Considering the distribution of the species recorded in the Project area, within the humid Chaco domain, none are classified as endemic to this biome (MADES, 2019, 2020; BRUSQUETTI & LAVILLA, 2006) (**Table 5.3.2.4.1.c**). Most have a wide distribution with occurrence in other habitat types, present in other geographical regions, such as Argentina, Bolivia and Brazil (IUCN, 2023).

Species of important economic or food value to local populations

During the first primary data collection campaign, one species of lizard (lizard overo) was recorded, which is considered to be a game species, i.e. it is subject to illegal hunting pressure, which may be for food and/or commercial purposes. Through secondary data records, the anaconda (*Eunectes notaeus*) is added to this status. Both are included in CITES Appendix II, and their economic importance lies in the commercial value of their skins, which is why they are used in the leather market for leather goods. The species most commonly used for this, and although the local trade market is prohibited, appliqués with these skins can still be found in national craft markets.

Alien, introduced, invasive or native invasive species

The only exotic reptile species present in Paraguay is *Hemidactylus mabouia*, whose presence was not confirmed in the study area.

Final considerations

Comparison between the results of the field surveys and the secondary data indicates that only 39% of the expected richness of the study region was recorded in the field. Despite this, the primary data collected in the field added four taxa that were not included in the secondary data list, although these are records of widespread species that may occur in the Project region.

In total, 19 species of amphibians and reptiles were recorded during the first campaign in the Project area and 15 species during the second campaign. The first was carried out in the warmer period and the second in the cooler period. In both campaigns a greater representation of frogs of the family Leptodactylidae was observed.

Consolidating the results of the primary data from the two surveys (excluding species common to both surveys), 27 species were recorded, of which 21 represent four families of the order Anura and three of the order Squamata.

The results, based on the sampling effort (second season), show an upward rarefaction curve, with no signs of stabilisation, a result consistent with studies over a short period of time, especially when it comes to the particularities concerning the way of life of amphibians and reptiles. These results are corroborated by the richness and diversity estimators.

In general, the records made denote species that adapt quite well to environments with a certain degree of anthropisation, having an ecological plasticity that allows them to adapt to different environments.

Data collection at different seasonal periods proved to be quite effective in terms of the complementarity of sampling. Most of the species found are generalists, opting for any type of environment, with some of them showing high levels of anthropophilia (predilection for human dwellings), such as *Scinax* fuscovarius and *S. nasicus* in extreme cases.

With the exception of four taxa, all species recorded through primary data are recorded for the Project region (23 species) through secondary data collection. By concatenating the numbers of primary and secondary data, there are a total of 63 species, distributed in six families of the order Anura and 12 of Squamata.

Among the reptile and amphibian species recorded, none are listed as endangered in the national or international lists consulted. Two species, the anaconda (*Eunectes notaeus*) and the Brazilian lizard (*Salvator merianae*) are included in Appendix II of the CITES list.

None of the species recorded are considered endemic to the region, most are widely distributed and occur in different types of biomes.

5.3.2.4.3
Insectivorous Aerial Bats

First campaign

With the first bat survey campaign, carried out from 04 to 08 March 2023, 488 records were obtained of bats belonging to the order Chiroptera, in 13 taxa, distributed in two families (**Table 5.3.2.4.3.a** in **Annex 10**). The records were obtained by a standardised method using vocalisations obtained by ultrasonic recorders (Songmeter SM4 BAT FS bioacoustic device) to identify the species.

Of the 13 taxa, only one can be identified to genus level: *Eumops* sp. The other 12 identified taxa were classified to specific level, according to the recent review of the bioacoustics of aerial insectivorous bats occurring in South America and bibliographies with acoustic identification keys (LÓPEZ-BAUCELLS *et al*., 2016, ARIAS-AGUILAR, *et al*., 2018) (**Table 5.3.2.4.3.a**).

With the richness and abundance obtained during this survey, among the families, the most representative was the Vespertilionidae with six taxa and 327 records (67%), followed by the family Molossidae with seven taxa and 161 records (33%) (**Table 5.3.2.4.3.a**).

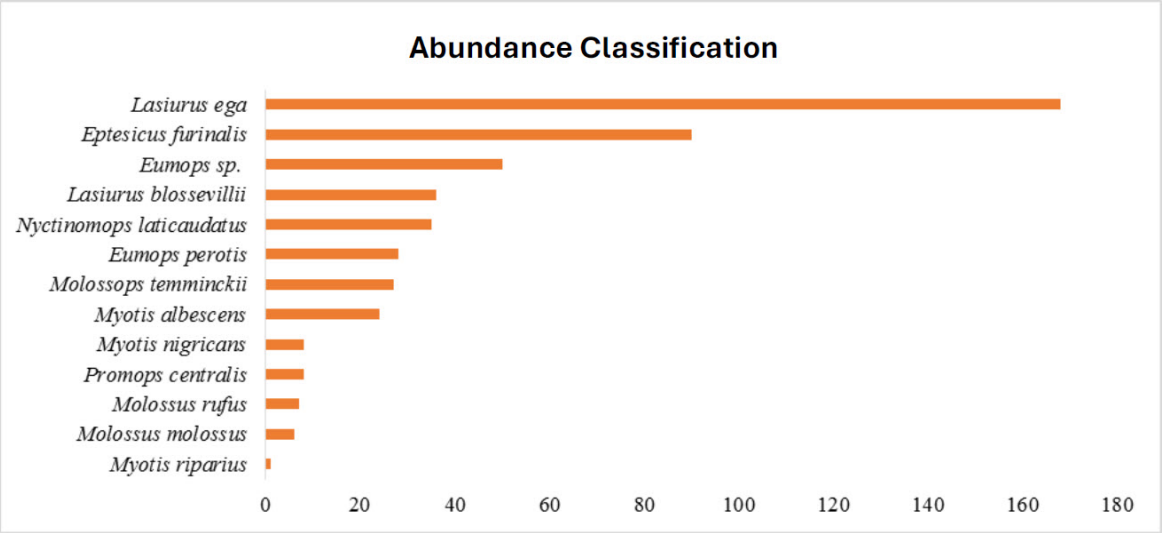
State of conservation

Regarding the conservation status of the species recorded, according to the national list of protected species of wild fauna of the Mammalia class (Resolution SEAM No. 632 of 2017), none were categorised as endangered. Likewise, there are no species categorised according to the international classification of the IUCN (2022) and CITES (2023) (**Table 5.3.2.4.3.3.a**).

Abundance classification

The following is the classification of the abundance of bats recorded during the first survey campaign (**Figure 5.3.2.4.3.a**). Looking at the graph below, it can be seen that one species stood out in relation to the others, being the *Lasiurus ega bat*, which presented a total of 168 records, corresponding to around 34% of the total records obtained during this first campaign. This was followed by the species *Eptesicus furinalis* with 90 records (18%). This was followed by the taxon *Eumops* sp. with 50 records, representing 10% of the total. The other species obtained records between 7.4 and 0.2% (**Figure 5.3.2.4.3.**a and **Table 5.3.2.4.3.a**).

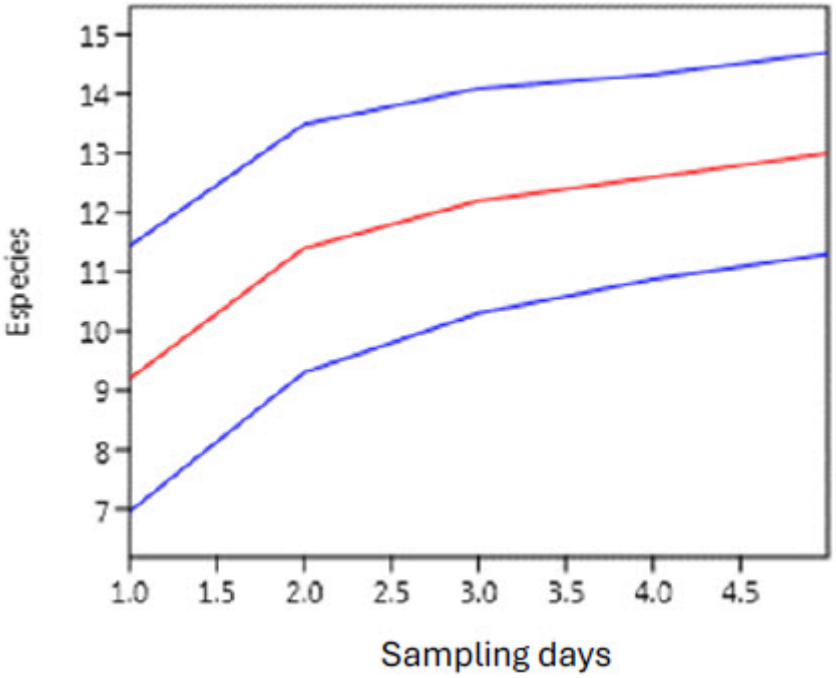
Figure 5.3.2.4.4.3.a
Ranking of bat abundance recorded in the first campaign



Sampling adequacy

In this first campaign, five days of sampling effort were dedicated to the survey of bats in the Project's area of influence. The species rarefaction curve generated is ascending, with no signs of stabilisation, indicating that the actual richness was not reached and that a greater number of species is expected for the areas sampled (**Figure 5.3.2.4.3.b**).

Figure 5.3.2.4.3.b
Rarefaction curve per sample for the first season



Second campaign

In the second bat survey campaign, carried out from 20 to 24 June 2023, 103 records were obtained belonging to nine species, distributed in three families (**Table 5.3.2.2.4.3.b** in **Annex 10**). The records were obtained with the same method as in the first campaign, using the Songmeter SM4 BAT FS bioacoustic device for species identification.

Of the nine taxa, only one can be identified to genus level: Eumops sp. The other eight identified taxa were classified to specific level, according to the recent review of the bioacoustics of aerial insectivorous bats occurring in South America and bibliographies with acoustic identification keys (LÓPEZ-BAUCELLS *et al*., 2016, ARIAS-AGUILAR, *et al*., 2018) (**Table 5.3.2.4.3.b**).

With the richness and abundance obtained throughout this campaign, among the families, the most representative were the Vespertilionidae with four taxa and 69 records (67%), and the family Molossidae with four taxa and 32 records (31%), followed by the family Noctilionidae with one taxon and only two records (2%) (**Table 5.3.2.4.3.b**).

State of conservation

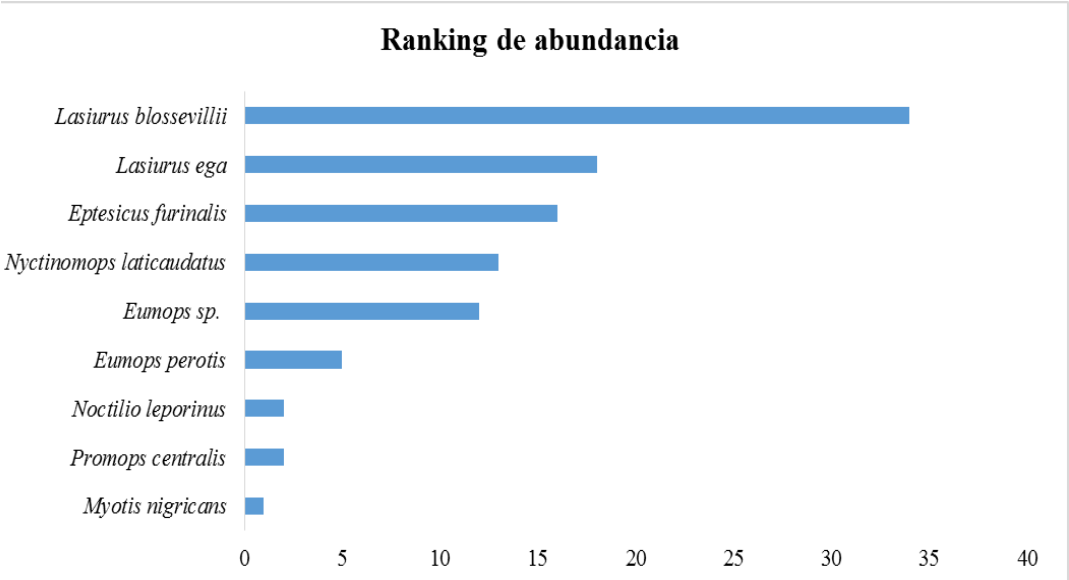
With regard to the degree of conservation of the species recorded, according to the national list of protected species of wild fauna of the Mammalia class (Resolution SEAM No. 632 of 2017), none has a threat classification. Similarly, according to the international classification of the IUCN (2022) and CITES (2023), none of the species recorded is categorised as endangered (**Table 5.3.2.4.3.3.b**).

Abundance classification

The following is the ranking of the abundance of bats recorded during the second survey campaign (**Figure 5.3.2.4.1.c**). The following graph shows that one species stood out above the rest, being the bat of the species *Lasiurus blossevillii*, which presented a total of 34 records, corresponding to around 33% of the total number of records obtained during this second campaign.

This was followed by the bat species *Lasiurus ega* with 11 records (17%), followed by the species *Eptesicus furinali*, with 16 records (16%). The species *Nyctinomops laticaudatus* obtained 13 records (13%), and the taxon *Eumops* sp. 12 (12%). This was followed by the species *Eumops perotis* with five records (5%), the fishing bat (*Noctilio leporinus*) with 2 (2%), *Promops centralis* with two (2%) and, finally, *Myotis nigricans*, with only one record (1%) (**Figure 5.3.2.2.4.1.c** and **Table 5.3.2.4.3.b**).

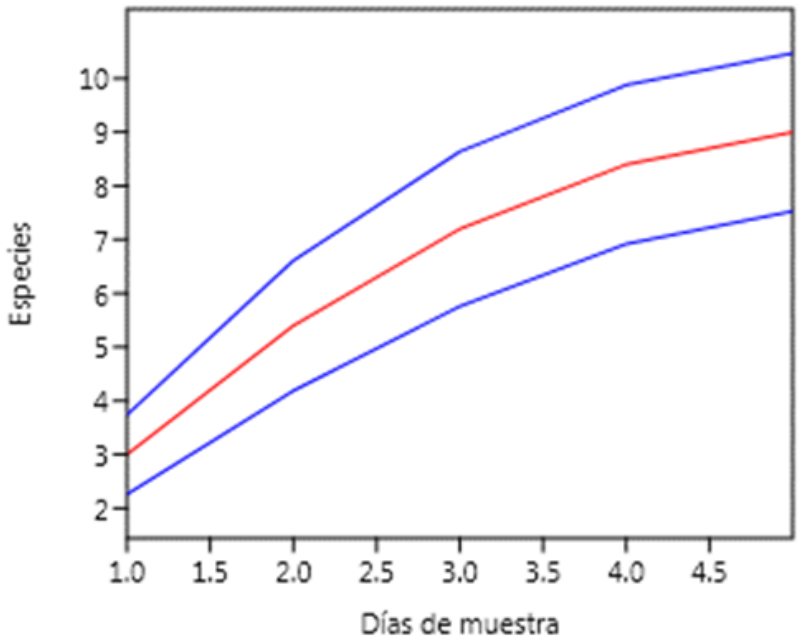
Figure 5.3.2.4.4.3.c
Ranking of the abundance of bats recorded in the second campaign



Sampling adequacy

In this second campaign, five days of sampling effort were also devoted to bat surveys in the project's area of influence. The species rarefaction curve generated is upward, with no signs of stabilisation, indicating that the actual richness was not reached and that a higher number of species is expected for the areas sampled (**Figure 5.3.2.4.3.d**).

Figure 5.3.2.4.4.3.d
Rarefaction curve per sample for the second season



Consolidation of campaigns

Considering the results obtained in the two bat survey campaigns, a total of 591 records have been made, belonging to 14 taxa, which are distributed in three families (**Table 5.3.2.4.3.c**).

Comparison between primary and secondary ***data***

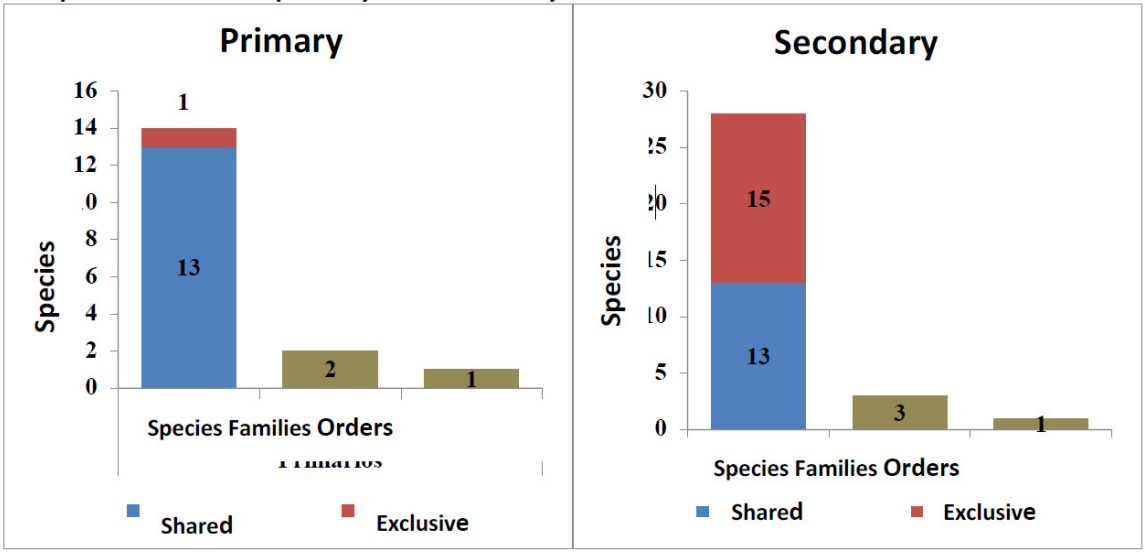
The list of species expected for the Project based on secondary data records 28 species of bats, belonging to the order Chiroptera and distributed in three families **(Table 5.3.2.4.1.c** in **Annex 10**). For this study, we consulted existing scientific reports, published or unpublished, that refer to the biodiversity of the area. In particular, the lists of official institutions such as the Ministry of Environment and Sustainable Development, National Museum of Natural History of Paraguay - MNHNP, Faculty of Chemical Sciences - FCQ, National Institute of Territorial Development - INDERT, National Institute of Statistics - INE, Ministry of Agriculture and Livestock - MAG, National Forestry Institute - INFONA, among others, were used.

Thus, when considering both primary and secondary surveys, there are a total of 29 taxa, distributed in four families (**Table 5.3.2.4.3.c**). Of this total, 13 species are common to both surveys, meaning that they were recorded during the survey campaigns, but are also included in the list of species expected to occur in the Project region (**Figure 5.3.3.2.4.3.e**).

In terms of exclusivities, i.e. species that are only present in one of the two studies carried out, the field surveys obtained records for one taxon, identified at genus level as *Eumops* sp., however, the presence of this genus is indicated in the list of bats of probable occurrence in the region based on secondary data (**Figure 5.3.2.4.3.e**).

The number of bat species recorded in the field, compared to the list of species expected for the region according to secondary data, represents approximately 50% of the richness obtained for the Project area. Even so, when considering the species with potential occurrence for the area, no new species were recorded during the survey campaigns. However, the presence of the genus *Eumops* sp. was recorded, indicated in the list of bats likely to occur in the region according to secondary data.

Figure 5.3.2.4.4.3.e
Comparison between primary and secondary data



Thus, with the richness obtained during the two campaigns, among the families, Molossidae was the most representative, with seven species, representing approximately 50% of the total. This was followed by the family Vespertilionidae with six species, representing 42.9% of the richness, and finally the family Noctilionidae with only one species (7.1%), the *Noctilio leporinus* (fishing bat) (**Figure 5.3.2.2.4.1.f** and **Table 5.3.2.2.4.1.c**).

As for the most abundant species, looking at the graph below (**Figure 5.3.2.4.3.g**), it can be seen that for the consolidated results, one species stood out in relation to the others, namely *Lasiurus ega*, which presented a total of 186 records, corresponding to about 31.5% of the total number of records obtained during the survey campaigns. This is followed by the species *Eptesicus furinalis* with 106 records (17.9%). This is followed by 70 records of the species *Lasiurus blossevillii*, representing 11.8% of the sample. In fourth place is the taxon identified at genus level, *Eumops* sp. with 62 records (10.5%). The remaining species have values ranging from 8.1% to 0.2% (**Figure 5.3.2.4.3.3.g**).

Figure 5.3.2.4.4.3.f
Distribution of the number of species among families

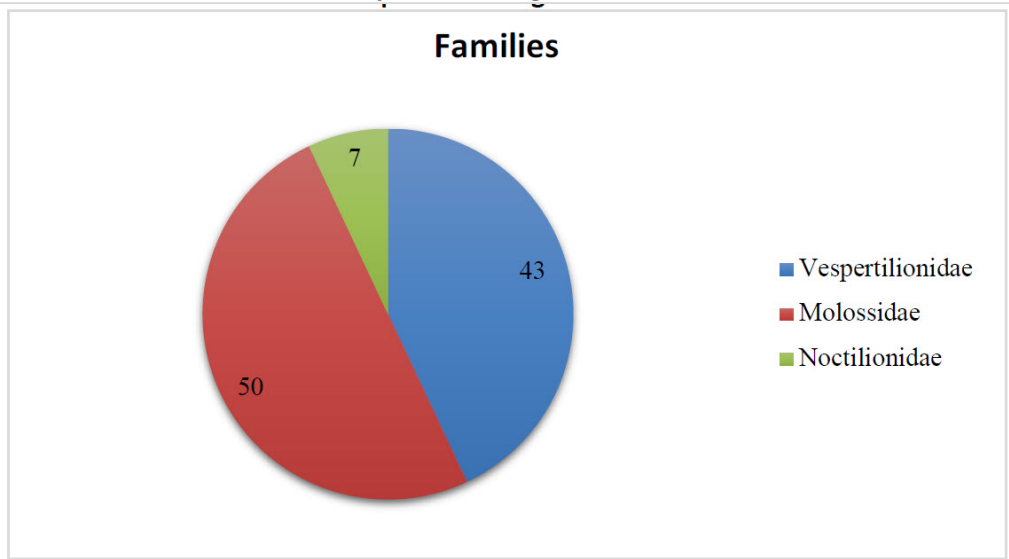
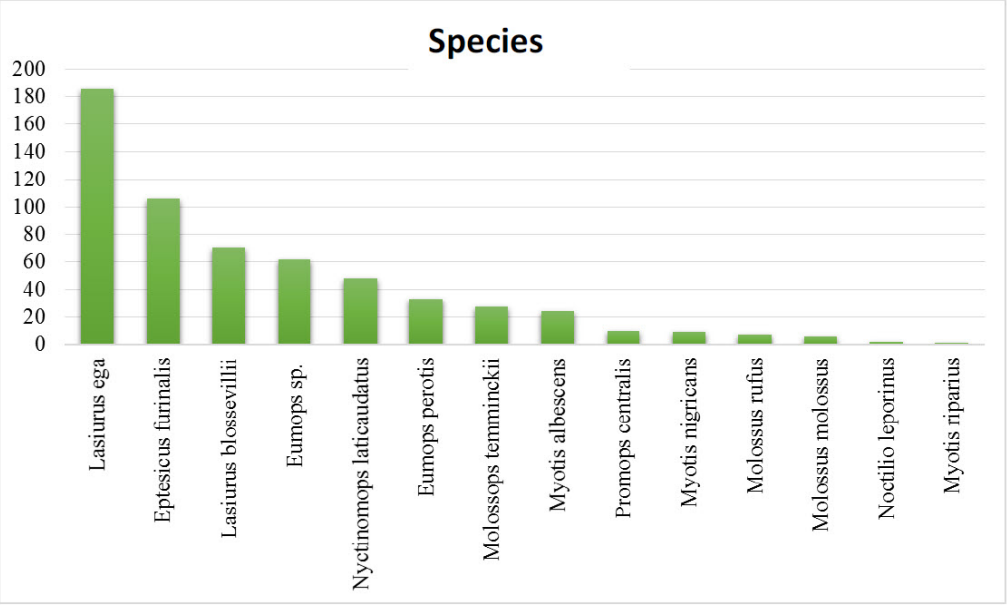


Figure 5.3.2.4.4.3.g
Distribution of the number of records among species



State of conservation

Regarding the conservation status of the species recorded, according to the national list of protected species of wild fauna of the class Mammalia (Resolution SEAM No. 632 of 2017), the species *Peropteryx macrotis* was categorised as "Endangered" - EN. However, this species was only recorded in the secondary data survey. The presence of this species was not recorded in the field surveys. Similarly, according to the IUCN international classification (2022), there is one species classified as Near Threatened (NT), the bat *Myotis ruber*. A taxon is considered Near Threatened when, when assessed against the criteria, it is not currently classified as threatened,

but is close to being classified (approaching the quantitative thresholds of the criteria) or is likely to enter a threatened category in the near future (IUCN 2022) (**Table 5.3.2.4.4.3.c**).

Also in terms of secondary data, two taxa are classified as "Data Deficient" - DD, being the species *Myotis simus* and *Cynomops abrasus*. A taxon is considered to be "Data Deficient" when there is insufficient information to make a direct or indirect assessment of its extinction risk, based on its distribution and/or population status. A species in this category may be well studied and its biology well known, but adequate data on its distribution and/or abundance are lacking. Distribution and/or abundance. Classifying a species in this category indicates that more information is needed, but that the possibility that it may be threatened is recognised, and that future research may indicate a threatened category (IUCN 2022). Finally, the remaining species are classified as of "Least Concern" - LC, taxa with a wide distribution and abundant taxa are normally included in this category. Rare and restricted taxa may also be classified as LC, provided there are no significant threats (IUCN 2022).

Endemism

In terms of endemism, none of the species recorded are considered endemic to the biome (PARAGUAY, 2023).

Species of important economic or food value to local populations

There are no studies that indicate in detail the economic importance of the group of aerial insectivorous bats, but the available information is already sufficient to indicate their importance in economic terms, whether in food production, epidemiological issues or in the availability of extremely important elements, such as the cycling of nitrogen through their faeces (guano) (REIS *et al*., 2008).

Predation of crepuscular and nocturnal insects by aerial insectivorous bats, which are undoubtedly the most numerous, due to the abundance of prey, is extremely important for reducing the number of mosquitoes that transmit dengue fever, leishmaniasis, malaria, as well as insects that are harmful to various types of crops, thus reducing the amount of pesticides used in plantations (YALDEN & MORRIS, 1975). Their importance as insect controllers is immense, as some species can eat up to one and a half times their body weight in a single night (GOODWIN & GREENHAL, 1961). The insects are nutritious and provide fertile guano, which can even be marketed due to the large amount of nitrogen it contains (REIS *et al*., 2008).

Species not described for the area or for science

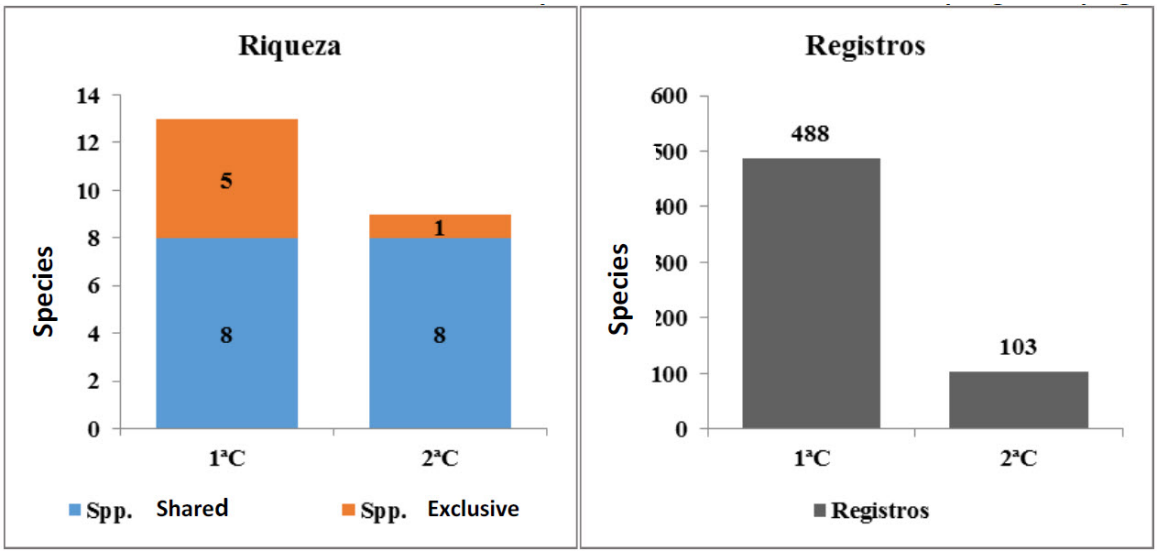
Due to the state of the art of neotropical bioacoustics, it is not possible to rule out the hypothesis that species not identified at the specific level are new to science or to the Project's area of influence. For species identified at the specific level, there were no records of species not described for the area.
However, it is important to highlight that the traditional method of mist-netting is not efficient for the detection of aerial insectivores, the use of bioacoustics is allowing a broad reordering in the understanding of the biogeography of these groups of bats, as false absences influenced by the traditional method are being corrected by the use of bioacoustics (MORATELLI & WILSON, 2013, HINTZE *et al*., 2020).

Comparison between the two sampling campaigns

As mentioned, a total of 591 records were obtained in the two campaigns, belonging to 14 taxa, distributed in three families (**Table 5.3.2.4.3.3.c**).

For richness, the highest diversity value was obtained in the first survey campaign, with 13 species, of which five were exclusive, i.e. they were only recorded in the first campaign. In the second campaign, a total of nine species were obtained, one of which was exclusive. Thus, the difference in richness between the campaigns was approximately 9.7% (**Figure 5.3.2.4.3.h**). For the abundance values, the difference is considerable, with the first season having the highest value with 488 records, while the second season had a total of 103 records. This difference between the sampling campaigns may be related to seasonality, as the first campaign was carried out in the less rainy season of the year (dry), and the second in the rainy season (**Figure 5.3.2.2.4.3.h**).

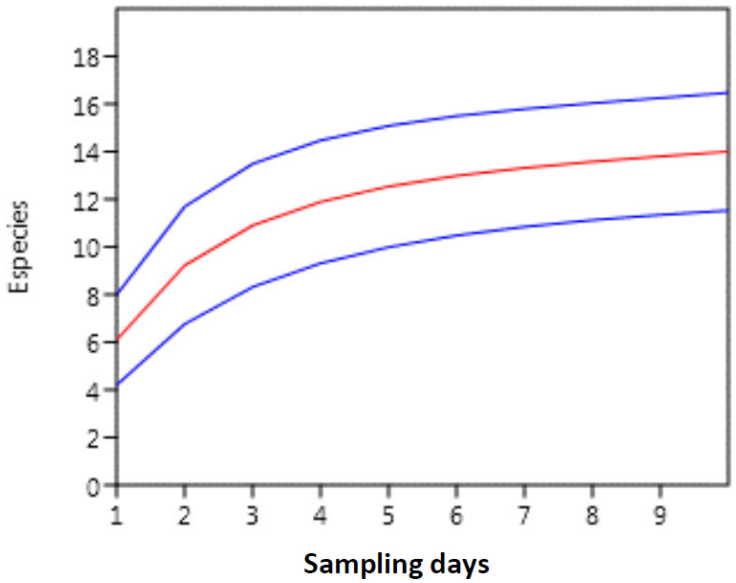
Figure 5.3.2.4.3.h
Distribution of bat richness, exclusivity and records between sampling campaigns



Sampling adequacy

In order to check the effectiveness of the efforts during the survey campaigns, a rarefaction curve was made for the total observed (**Figure 5.3.2.4.3.i**). This curve, even considering the two sampling campaigns (10 days), shows an upward trend, but with a slight tendency to stabilise, indicating that, although a large part of the expected richness has been obtained, more species are still expected for the total richness of the study area. These results were already expected, taking into account that studies with small sampling efforts are not enough to reach stability of the curves, which should only occur in the long term, especially when considering endemic and/or endangered species, which are naturally rare and have low population density, requiring much more time to be recorded in the field (COSTA-BRAGA *et al*., 2014; STRAUBE *et al*., 2010; VASCONCELOS, 2006). This result is corroborated by the richness estimators (Chao2 and Jacknife 1), which estimated more species for the Project region (see below).

Figure 5.3.2.4.4.3.i
Rarefaction curve per sample for total



Estimators of wealth, diversity and equity

Table 5.3.2.2.4.1.d shows richness, number of records, incidence-based richness estimators (Chao2 and Jackknife 1), as well as alpha diversity indices (Fisher's alpha and Shannon's exponential) and equitability.

The richness estimators generated (Chao 2 and Jacknife 1) corroborate the results shown by the species rarefaction curves (**Figure 5.3.2.4.3.i**), with estimates higher than those observed. For the Chao 2 estimator, 14.5 species were estimated and for Jacknife 1 the estimate was 15.5 species, indicating that sampling sufficiency was 96.89% and 88.7%, when compared to the total number of species recorded (S=14), respectively. Thus, these values indicate that 3.11 (Chao 2) and 11.39 (Jacknife 1) species are still expected for the study area (**Table 5.3.2.4.1.1.d**).

The Shannon diversity index (also called Shannon-Wiener index (H')) is one of several indices used to measure diversity in categorical data. It is simply the entropic information of the distribution. This index measures the degree of uncertainty in predicting to which species a randomly chosen individual will belong in a sample of S species and N individuals. In addition, it allows the index values to be compared directly with the observed richness, and the higher the index value, the greater the diversity of the area considered (HILL, 1973; KEYLOCK, 2005; LUDWIG & REYNOLDS, 1988; TUOMISTO, 2010). For this index the value was 2.1 (**Table 5.3.2.2.4.1.d**), which can be considered high, as the values assumed by the Shannon-Wiener index are between 1.5 and 3.5 and only rarely exceed the value of 4.5 (MAGURRAN, 1988).

Another index used is Fisher's Alpha, which has some advantages over other diversity indices in that it is little influenced by sample size or the abundance of the most common species (TAYLOR & FORSMAN, 1976). Fisher's Alpha index relates the number of species (S) to the number of individuals (N) in a community by the following equation: $S = \alpha \ln (1 + N/\alpha)$ (FISHER *et al.*, 1943). In the present study, the index was 2.6 (**Table 5.3.2.2.4.1.1.d**).

Evenness expresses how the number of individuals is distributed among the different species, i.e. it indicates whether the different species have similar or divergent abundance (number of individuals). It is proportional to diversity, i.e. the ratio between the actual diversity and the maximum existing diversity. Thus, Equitability ranges from 0 (zero) to 1 (one), and for values close to one, it indicates a uniform distribution of abundance of records in the sampling universe (richness) (BROWER & ZAR, 1984). For the present study, the index was 0.8, indicating a greater homogeneity of abundance over species (**Table 5.3.2.4.1.d**).

Table 5.3.2.4.1.d
Richness, diversity and homogeneity estimators for bat survey surveys

Indices	Total
Observed Wealth (S)	14
Number of records (N)	591
Estimated Wealth (Chao 2)	14.5
Estimated Wealth (Jacknife 1)	15.8
Diversity (Shannon, eH)	2.1
Diversity (Fisher's Alpha)	2.6
Equity_J	0.8

Final considerations

The primary and secondary bat surveys recorded a total of 29 taxa, distributed in four families of the order Chiroptera. Of this total, 13 species are common to both studies, meaning that they were recorded during the survey campaigns, but are also included in the list of species expected to occur in the Project region. Due to the state of the art of Neotropical bioacoustics, it is not possible to rule out the hypothesis that species not identified at the specific level are new to science or to the Project's area of influence. For species identified at the specific level, there were no records of species not described for the area.

Regarding the degree of conservation of the species recorded in the field surveys, according to the national list of protected species of wild fauna of the Mammalia class (Resolution SEAM No. 632 of 2017), none were categorised as endangered. Likewise, there are no species categorised according to the international classification of the IUCN (2022) and CITES (2023). Nor were there any species considered endemic to the biome. Based on secondary data, one species is considered threatened at the national level (*Peropteryx macrotis*). At the international level, one species is considered near threatened (*Myotis ruber*) and two are classified as species for which insufficient data are available to verify their threat status (*Myotis simus* and *Cynomops abrasus*).

In terms of sampling sufficiency, the species rarefaction curve generated is upward, but with a slight tendency to stabilise, indicating that, although much of the expected richness has been obtained, more species are still expected for the total richness of the study area. The richness estimators generated corroborate the results shown by the species rarefaction curves, with higher estimates than those observed.

5.3.2.4.4
Medium and Large Terrestrial Mammals

First campaign

With the first survey campaign of terrestrial mammals, carried out from 04 to 08 March 2023, 23 records of medium and large mammals were obtained, belonging to 11 taxa, distributed in seven orders and nine families (**Table 5.3.2.4.4.a**). Records were obtained by standardised (active search and camera traps) and non-standardised (chance encounters) methods. However, it should be noted that only values obtained by standardised methods will be taken into account for the analyses, and that non-standardised methods are considered in the qualitative characterisation of the group.

With the richness and abundance obtained during the first campaign, among the orders, Carnivora was the most representative, with five taxa and 12 records, representing approximately 52% of the total sampling. This was followed by the remaining orders with only one species each, and the abundance was distributed as follows: Primates with five records (N=22%), Cetartiodactyla with two records (N=9%), Cingulata (N=1%), Didelphimorphia (N=1%), Lagomorpha (N=1%) and, Pilosa (N=1%) (**Table 5.3.2.4.4.4.a**).

In terms of families, the most representative was Canidae with seven records (30%), Atelidae with five (22%), Felidae with three (N=13%). The families Cervidae and Procyonidae had two records each (17%). Each of the families Leporidae, Myrmecophagidae, Dasypodidade and Didelphidae with one record each (17%) (**Table 5.3.2.4.4.4.a**).

State of conservation

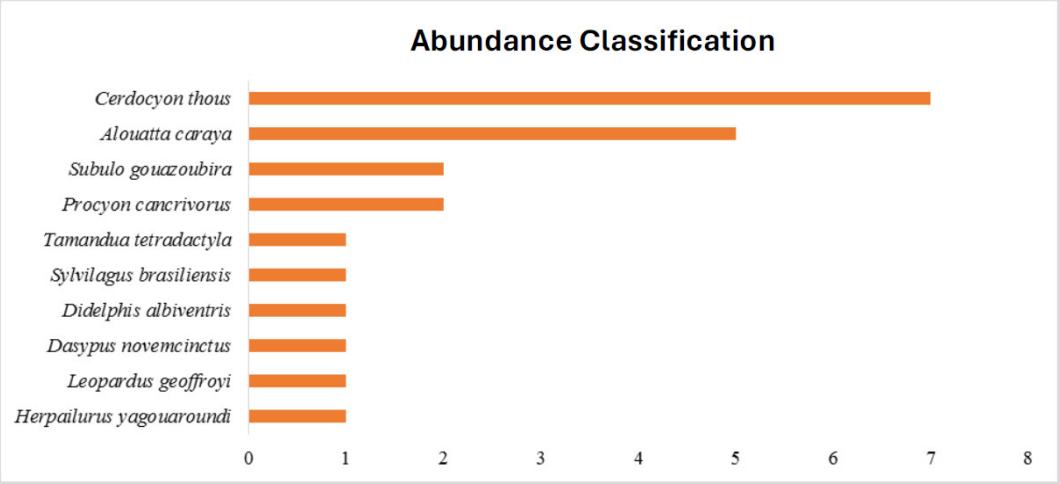
Regarding the conservation status of the species recorded, according to the national list of protected species of wild fauna of the Mammalia class (Resolution SEAM No. 632 of 2017), none has been categorised as endangered. Likewise, there are no species categorised according to the international classification of the IUCN (2022) (**Table 5.3.2.4.4.4.a**).

While for the international CITES list (2023), five recorded species are included in Appendix II, which includes species that are not threatened with extinction, but could reach this status if strict monitoring is not carried out, namely: Howler monkey (*Alouatta caraya*), Crab-eating fox (*Cerdocyon thous*) and the felidae family, with the Moorish cat (*Herpailurus yagouaroundi*) and the Bobcat (*Leopardus geoffroyi*) (CITES, 2023) (**Table 5.3.2.4.4.a**).

Abundance classification

The abundance ranking of medium and large mammals recorded during the first survey campaign is presented below (**Figure 5.3.2.4.4.a**). Looking at the graph below, one species stands out from the rest, being the crab fox (*Cerdocyon* thous), which presented a total of seven records, corresponding to about 30% of the total values obtained during this first survey campaign. It was followed by the howler monkey (*Allouatta caraya*) with five records (22%). The honey bear (*Tamandua tetradactyla*), the wild rabbit (*Sylvilagus brasiliensis*), the common weasel (*Didelphis albiventris*), the large mulita (*Dasypus novemcinctus*), and the Moorish cat (*Herpailurus yagouaroundi*) and wildcat (*Leopardus geoffroyi*), each obtained one record each, totalling 31% of the records. The roe deer (Subulo gouazoubira) and the crab-eating raccoon (*Procyon cancrivorus*) had two records each (17%) (**Figure 5.3.2.2.4.4.4.a** and **Table 5.3.2.2.4.4.a**).

Figure 5.3.2.4.4.a
Ranking of the abundance of mammals recorded in the First Campaign

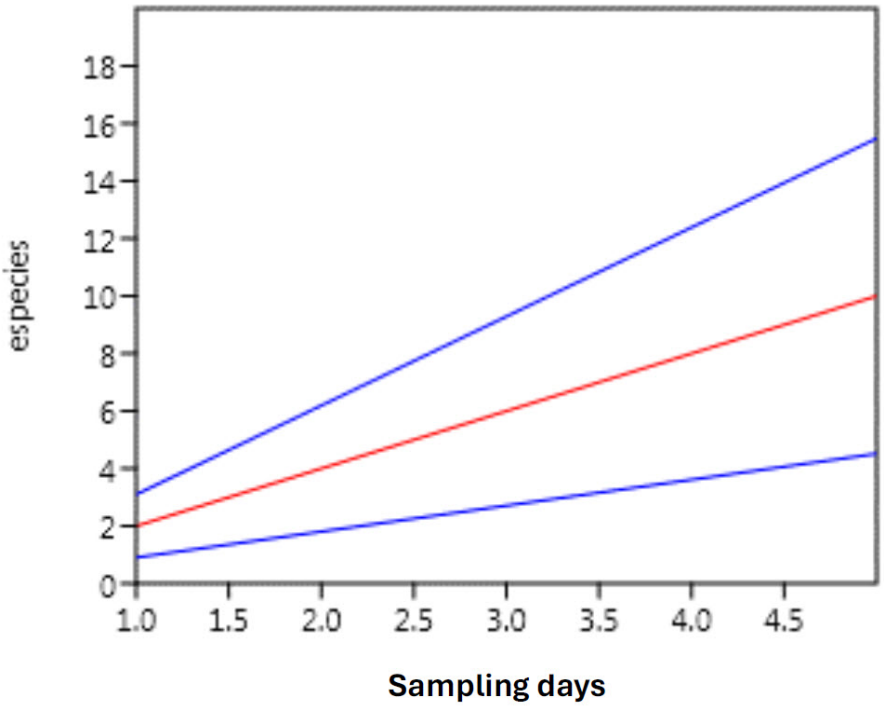


One indirect track record was collected from a wild felid, which could not be identified to species level. However, these records possibly belong to one of the felid species confirmed by the camera traps.

Sampling adequacy

In this first campaign, five days of effort were devoted to sampling mammals in the Project's area of influence. The species rarefaction curve generated is ascending, with no signs of stabilisation, indicating that the actual richness was not reached and that a greater number of species is expected for the areas sampled (**Figure 5.3.2.4.4.b**).

Figure 5.3.2.4.4.b
Rarefaction curve per sample for the first season



<u>Second campaign</u>

In the second mammal survey campaign, carried out from 20 to 24 June 2023, 62 records were obtained belonging to nine mammal species, distributed in six orders and eight families (**Table 5.3.2.4.4.4.b** in **Annex 10**).

Records were obtained by standardised (active search and camera traps) and non-standardised (chance encounters) methods. However, it should be noted that only values obtained by standardised methods will be taken into account for the analyses, and that non-standardised methods are considered in the qualitative characterisation of the group.

With the richness and abundance obtained during this campaign, among the orders, Carnivora was the most representative, with three species and 27 records, representing approximately 44% of the total. This was followed by the order Didelphimorphia with two species and 19 records, representing approximately 31% of the total records. All other orders had only one species each, and abundance was distributed as follows: Cingulata with seven records (N=11%),

Cetartiodactyla with six records (N=10%), Lagomorpha with two (N=3%) and Primates with only one (N=2%) (**Table 5.3.2.4.4.4.b**).

The most representative family was Didelphidae with two species (S=2) and the most abundant with 19 records (31%). The other families had one species each. The records showed abundance values as follows: Canidae (27%), Procyonidae (13%), Dasypodidae (N=11%), Cervidae (10%). The families Felidae and Leporidae had two records each (6%) and, finally, the family Atelidae had only one record (2%) (**Table 5.3.2.2.4.4.b**).

State of conservation

Regarding the conservation status of the species recorded, according to the national list of protected species of wild fauna of the Mammalia class (Resolution No. 632 of 2017), none of them has a threat classification. Similarly, according to the IUCN international classification (2022), none of the species recorded are categorised as endangered (**Table 5.3.2.4.4.4.b**).

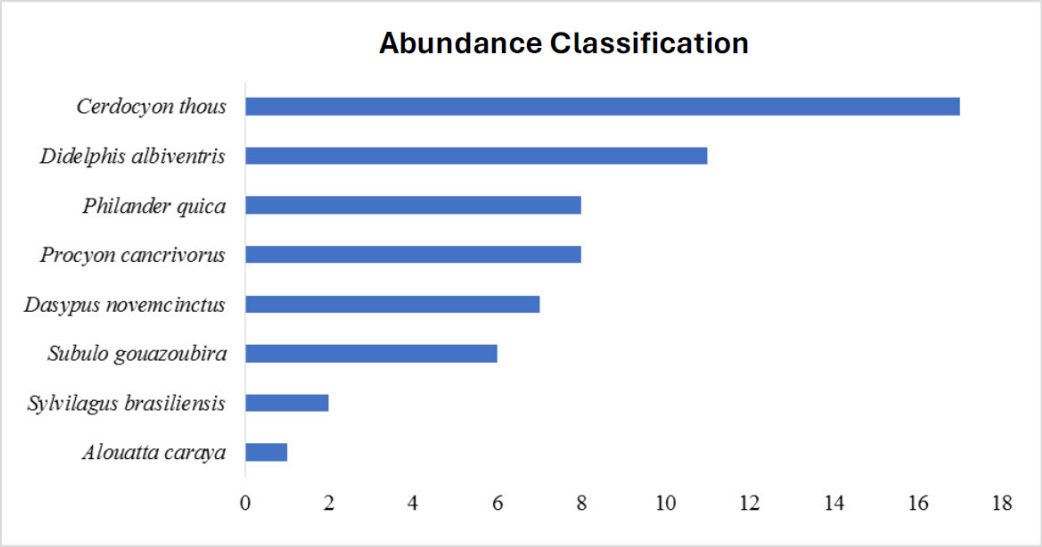
While for the international CITES list (2023), three recorded species are included in Appendix II, which includes species that are not threatened with extinction, but could become so if not strictly monitored, namely the Howler Monkey (*Alouatta caraya*), the Crab-eating Fox (*Cerdocyon* thous) and the felidae family (CITES, 2023) (**Table 5.3.2.4.4.**b).

Abundance classification

The ranking of the abundance of mammals recorded during the second survey campaign is presented below (**Figure 5.3.2.4.4.c**). The following graph shows that one species stands out from the rest, namely the crab fox (*Cerdocyon thous*), which made a total of 17 records, corresponding to around 28% of the total number of records obtained during the second survey campaign. The common fox (*Didelphis albiventris*) followed with 11 records (19%), followed by the crab-eating raccoon (*Procyon cancrivorus*) with eight records (13%), and the four-eyed fox (*Philander quica*) with the same values (13%). The large mulita (*Dasypus novemcinctus*) with seven (12%) and the corzuela (*Subulo gouazoubira*) with six (10%) and the wild rabbit (*Sylvilagus brasiliensis*) with two records (2%). Finally, the howler monkey (*Alouatta caraya*) had only one record (1%) (**Figure 5. 3.2.2.4.4.c** and **Table 5.3.2.2.4.4.b**).

Indirect track records of a wild felid were collected, which could not be identified to species level. However, these records possibly belong to one of the felid species confirmed by the camera traps.

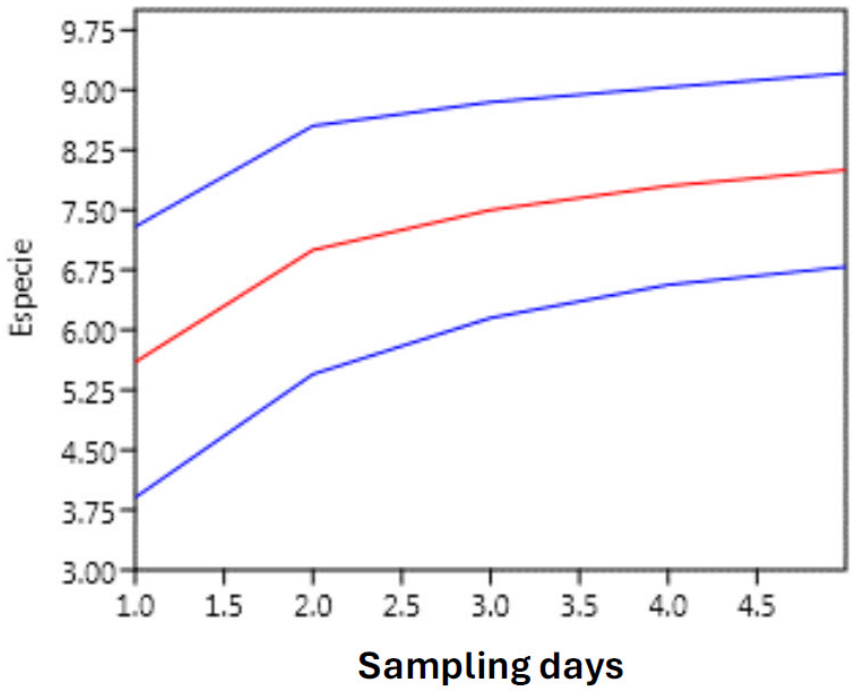
Figure 5.3.2.4.4.c
Ranking of the abundance of mammals recorded in the second campaign



Sampling adequacy

In this second campaign, five days of sampling effort were also devoted to mammal surveys in the area of influence of the project. The species rarefaction curve generated is upward, with no signs of stabilisation, indicating that the actual richness was not reached and that a higher number of species is expected for the areas sampled (**Figure 5.3.2.4.4.d**).

Figure 5.3.2.4.4.d
Rarefaction curve per sample for the second season



Consolidation of campaigns

Considering the results obtained during the two surveys of medium and large mammals, a total of 85 records were made, belonging to 12 taxa, distributed in seven orders and nine families (**Table 5.3.2.4.4.c**).

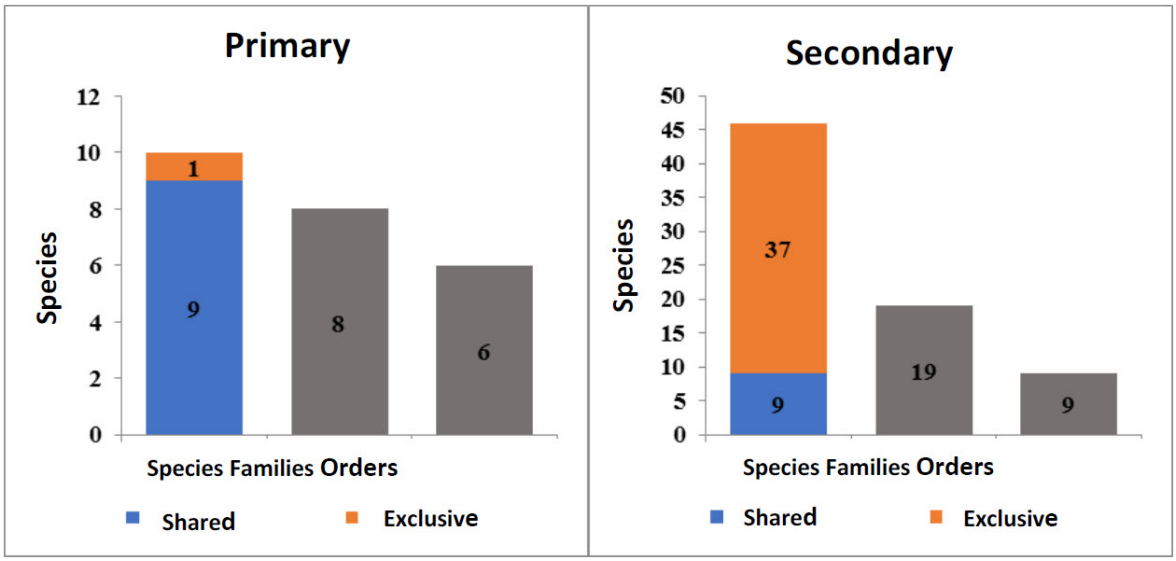
Records were obtained by standardised (active search and camera traps) and non-standardised (chance encounters) methods. In the following, the analyses will be presented considering the values obtained by the standardised methods.

Comparison between primary and secondary data

The list of expected species for the Project based on secondary data (AII) records 46 species of medium and large mammals, distributed in nine orders and 19 families **(Table 5.3.2.4.4.c** in **Annex 10**). In particular, lists from official institutions such as the Ministry of Environment and Sustainable Development, National Museum of Natural History of Paraguay - MNHNP, Faculty of Chemical Sciences - FCQ, National Institute of Territorial Development - INDERT, National Institute of Statistics - INE, Ministry of Agriculture and Livestock - MAG, National Forestry Institute - INFONA, among others (**Table 5.3.2.4.4.c**) were used (**Table 5.3.2.4.c**).

Thus, when considering both primary and secondary surveys, there are a total of 47 taxa, distributed in nine orders and 19 families (**Table 5.3.2.4.4.c**). Of this total, nine species are common to both studies, meaning that they were recorded during the survey campaigns, but are also included in the list of species expected to occur in the Project region (**Figure 5.3.3.2.4.4.e**).

Figure 5.3.2.2.4.4.e
Comparison between primary and secondary data



In terms of exclusivities, i.e. species that are only present in one of the two surveys conducted, the field surveys obtained records for one species, the four-eyed weasel (*Philander quica*), whose presence in the region is not indicated in the list of mammals of probable occurrence

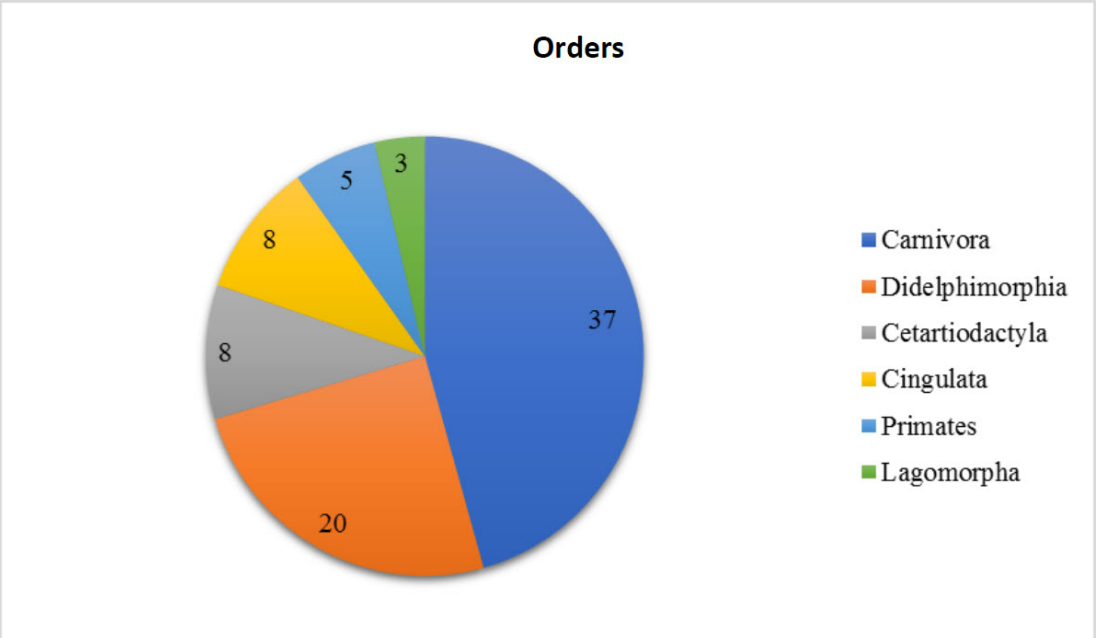
based on secondary data. This marsupial falls into the category of small mammals, however, it was recorded by camera traps.

The number of mammals recorded in the field, compared to the list of species predicted for the region based on secondary data, represents approximately 22% of the richness obtained for the Project area. Furthermore, when considering the species with potential presence for the area, only one new species was recorded during the survey campaigns, which belongs to the category of small mammals.

It is important to mention that, in order to increase the comparability of the results, only the records obtained through the standardised methodologies executed in the two mammal survey campaigns will be used for all the following analyses.

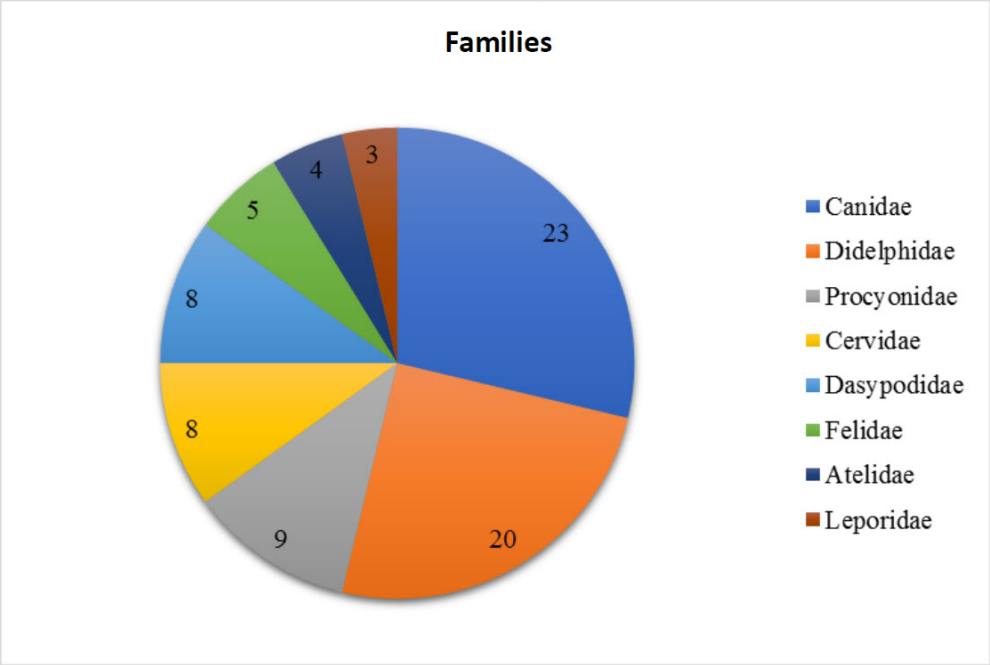
Thus, with the richness obtained during the two campaigns, among the orders, Carnivora was the most representative, with four species and 37 records, representing approximately 46% of the total. It is followed by the order Didelphimorphia with two species and twenty records (25%), Cetartiodactyla (10%), Cingulata (10%), Primates (6%) and Lagomorpha (4%) with one species each (**Figure 5.3.2.2.4.4.4.g** and **Table 5.3.2.2.4.4.c**).

Figure 5.3.2.4.4.f
Distribution of the number of registrations between the Orders



The most representative families in terms of species richness were Didelphidae and Felidae, both with two species each. All other families had only one species each. In terms of abundance, the family with the highest number of records was Canidae with 23 records (29%). It was followed by Canidae with 20 (25%), Procyonidae with nine (11%), Cervidae and Dasypodidae with eight records (10%) each. Finally, Felidae with five records (6%) Atelidae with four (5%) and Leporidae with three records (4%) (**Figure 5.3.3.2.4.4.4.g** and **Table 5.3.2.2.4.4.c**).

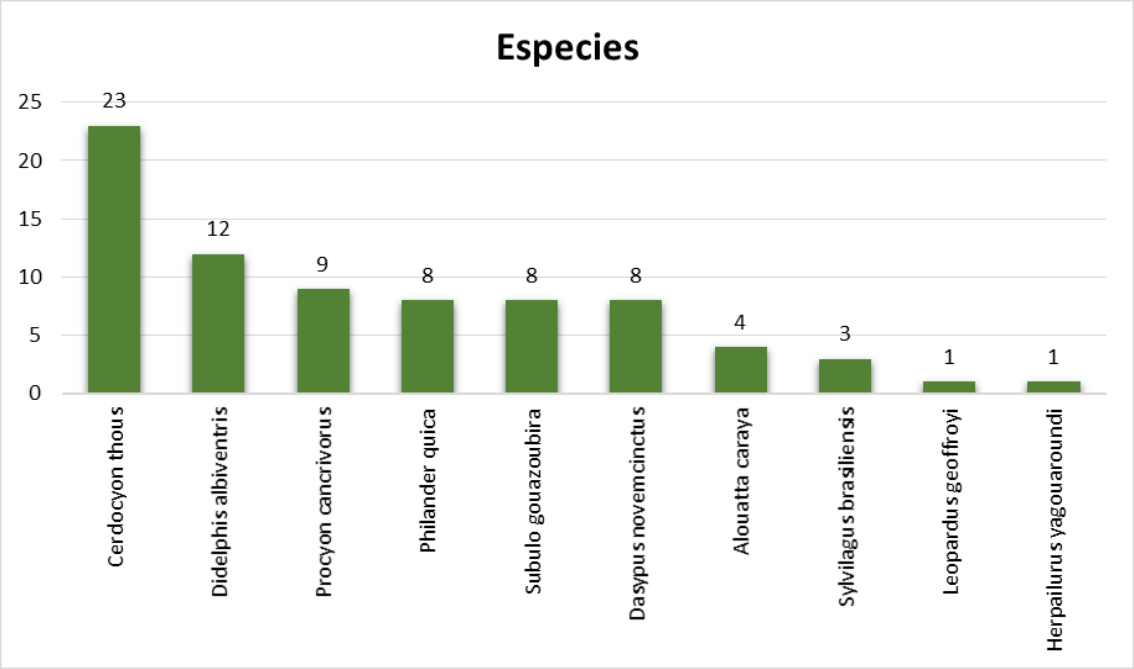
Figure 5.3.2.4.4.g
Distribution of the number of records among Families



As for the most abundant species, looking at the graph below (**Figure 5.3.2.4.4.h**), it can be seen that for the consolidated results one species stood out in relation to the others, being the crab fox (*Cerdocyon thous*), which presented a total of 23 records, corresponding to around 29% of the total number of records obtained throughout the survey campaigns. It was followed by the common fox (*Didelphis albiventris*) with 12 records (15%). These records were provided by the camera trapping method and proved effective when baited (**Figure 5.3.2.4.h**).

This is followed by the crab-eating raccoon (*Procyon cancrivorus*) with nine records (11%), eight of which were obtained by the active search method. The four-eyed weasel (*Philander quica*) was recorded in eight events (10%) captured by camera trapping, as well as the corzuela (*Subulo gouazoubira*) with eight records (10%), and the large mulita (*Dasypus novemcinctus*) with eight records (10%). The following species were recorded using the active search method, with the howler monkey (*Alouatta caraya*) with four records (5%), the wild rabbit (*Sylvilagus* brasiliensis) with three records (4%), and the felid wildcat (*Leopardus geoffroyi*) and bobcat (*Herpailurus yagouaroundi*) with only one record each, totalling 2%.

Figure 5.3.2.4.4.h
Distribution of the number of records among medium and large mammal species



State of conservation

Regarding the conservation status of the species recorded in the field campaigns, according to the national list of protected species of wild fauna of the Mammalia class (Resolution SEAM No. 632 of 2017), none has been categorised as endangered. Likewise, no species categorised according to the IUCN international classification (2022) were recorded in the field (**Table 5.3.2.4.4.c**). On the other hand, considering the list of probable occurrence in the region (secondary data), there are 4 vulnerable species (VU) according to the IUCN (*Leopardus tigrinus*, *Tapirus terrestres*, *Blastocerus dichotomus* and *Tayassu pecari*). Two others are considered endangered (EN) (*Pteronura brasiliensis* and *Catagonus wagneri*). Finally, *Lontra longicaudis*, *Leopardus braccatus*, *Leopardus wiedii* and *Panthera onca* are classified as Near Threatened (NT). For the international CITES list (2023), 9 species are listed in Appendix I, of which only 1 (*Leopardus geoffroyi)* was recorded in the field. Appendix II lists 17 species, 4 of which were recorded in the field.

Endemism

In terms of endemism, none of the species recorded in the field are considered endemic to the biome (PARAGUAY, 2023).

Species of important economic or food value to local populations

The confirmed presence of highly specialised species dependent on structured environments, such as the wildcat (*Leopardus geoffroyi*) and the brown cat (*Herpailurus yagouaroundi*), is of important conservation value. They are also indicators of environmental quality, as even under anthropogenic influence the region is still able to support elements with high environmental requirements.

Historically, humans and wild mammals have interacted in a variety of ways, which may culminate in relationships that vary according to specific regional and national cultures. In addition to being used as food, mammals are used as fuel, medicines, creation of artefacts such as ornaments, sources of beauty and inspiration, as well as symbols of divinity (ALVES *et al*., 2016; FERNANDES-FERREIRA, 2014). In this study, species that can be hunted to be used as different sources of products, or that can be captured due to conflicting relationships, were considered to be cinegetic.

Among the records, two species were assessed as having potential hunting value in the Project area and may be subject to human hunting pressure: the common weasel (*Didelphis albiventris*), the large mulita (*Dasypus novemcinctus*), the honey anteater (*Tamandua tetradactyla*), the bush rabbit (*Sylvilagus brasiliensis*), the crab fox (*Cerdocyon thous*), the gato montês (*Leopardus geoffroyi*), the gato moro (*Herpailurus yagouaroundi*) and the corzuela (*Subulo gouazoubira*).

It should be noted that carnivorous animals such as the canids and felids mentioned above may be hunted in retaliation for attacks on domestic livestock.

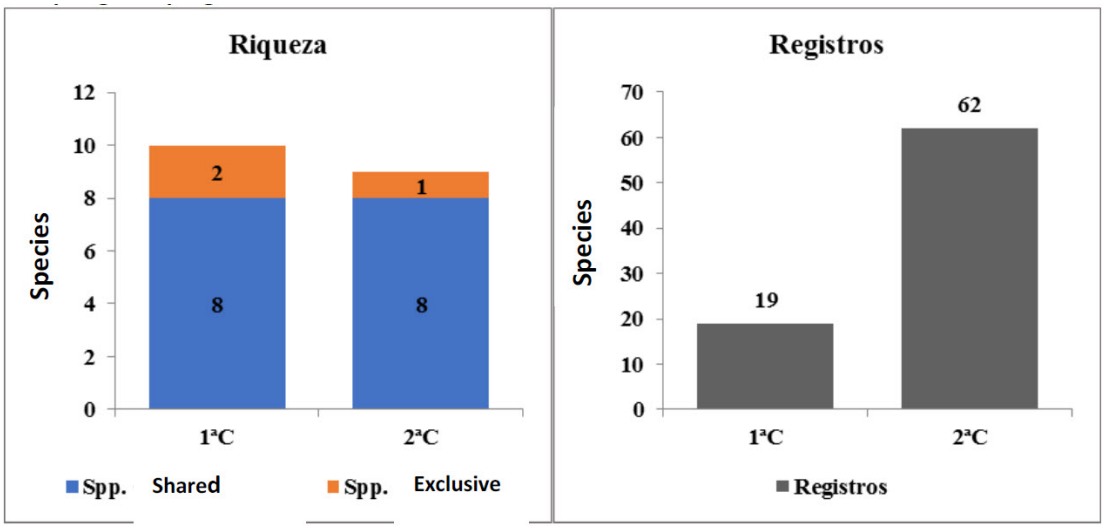
Alien, introduced, invasive or native invasive species
No alien, introduced, invasive or invasive native species of medium and large mammals were recorded in this study.

<u>Comparison between the two sampling campaigns</u>

As previously mentioned, a total of 85 records were obtained in the two field campaigns, belonging to 12 taxa, distributed in seven orders and nine families (**Table 5.3.2.2.4.4.c**).

For richness, the highest diversity value was obtained in the first campaign, with 10 species, of which two were exclusive, i.e. they were only recorded in this first campaign. While in the second campaign a total of nine species were obtained, one of which was exclusive, so the difference in richness between the campaigns was approximately 1% (**Figure 5.3.2.4.4.4.j**). And for the abundance values, despite the slight difference, the opposite is observed, with the second season having the highest value, with 62 records, while the first season had a total of 19 records, which means a difference in value of only 30% between the sampling seasons (**Figure 5.3.2.2.4.4.j**).

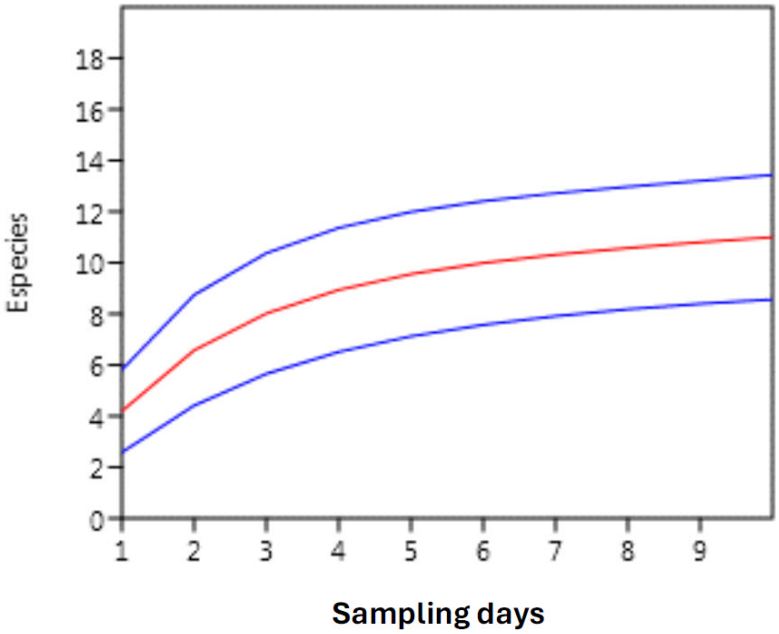
Figure 5.3.2.2.4.4.j
Distribution of richness, exclusivity and records of medium and large mammals between sampling campaigns



Sampling adequacy

The rarefaction curve resulting from the two surveys of the medium and large mastofauna is shown in **Figure 5.3.2.4.4.k**. Even considering the two sampling campaigns (10 days), the curve shows an upward trend, but with a slight tendency to stabilise, indicating that, although much of the expected richness has been obtained, more species are still expected for the total richness of the study area (**Figure 5.3.3.2.4.4.k**). These results were already expected, taking into account that studies with small sampling efforts are not sufficient to reach stability of the curves, which should only occur in the long term, especially when considering endemic and/or endangered species, which are naturally rare and have low population density, requiring much more time to be recorded in the field (COSTA-BRAGA *et* al., 2014; STRAUBE *et* al., 2010; VASCONCELOS, 2006). This result is corroborated by the richness estimators (Chao2 and Jacknife 1), which estimated more species for the Project region (see below).

Figure 5.3.2.4.4.k
Rarefaction curve per sample for total



Estimators of richness, diversity and homogeneity

Table 5.3.2.4.d shows the richness, number of records, incidence-based richness estimators (Chao2 and Jackknife 1), as well as alpha diversity indices (Fisher's alpha and Shannon's exponential) and evenness for the results of the medium and large mastofaunal surveys.

The richness estimators generated (Chao 2 and Jacknife 1) corroborate the results shown by the species rarefaction curves (**Figure 5.3.2.4.4.k**), with estimates higher than those observed. For the Chao 2 estimator, 11.45 species were estimated and for Jacknife 1 the estimate was 12.8 species, indicating that sampling sufficiency was 87.34 and 78.13%, when compared to the total number of species recorded (S=10), respectively. Thus, these values indicate that 12.66 (Chao 2) and 21.88 (Jacknife 1) species are still expected for the study area (**Table 5.3.2.4.d**).

The Shannon diversity index (also called Shannon-Wiener index (H')) is one of several indices used to measure diversity in categorical data. It is simply the entropic information of the distribution. This index measures the degree of uncertainty in predicting to which species a randomly chosen individual will belong in a sample of S species and N individuals. Furthermore, it allows the index values to be compared directly with the observed richness, and the higher the index value, the greater the diversity of the area considered (HILL, 1973; KEYLOCK, 2005; LUDWIG & REYNOLDS, 1988; TUOMISTO, 2010). For this index the value was 2.1 (**Table 5.3.2.4.4.d**), which can be considered high, as the values assumed by the Shannon-Wiener index are between 1.5 and 3.5 and only rarely exceed the value of 4.5 (MAGURRAN, 1988).

Another index used is Fisher's Alpha, which has some advantages over other diversity indices in that it is little influenced by sample size or the abundance of the most common species (TAYLOR & FORSMAN 1976). Fisher's Alpha index relates the number of species (S) to the number of

individuals (N) in a community by the following equation: S = α ln (1 + N/α) (FISHER *et al*. 1943). In the present study, the index was 3.4 (**Table 5.3.2.4.4.4.d**).

Evenness expresses how the number of individuals is distributed among the different species, i.e. it indicates whether the different species have similar or divergent abundance (number of individuals). It is proportional to diversity, i.e. the ratio between the actual diversity and the maximum existing diversity. Thus, Equitability ranges from 0 (zero) to 1 (one), and for values close to one, it indicates a uniform distribution of abundance of records in the sampling universe (richness) (BROWER & ZAR 1984). For the present study, the index was 0.9, indicating a greater homogeneity of abundance over species (**Table 5.3.2.4.4.4.d**).

Table 5.3.2.4.4.d
Richness, diversity and homogeneity estimators for medium and large mammal surveys

Indices	Total
Observed Wealth (S)	10
Number of records (N)	81
Estimated Wealth (Chao 2)	11.45
Estimated Wealth (Jacknife 1)	12.8
Diversity (Shannon, eH)	2.1
Diversity (Fisher's Alpha)	3.4
Equity_J	0.9

Final considerations

The primary and secondary surveys of medium and large mammals in the Project area resulted in a total of 47 taxa, distributed in nine orders and 19 families. Of this total, nine species are common to both surveys, and in terms of exclusivities, the field surveys obtained records for one species, the four-eyed weasel (*Philander quica*). This marsupial falls into the category of small mammals, and was recorded by camera traps.

With regard to the degree of conservation of the species recorded after the field survey, according to the national list of protected species of wild fauna of the Mammalia class (Resolution SEAM No. 632 of 2017), none were categorised as endangered. Likewise, there are no species categorised according to the international classification of the IUCN (2022) and CITES (2023).

No exotic, introduced, invasive or invasive native species were recorded in this study, nor were any species considered endemic to the biome.

The confirmed presence of highly specialised species dependent on structured environments, such as the wildcat (*Leopardus geoffroyi*) and the brown cat (*Herpailurus* yagouaroundi), is of significant value in terms of conservation. They are also indicators of environmental quality, because even under anthropogenic influence the region is still able to maintain elements with high environmental requirements. Among the records, two species were assessed as having potential hunting value in the Project area and may suffer from human hunting pressure: the common weasel (*Didelphis albiventris*), the large mulita (*Dasypus novemcinctus*), the honey bear (*Tamandua tetradactyla*), the bush rabbit (*Sylvilagus brasiliensis*), the crab fox (*Cerdocyon thous*), the wildcat (*Leopardus geoffroyi*), the blackamoor cat (*Herpailurus yagouaroundi*) and the roe deer (*Subulo gouazoubira*).

In terms of sampling sufficiency, the species rarefaction curve generated shows an upward trend, but with a slight tendency to stabilise, indicating that, although a large part of the expected richness has been obtained, more species are still expected for the total richness of the study area. The richness estimators generated corroborate the results shown by the species rarefaction curves, with higher estimates than those observed.

5.3.3
Ichthyofauna

The survey of the ichthyofauna in the area of influence of the Project was based on secondary data obtained from the studies of Menni (2004), Sverlij *et al*. (2013) and Brancolini *et al*. (2014), carried out in the lower basin of the Paraguay River. In addition, to compose the species list, the taxa studied in the works of Cardoso *et al*. (2016), Friel & Carvalho (2016) and Rosso *et al*. (2017), who studied or described species from the lower Paraguay River basin, were considered.

The species compiled from the studies cited are shown in **Table 5.3.3.a**. It should be noted that the list includes taxonomic updates for several taxa cited in the studies used as sources and these updates were made on the basis of the Eschmeyer Fish Catalogue (FRICKIE *et al*., 2023). In total, there are 168 taxa, four of which have only been identified to genus level. The 168 species collected are distributed in 45 families and 13 orders. Most taxa belong to the orders Characiformes and Siluriformes (**Figure 5.3.3.a**). This pattern of distribution by order is known for the Neotropical region, where Characiformes and Siluriformes predominate, followed by Perciformes (LOWE-MCCONNELL, 1987). Most of the species previously classified as Perciformes constitute the current order of Cichliformes, which is the 3rd most representative order in these studies.

Table 5.3.3.a
Species recorded in the Area of Indirect Influence - Lower Paraguay river basin

Order	Family	Species	IUCN	Exotic	Source
Atheriniformes	Atherinopsidae	*Odontesthes bonariensis*	DD		2
Characiformes	Acestrorhynchidae	*Acestrorhynchus altus*	DD		1
		Acestrorhynchus pantaneiro	LC		2, 5
	Anostomidae	*Leporinus friderici*	LC		1
		Leporinus lacustris	LC		5
		Megaleporinus obtusidens	LC		1, 2
		Schizodon borelli	LC		2, 5
	Bryconidae	*Brycon orbignyanus*			2
		Salminus brasiliensis			1, 2, 5
	Characidae	*Aphyocharax anisitsi*			1, 5
		Aphyocharax dentatus			1, 5
		Aphyocharax nattereri			5
		Astyanax abramis			1
		Astyanax alleni			1
		Astyanax bimaculatus	LC		1
		Astyanax lacustris	LC		1, 5
		Astyanax lineatus			1
		Charax gibbosus			1
		Charax leticiae			5
		Charax stenopterus			1
		Cheirodon interruptus			5

Table 5.3.3.a
Species recorded in the Area of Indirect Influence - Lower Paraguay river basin

Order	Family	Species	IUCN	Exotic	Source
		Ctenobrycon multiradiatus			1
		Cyanocharax sp			5
		Cynopotamus argenteus			1
		Deuterodon luetkenii			1, 5
		Galeocharax humeralis			1
		Gymnocorymbus ternetzi			1, 5
		Hyphessobrycon eques			1
		Hypostomus formosae			3
		Markiana nigripinnis	LC		1, 5
		Moenkhausia dichroura			1, 5
		Moenkhausia intermedia			1
		Moenkhausia sanctaefilomenae	LC		1
		Odontostilbe paraguayensis			1
		Odontostilbe pequira			1, 5
		Poptella paraguayensis			1
		Prionobrama paraguayensis			1, 5
		Psalidodon cf. fasciatus			1, 5
		Psalidodon pellegrini			5
		Psellogrammus kennedyi			1, 5
		Pseudocorynopoma doriae			1
		Roeboides descalvadensis			1, 5
		Roeboides microlepis	LC		1, 5
		Serrapinnus calliurus			5
		Serrapinnus kriegi			5
		Serrapinnus microdon			5
		Tetragonopterus argenteus			1, 5
	Crenuchidae	*Characidium cf. fasciatum*			1
	Curimatidae	*Curimatella dorsalis*			1, 2
		Cyphocharax platanus			1, 2
		Cyphocharax saladensis			2
		Cyphocharax spilotus			1
		Cyphocharax voga	LC		1, 2
		Potamorhina squamoralevis			1, 2
		Psectrogaster curviventris			1, 2, 5
		Steindachnerina brevipinna			1, 5
		Steindachnerina conspersa			1, 5
	Cynodontidae	*Raphiodon vulpinus*			1, 2
	Erythrinidae	*Hoplerythrinus unitaeniatus*	LC		1, 5
		Hoplias malabaricus	LC		1, 5
	Gasteropelecidae	*Thoracocharax stellatus*			1
	Hemiodontidae	*Hemiodus orthonops*			1, 2
	Iguanodectidae	*Piabucus melanostoma*			1
	Lebiasinidae	*Pyrrhulina australis*	LC		1, 5
	Parodontidae	*Apareiodon affinis*			1
	Prochilodontidae	*Prochilodus lineatus*			1, 2, 5
	Serrasalmidae	*Mylossoma duriventre*			1, 2
		Piaractus mesopotamicus			1, 2
		Pygocentrus nattereri			1, 2 , 5

Table 5.3.3.a
Species recorded in the Area of Indirect Influence - Lower Paraguay river basin

Order	Family	Species	IUCN	Exotic	Source
		Serrasalmus maculatus			5
		Serrasalmus marginatus			1, 2, 5
		Serrasalmus spilopleura			1
	Triportheidae	*Triportheus nematurus*			1, 2
		Triportheus pantanensis			5
Cichliformes	Cichlidae	*Apistogramma borellii*			1, 5
		Apistogramma commbrae			1
		Bujurquina vittata			1, 5
		Cichla kelberi			2
		Cichlasoma dimerus			1, 5
		Coptodon rendalli		EX	2
		Crenicichla semifasciata			1, 5
		Crenicichla vittata			1
		Gymnogeophagus balzanii			1, 5
		Oreochromis niloticus		EX	2
		Saxatilia lepidota			1, 5
Clupeiformes	Engraulidae	*Lycengraulis grossidens*	LC		2
Cypriniformes	Cyprinidae	*Cyprinus carpio*		EX	2
	Xenocyprididae	*Hypophthalmichthys molitrix*		EX	2
Cyprinodontiformes	Poeciliidae	*Poecilia reticulata*			4
	Rivulidae	*Austrolebias bellottii*			1
		Neofundulus paraguayensis			1
		Pterolebias longipinnis			1, 5
		Rivulus sp.			1
		Trigonectes balzanii			5
Gymnotiformes	Gymnotidae	*Gymnotus carapo*	LC		1
		Gymnotus inaequilabiatus			5
	Hypopomidae	*Brachyhypopomus gauderio*			5
	Rhamphichthyidae	*Rhamphichthys hahni*	LC		5
	Sternopygidae	*Eigenmannia trilineata*			5
		Eigenmannia virescens			1
		Sternopygus macrurus			1
Lepidosireniformes	Lepidosirenidae	*Lepidosiren paradoxa*	LC		1, 5
Myliobatiformes	Potamotrygonidae	*Potamotrygon motoro*	DD		5
Perciformes	Centrarchidae	*Micropterus salmoides*		EX	2
	Sciaenidae	*Plagioscion ternetzi*	DD		2
Pleuronectiformes	Achiridae	*Catathyridium jenynsii*	LC		1
Siluriformes	Ariidae	*Genidens barbus*			2
	Aspredinidae	*Amaralia oviraptor*	LC		6
	Auchenipteridae	*Ageneiosus inermis*			2
		Ageneiosus militaris			2
		Auchenipterus nigripinnis			1
		Auchenipterus osteomystax			1, 5
		Trachelyopterus cf. ceratophysus			1
		Trachelyopterus striatulus			1, 5
	Callichthyidae	*Callichthys callichthys*			1, 5
		Corydoras hastatus			1, 5
		Corydoras microps	LC		1

Table 5.3.3.a
Species recorded in the Area of Indirect Influence - Lower Paraguay river basin

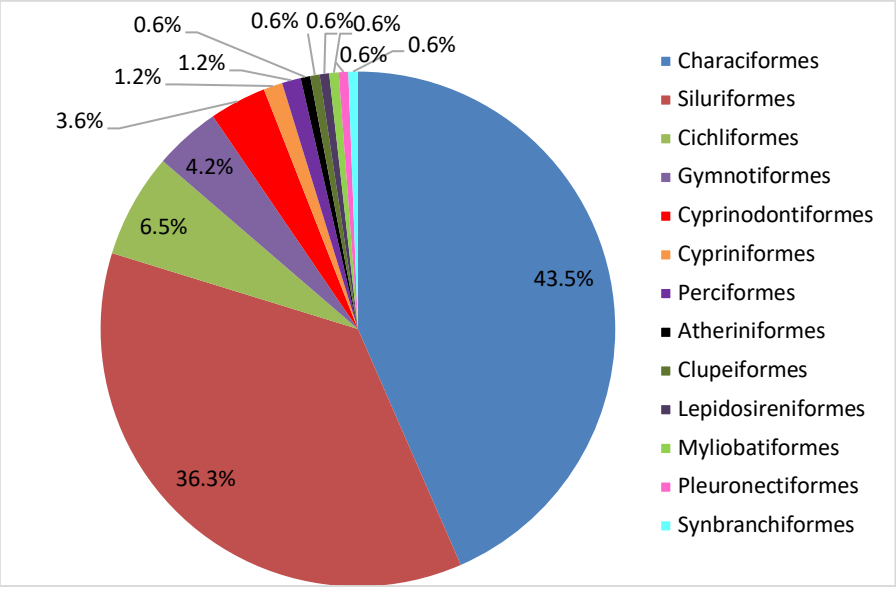
Order	Family	Species	IUCN	Exotic	Source
		Corydoras paleatus			1
		Hoplosternum littorale			1, 5
		Lepthoplosternum pectorale			5
		Megalechis thoracata			1
	Clariidae	*Clarias gariepinus*		EX	2
	Doradidae	*Anadoras weddellii*	LC		1, 5
		Ossancora eigenmanni			1
		Oxydoras kneri			2
		Pterodoras granulosus			1, 2
		Rhinodoras dorbignyi			1
		Trachelyopterus cf. galeatus			2
		Trachydoras paraguayensis			1
	Heptapteridae	*Pimelodella gracilis*	LC		1, 5
		Pimelodella howesi			1
		Pimelodella laticeps	LC		1, 5
		Rhamdia quelen	LC		5
	Hypopomidae	*Brachyhypopomus brevirostris*			1
	Ictaluridae	*Ictalurus punctatus*		EX	2
	Loricariidae	*Hisonotus maculipinnis*			1
		Hypoptopoma inexspectatum			1
		Hypostomus commersoni			1
		Hypostomus sp.1			5
		Hypostomus sp.2			5
		Loricaria simillima			1, 2
		Loricariichthys maculatus			1
		Loricariichthys platymetopon			5
		Otocinclus vittatus			5
		Potamorrhaphis eigenmanni	LC		1
		Pterygoplichthys ambrosetti			1, 5
		Pterygoplichthys multiradiatus			1
		Rineloricaria parva			1, 5
		Sturisoma robustum			1, 5
	Pimelodidae	*Bergiaria westermanni*	LC		1
		Hemisorubim platyrhynchos			1
		Hypophthalmus edentatus			2, 5
		Hypophthalmus oremaculatus	LC		2
		Luciopimelodus pati			1, 2
		Pimelodus albicans			1, 2, 5
		Pimelodus argenteus	LC		1
		Pimelodus maculatus	LC		1, 2
		Pimelodus ornatus			1, 5
		Pseudoplatystoma cf. fasciatum			1
		Pseudoplatystoma corruscans			1, 2, 5
		Pseudoplatystoma reticulatum			2, 5
		Sorubim lime	LC		1, 2, 5
		Steindachneridion scriptum			2
		Zungaro jahu			2
	Pseudopimelodidae	*Pseudopimelodus mangurus*	LC		2

Table 5.3.3.a
Species recorded in the Area of Indirect Influence - Lower Paraguay river basin

Order	Family	Species	IUCN	Exotic	Source
	Trichomycteridae	*Tridentopsis cahuali*			5
		Tridentopsis pearsoni			1
Synbranchiformes	Synbranchidae	*Synbranchus marmoratus*	LC		1, 5

Note: Conservation status according to IUCN - LC: "Last Concern" - of little concern; DD: Data Deficient. References: 1 - Menni (2004); 2 - Sverlij *et al*. (2013); 3 - Cardoso *et al*. (2016); 4 - Rosso *et al.* (2017); 5 - Brancolini *et al*. (2014); 6 - Friel & Cardoso (2016).

Figure 5.3.3.a
Distribution of taxa among the different orders collected



The International Union for Conservation of Nature (IUCN, 2022) has not yet classified the threat status of most of the species compiled in **Table 5.3.3.a**. Of those that have been classified, none are considered to be under any degree of threat of extinction and most are classified in the category of low concern (LC). At the national level, there is still no threat ranking list for fish.

In the interview conducted in the community of Puerto Lobato for the study on the characterisation of fishing activity in the IIA of the Project (**Section 5.4.1.5.3**), the capture of surubí was mentioned in the local fishing activity for commercial or subsistence purposes. Among the taxa listed in **Table 5.3.3.a are** three species of the genus Pseudoplatystoma (*P. corruscans*, P. reticulatum and *P.* cf. *fasciatum*) which are popularly known as surubí. Furthermore, during the survey of the fishing activity, the interviewee also mentioned fishing for smaller whitefish, which are basically used for self-consumption, but did not mention the names of the fish that are treated locally as whitefish. Therefore, it was not possible to identify which of the species potentially present in the IIA are part of this group of whitefish caught by the local population.

Of the total number of taxa collected, seven species (*Oreochromis niloticus*, *Cyprinus carpio*, *Micropterus salmoides*, Hypophthalmichthys molitrix, *Clarias gariepinus* and *Ictalurus punctatus*) are exotic, i.e. originating from other continents and introduced into the river basin.

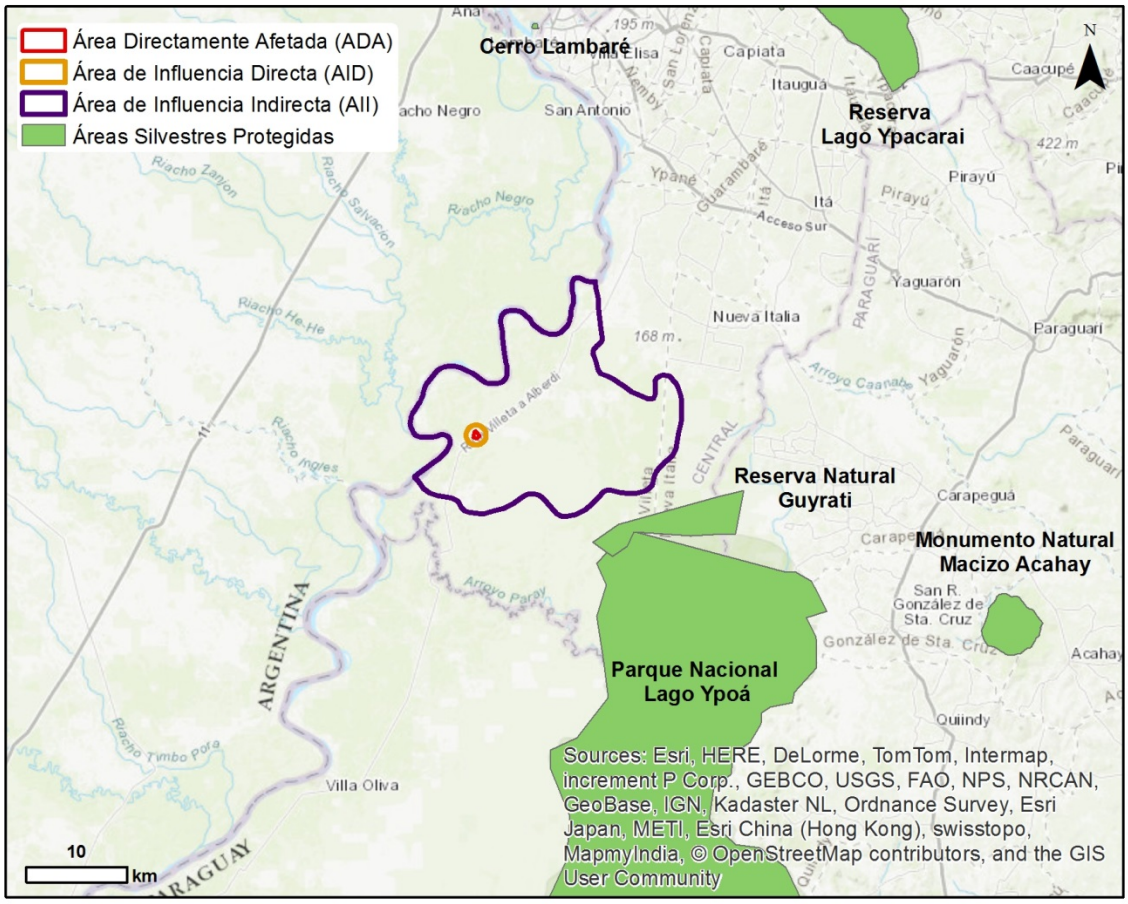
5.3.4
Areas of Biodiversity Interest

5.3.4.1
Wildlife Protected Areas (WPAs)

The objective of Law N° 352/94 on Protected Wildlife Areas (ASP) is to establish general rules for the regulation and management of the National System of Protected Areas of Paraguay (SINASIP). SINASIP is the set of Protected Wildlife Areas of ecological and social relevance, at international, national and local level, under an orderly and directed management that allows the fulfilment of the conservation objectives and policies established by the Paraguayan government, according to Article 5 of the Law of Protected Wildlife Areas.

According to SINASIP's 2022 Updated Map[1] , the project's IIA does not overlap with any protected wildlife areas. The closest PWAs are the Guyrati Nature Reserve and the Lago Ypoá National Park (**Figure 5.3.4.1.a**), which are about 3 kilometres from the IIA boundary.

Figure 5.3.4.1.a
Protected Wildlife Areas in the project region



Source: MADES.

[1] Map (mades.gov.py)

The Guyrati Nature Reserve is an ASP under private ownership created in November 2010 (Decree N° 5450, rectified by Decree N° 10042).

Lago Ypoá National Park is an ASP under public domain created in 1992 by Decree 13681 The park is a permanent freshwater lagoon, with associated marshy areas (estuaries and reservoirs) and close to the Cabral and Verá lagoon. The area is made up of small elevations and low, floodable regions.

The natural communities present in the area are: lacustrine, palustrine, riparian and terrestrial. The lake communities include Lake Ypoá and the Cabral and Verá lagoons. The marsh communities include the estuaries and reservoirs, while the riparian community comprises numerous small bodies of water. The estuaries are mainly covered by the genera *Cyperus, Panucum*, *Thalia* and *Canna*.

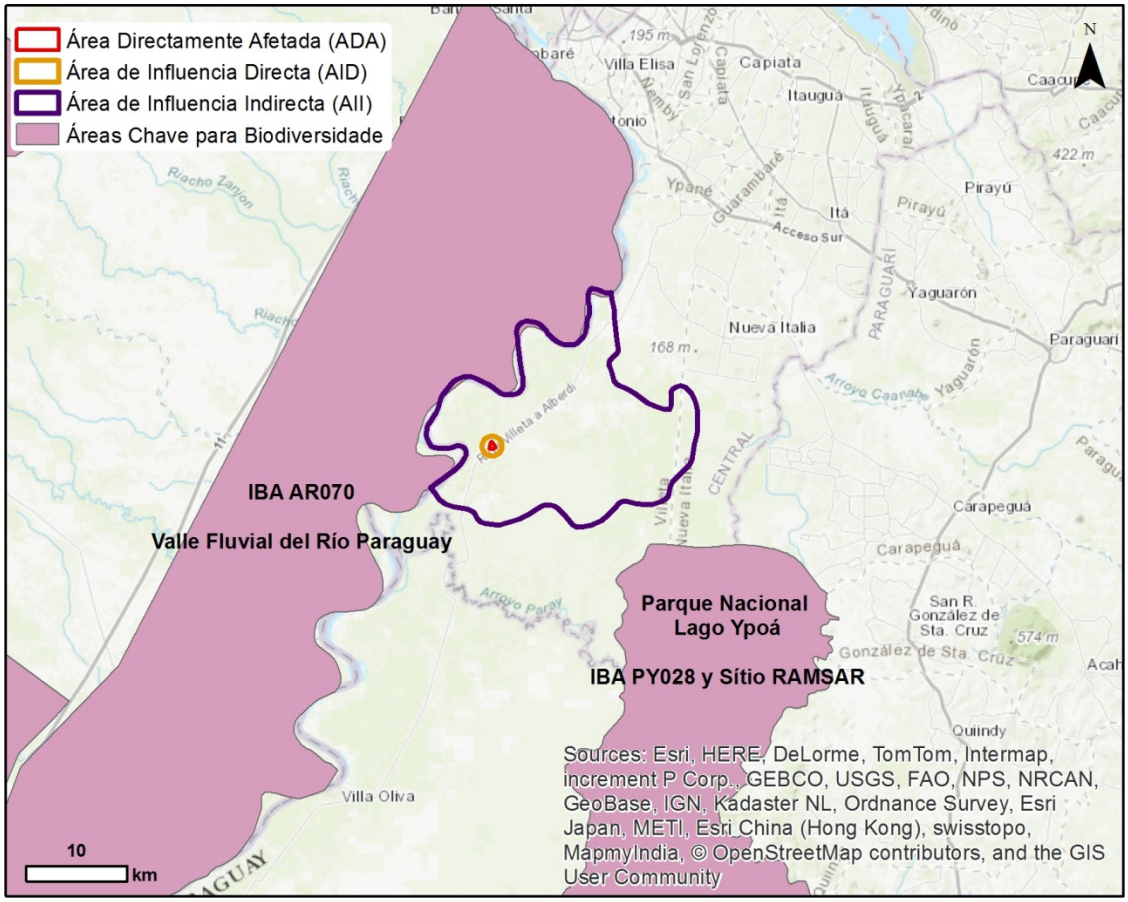
The terrestrial communities are represented by semi-deciduous forest, which develops in the highest places and trees with an average height of 15 m, the savannas, of herbaceous vegetation with scattered trees and shrubs, and the rocky outcrops, granitic outcrops associated with Bromeliaceae, and Cactaceae. In the faunal community, 134 species of birds and 21 species of mammals were recorded.

Lago Ypoá National Park is also an area of international importance, classified as a Ramsar Site and an *Important Bird Area (IBA*).

5.3.4.2
Other Areas of Biodiversity Interest

In addition to the Wildlife Protected Areas, there are other internationally recognised Important Biodiversity Areas close to the Project IIA, an IBA in Argentinean territory, as well as Lake Ypoá, which is an IBA and a Ramsar Site (**Figure 5.3.4.2.a**).

Figure 5.3.4.2.a
Internationally recognised Important Biodiversity Areas



Source: own elaboration.

The identification of Important Bird Areas (IBAs) is an initiative of the English organisation BirdLife International, which seeks to identify important sites for conserving globally threatened bird species, combining technical-scientific bases with the identification of critical areas for biodiversity. Although these sites are not considered protected areas, the idea is to take them into account in conservation efforts.

The IBA concept encompasses three important aspects: bird species, geographical area and conservation effort (CARTES, 2008). Birds, known as indicator species, demonstrate that these sites are important for other taxonomic groups, therefore, the conservation effort for these sites should be greater in each country. The main focus of IBAs is the conservation of threatened, endemic, restricted and congregatory birds.

The closest IBA to the project is AR070 Fluvial Valley of the Paraguay River, which is located in the Argentinean territory, on the banks of the Paraguay River, occupying a strip of up to 40 km wide from the coast of the Paraguay-Parana axis to the national route N° 11 in Argentina.

According to *BirdLife International* (2023[2]), the entire area is subject to a regime of floods and floodwaters, with flood pulses. From the coast to the west, Chaco forests, carob tree (*Prosopis*

[2] BirdLife Data Zone

sp.) or caranday palm (*Copernicia alba)* savannahs and marshes succeed one another and occupy different areas.

The area has been little prospected. Nine globally threatened species have been recorded, but the area also has records without current confirmation for some threatened grassland species such as the collared yetapa (*Alectrurus risora*), the tufted tachuri (*Culicivora caudacuta*) and the hooded cachilo (*Coryphaspiza melanotis*). Temporary flocks of capuchins of the genus *Sporophila* are often present during migrations. There are interesting data for the area, including rare or restricted distribution species in the region such as the great spotted owl (*Pulsatrix perspicillata*) and the widow eagle (*Spizastur melanoleucus*). Nearctic migrants such as the osprey (*Pandion haliaetus*) and the red kite (*Ictinia mississippiensis*) are also recorded, as well as a high diversity and density of waterbirds.

Lake Ypoá National Park is home to several types of habitats; aquatic environments, flooded grasslands and gallery forests, and therefore has a very varied avifauna, with waterfowl of estuaries and forests, with some species of grasslands and chaco species.

There are no other internationally recognised areas of biodiversity importance in the region.

5.3.5
Critical habitat analysis

The critical habitat (HC) analysis was conducted based on the biodiversity survey conducted on the Project site and the definitions of each of the HC triggering criteria. Biodiversity values were assessed against the definitions of each of the 5 criteria (threatened species, endemic species, migratory congregants, native ecosystems and key evolutionary processes), and these were termed priority biodiversity values. Species listed as threatened by the national and/or international lists were analysed for HC trigger thresholds, according to the thresholds and definitions presented in the Guidance Notes (GN) of Guidance Note (GN 06) for each criterion.

NO59 of the 06 GN provides guidance that an ecologically appropriate analysis area (EAEA) should be identified to determine the presence of HC for each regularly occurring species in the project region, or ecosystem, that falls within one of the HC criteria, according to specific thresholds. The delineation of this AAEA should consider the distribution of the species and the connectivity of the landscape, which supports the ecological processes necessary for the survival of the species. AAEAs represent a regional cut-off of species distribution and support the HC trigger analysis. Thus, the AAEA delineation should be made for the area of insertion of the project under analysis, but is not limited to its area of influence. For biodiversity values that have similar ecological characteristics, a single AAEA can be delineated.

The AAEA delineation for potentially HC-triggering biodiversity values considered native habitats in the Project Influence Area and their continuity in the landscape, species occurrence phytophysiognomies, habitat continuation and river boundaries.

5.3.5.1
Criterion 1

The IUCN Red List is a biodiversity indicator to report on the range, population size, habitat and ecology, use and/or trade and threats to species.

As part of criterion 1, NO70 of the 06 ND determines that these are species threatened with extinction in the globally *endangered (endangered/EN*) and critically *endangered (critically endangered/CR*) categories (according to the IUCN Red List of Threatened Species). NO71 also highlights that regional or local threat assessments, using the same IUCN criteria, may be considered at the discretion of the analysis team.

NO72 sets the HC trigger thresholds for criterion 1, which are as follows:

a) Areas supporting globally important concentrations of a species classified as CR or EN by IUCN (≥ 0.5% of the global population AND ≥ 5 breeding units of a CR or EN species);
b) Areas supporting globally significant concentrations of a species classified as Vulnerable (*vulnerable/VU*) or *Near Threatened* (*near threatened/NT*) by the IUCN, the loss of which would result in the alteration of the threatened status for EN or CR and meet the thresholds set out in NO72(a);
c) As appropriate, areas containing significant concentrations of a species classified as EN or CR at national or regional level.

Paraguay's threatened flora list does not use the IUCN Red List criteria (IUCN, 2010)[34] . Thus, item NO72(c) is not applicable to this assessment for flora.

For species potentially triggered by NO72(a), the analysis of HC thresholds was performed by comparing the species' AAEA to the species' *Area of Occupancy (AOO).* The threshold defined in NO72(a) is based on the population size of mature individuals relative to the overall population of the species. This information is not available in the literature for the vast majority of species. Equally difficult is the determination of the number of reproductive units of a given species. Therefore, to allow analysis of the activation of the framing boundary, the assumption was made that the individuals of a population are equally distributed within its AOO. Therefore, the verification of whether the classification limit is triggered is done by direct comparison between the AOO of a species with its AAEA, within the Project's area of analysis.

The AOO of a taxon is defined as the area within the *Extent of Occurrence (Extent of* Occurrence/EOO[5]) that it can actually occupy, excluding occasional occurrences. This measure reflects the fact that a taxon does not usually occupy the full extent of its EOO, which may contain habitats unsuitable for the needs of a particular species (IUCN, 2001). Thus, the AOO must be adapted to the biological and ecological characteristics of the taxon, i.e. to the characteristics of the phytophysiognomy of occurrence, altitude, etc., necessary to satisfy the

3 RL-2012-002-En.pdf (iucn.org)

4 Home | National Red List

5Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all known, inferred or projected locations of current occurrence of a taxon, excluding exceptional cases (IUCN, 2012).

demands for food, shelter and reproduction and to sustain the population of each species. In this context, the AOO provides an idea of the geographic extent of the overall population of each species, which allows inferring the importance of the AAEA in the overall context of supporting the population of a given species.

For potential HC trigger species according to NO72(b), the occurrence of a significant population density within the AAEA was verified. This assessment was made on the basis of the available literature data, both primary and secondary. The available information was assessed together to determine whether there are indications or information on the existence of significant concentrations of individuals in the area.

The trigger assessment by NO72(b) sought to understand whether, based on the observed population density for each potential trigger species and the known and described impacts of the Project, there will be a significant reduction in that population that would alter its threat status. According to IUCN (2012), the change in threat status of a species classified as VU (Vulnerable) to EN (Endangered) should be assessed based on 5 criteria:

a) An observed, estimated, inferred or suspected population reduction of ≥50% or ≥70%, whether or not due to reversible causes, over the past 10 years or three generations;
b) Geographical distribution = EOO with less than 5,000 km² or AOO estimated at less than 500 km²;
c) Population size estimated at less than 2,500 mature individuals and in continuous decline estimated at least 20% over five years or in continuous decline in the number of mature individuals;
d) Population estimated at less than 250 mature individuals;
e) Quantitative analysis indicating the probability of extinction in nature of at least 20% in 20 years or five generations.

For a species to be considered potentially triggering under NO72(b) and meet the HC threshold, these changes in threat status must occur as a result of Project impacts. Considering the requirements for classifying a species as EN (Endangered), this alteration is more likely to occur in projects with potentially widespread land use impacts, especially when considering the global scale of the species[6] .

The Project is being implemented in an area predominantly occupied by natural habitats. Conversion of natural habitats will occur on 25.67 hectares, including the current plant site and future expansion of the Plant and the transmission line easement strip (50 m wide), representing 82% of the directly affected Project area (see **Section 5.3.1.4**). However, these 25.67 hectares represent only 10% of the total native vegetation of the AID[7] , and 0.3% of the total native vegetation of the IIA[8] .

6 The understanding of the potential for species classified as vulnerable to trigger the critical habitat threshold is present in the Inter-American Development Bank's (IDB) Socio-environmental Policy Framework, specifically in the Padrão de Desempenho Socioambiental (PDAS) 6. This policy framework refers to the standards and guidelines that the IDB follows to assess and manage the socio-environmental impacts of its projects and activities, and PDAS 6 specifically addresses biodiversity conservation and critical habitat protection.

7 According to the mapping carried out by JGP, see Section 5.3.1.2.

8 According to the mapping of the MapBiomas Chaco project year 2021, see Section 5.3.1.1.

Thus, although natural habitat conversion represents the largest proportion of the ADA, because the land is not large, it does not represent a significant proportion of the natural habitats of the AID and AII. Therefore, it is understood that there will not be widespread land use conversion in the Project's area of influence for implementation.

Fauna and flora species with potential or confirmed occurrence in the Project area were assessed in relation to their suitability for the definitions in items (a) and (b) of NO72.

From the flora survey data, it was found that no species is classified as VU, EN or CR by the IUCN. From the fauna the result was that there is only one (1) species classified as EN/CR (item a of the NO72), the otter *Pteronura brasiliensis*, and 6 classified as VU by the IUCN, evaluated according to the limits established in item (b) of the NO72.

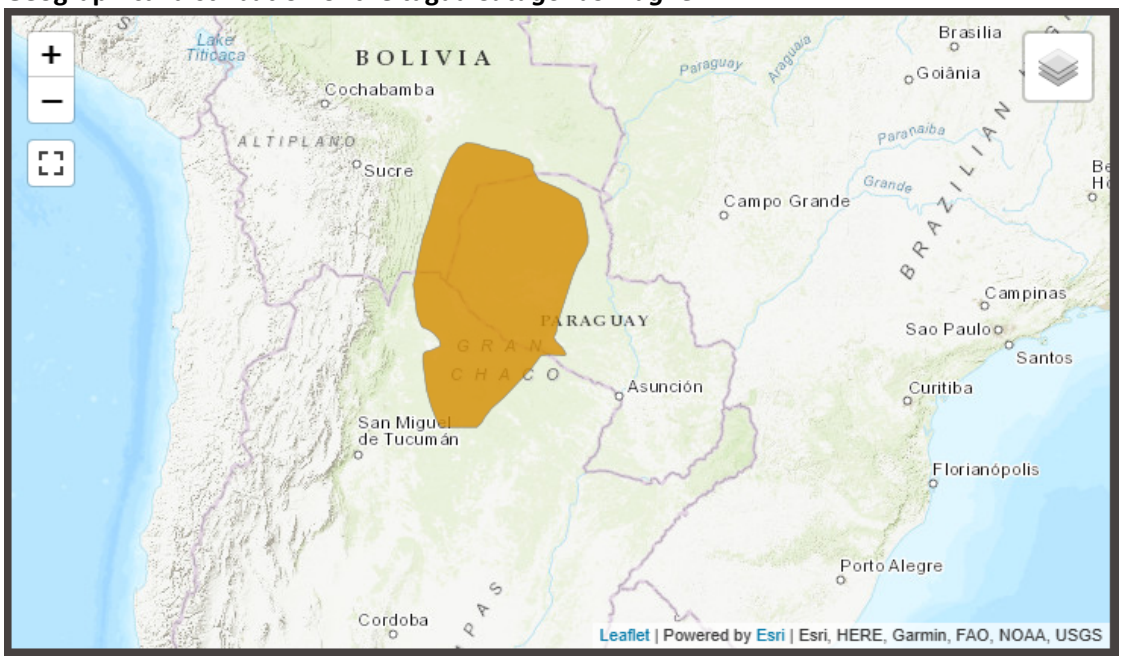
The tapetí *S. brasiliensis*, although classified as EN by the IUCN, was not included in the assessment in relation to boundary NO72(a) because the species classified as EN by the IUCN is restricted to the Pernambuco Endemism Centre in northeastern Brazil. The species identified in the Project region is probably another species that needs to be better studied to define its classification, distribution and threat status.

The taguá *Catagonus wagneri* and the armadillo *Priodontes maximus* were included in the list of potential occurrence in the Project's area of influence through secondary data. Rumbo (2010) lists these two species as occurring in the Humid Chaco region, which is distributed in both eastern and western Paraguay. However, according to the different databases consulted (IUCN, GBIF, *Map of Life*), the most recent distribution of these two species does not include the Project region.

The taguá *Catagonus wagneri* is distributed in the northwest of the Chaco Seco, in the western region of Paraguay (**Figure 5.3.5.1.a**). The armadillo *Priodontes maximus* is widely distributed throughout Latin America, however, specifically in Paraguay it occurs in the western region of the country (**Figure 5.3.5.1.b**).

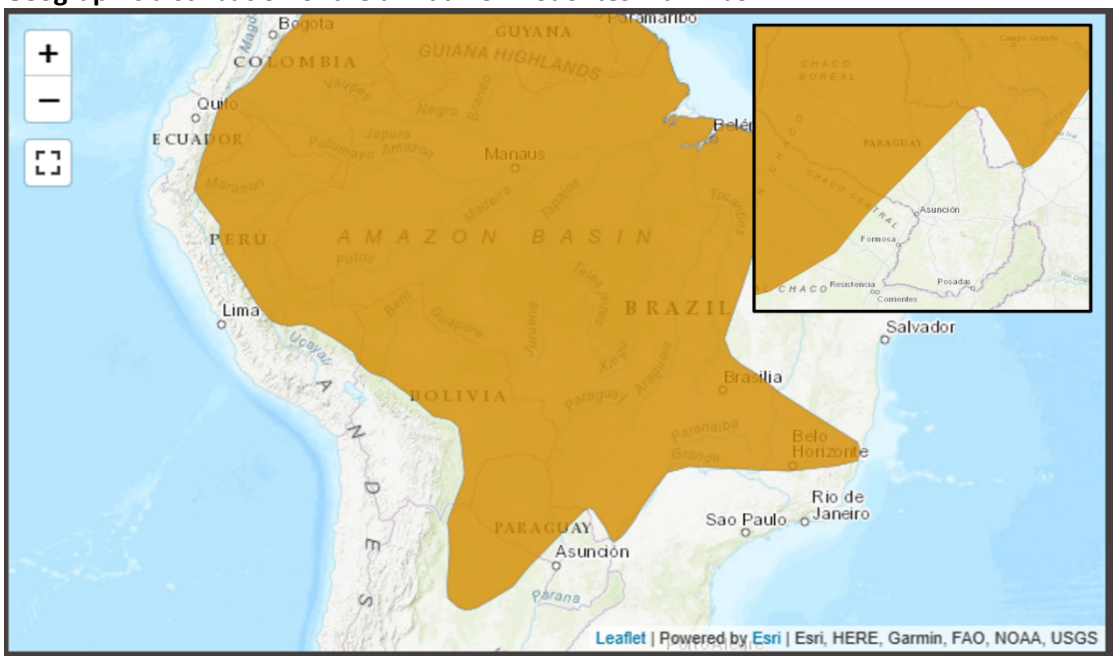
The armadillo *P. maximus* is a highly specialised and sensitive species, being one of the first mammal species to disappear as a result of anthropogenic actions, being absent in areas of historical occurrence throughout its original distribution (WETZEL *et al*., 2008). The taguá *C. wagneri* is most strongly associated with the Dry Chaco, with few historical records in the Humid Chaco region. Associated with this, intense human occupation, environmental changes and anthropogenic influences in the project area prevent any possibility of occurrence of the species in the region (ALTRICHTER *et al*., 2015).

Figure 5.3.5.5.1.a
Geographical distribution of the taguá *Catagonus wagneri*



Source: IUCN (*Catagonus wagneri* (Chacoan Peccary) (iucnredlist.org)

Figure 5.3.5.1.b
Geographic distribution of the armadillo *Priodontes maximus*

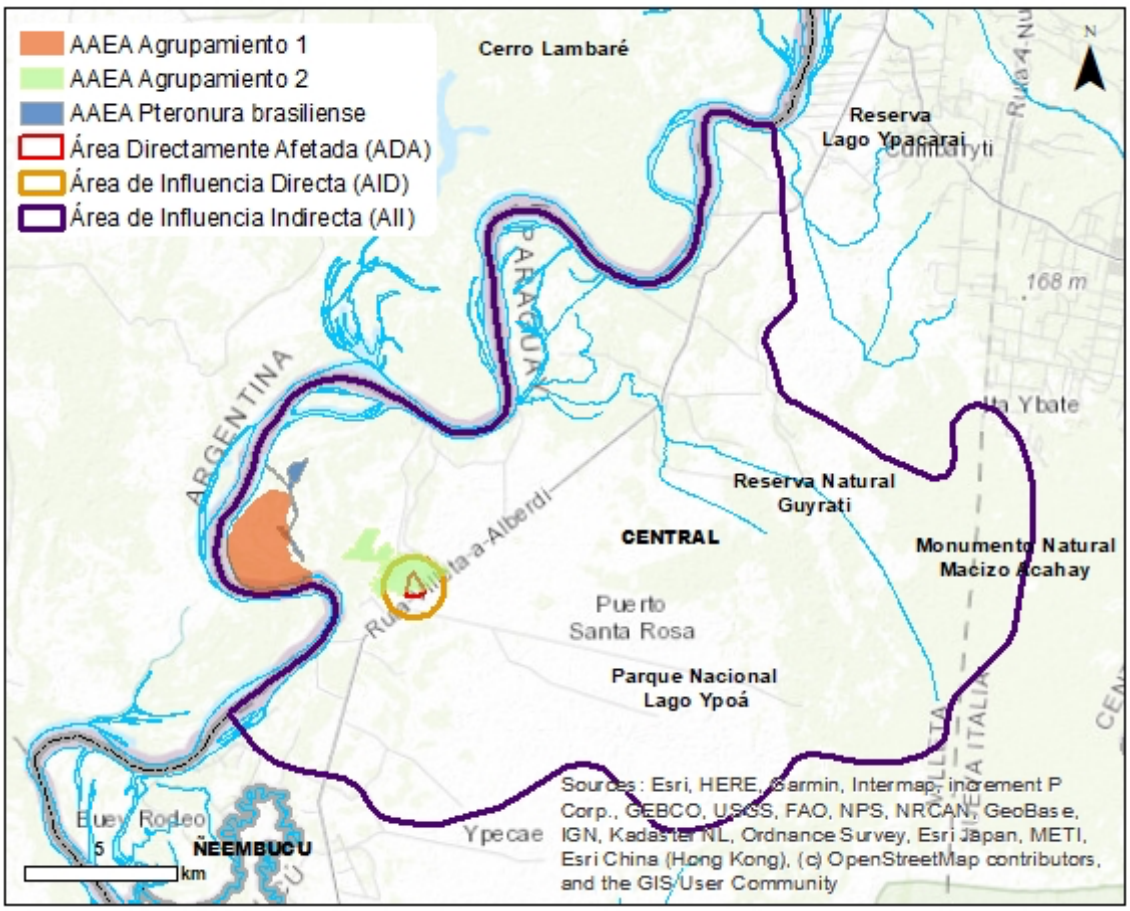


Source: IUCN (*Priodontes maximus* (Giant Armadillo) (iucnredlist.org))

The analysis performed according to NO72 item "a" is presented in **Table 5.3.5.1.a**, and the analyses performed according to NO72 item "b" are presented in **Table 5.3.5.1.b**. As can be seen in these tables, no species triggered the HC inclusion limit according to criterion 1.

The delineation of the AAEAs is presented in **Figure 5.3.5.1.c** below.

Figure 5.3.5.1.c
Ecologically appropriate area of analysis used in the verification of thresholds



Source: Own elaboration.

Table 5.3.5.1.a
Criterion 1 critical habitat activation analysis according to Guidance Note 72 item "a".

Group	Species	Popular name	Type of registration	Threat status	Criterion	Ecology and distribution	EOO (km)²	AOO (km)²	AAEA (km)²	AAEA/ AOO (%)	Conclusion HC	Source
Mammalia	*Pteronura brasiliensis*	Lobito Gargantilla	Secondary	EN (IUCN)	NO72-a	Semi-aquatic mammal species inhabiting South America, with distribution in several countries: Brazil, Peru, Colombia, Venezuela, Guyana, Suriname and French Guiana. It occurs in freshwater river, lake and lagoon habitats, as well as marsh and wetland areas. The species' preferred habitat appears to be rivers with good water quality, well-preserved native vegetation on the banks and abundant food reserves.	8,263,663.50	2,528.00	0.20	0.01%	There are no preferred habitats for the species near the Project site. These habitats are mostly found near the banks of the Paraguay River, about 4 km away from the Project's ADA, where the AAEA was delimited. The 0.5% limit was not reached. The species is not a HC trigger.	IUCN, GBIFF EOO and AOO delimited with GeoCAT

Table 5.3.5.1.b
Criterion 1 critical habitat activation analysis according to Guidance Note 72 item "b".

Group	Species	Popular name	Type of registration	State of threat	Agrup.	Habitat	Analysis	Global abundance	EOO (km)²	AAEA (km)²	Estimated global population (in ind.)	Estimated population in the AAEA (in ind.)	Representativeness of the AAEA in the overall population (%)	Conclusion HC	Source
Birds	*Alectrurus risora*	Guyra jetapa	Secondary	EN (MADES)/ VU (IUCN)	1	Bird of South America and found mainly in the Cerrado region of Brazil (especially in the states of Mato Grosso and Mato Grosso do Sul) and Gran Chaco in Paraguay. It prefers grassland habitats and open areas within floodplains and grasslands near water bodies.	Occurs in Brazil, Paraguay, Argentina and Uruguay up to the 500 m altitude limit. The global population is estimated at 10,000 - 19,999 individuals based on an assessment of known records, abundance descriptions and range size. This estimate is equivalent to 6,000 - 15,000 mature individuals.	6,000 - 15,000 mature individuals.	132,000.00	5.67	60.00	0.003	0.4%	There are no preferred habitats for the species near the Project site. These habitats are mostly found near the banks of the Paraguay River, about 4 km away from the Project ADA, where the AAEA was delineated. Thus, the impact of vegetation cover reduction in the ADA will not impact the species population so as to meet the criteria for change in threat category. The population estimate in the AAEA is 0.4% of the overall population.	IUCN, GBIF, BirdLife
Mammalia	*Myrmecophaga tridactyla*	Giant Anteater	Secondary	VU (IUCN)	2	It inhabits wet and dry forest regions, savannahs and open fields.	It occurs in areas of South America, including countries such as Brazil, Paraguay, Bolivia, Colombia, Venezuela and Ecuador. There is little information about the local population, it is described in some studies as locally uncommon or rare. Smith (2012) states that the species is extinct in eastern Paraguay. However, other studies suggest that the Chaco Umedo is the preferred environment for the species (LAINO *et al*., 2020). A study conducted in the Brazilian Pantanal reached 0.34	0.34 ind./km²	2,500,000.00	3.12	4,250,000.00	1.06	0.002%	The population estimate in the AAEA is 0.002% of the global population. Thus, the impact of vegetation cover reduction in the ADA will not impact the species population so as to meet the criteria for change in threat category (≥50% or ≥70% reduction).	IUCN, GBIFF; Desbiez & Medri, 2010; Smith, 2012; Laino *et al.*, 2020

Table 5.3.5.1.b
Criterion 1 critical habitat activation analysis according to Guidance Note 72 item "b".

Group	Species	Popular name	Type of registration	State of threat	Agrup.	Habitat	Analysis	Global abundance	EOO (km)²	AAEA (km)²	Estimated global population (in ind.)	Estimated population in the AAEA (in ind.)	Representativeness of the AAEA in the overall population (%)	Conclusion HC	Source
							ind./km² (DESBIEZ & MEDRI, 2010). In the project region it was recorded only by secondary data.								
Mammalia	*Leopardus tigrinus*	Jaguarete'i	Secondary	VU (IUCN)	2	Occurs in savannahs, forests and areas of dense vegetation.	The species is naturally rare, with population estimates ranging from 1-5 individuals per 100 km2. In areas with low or absent ocelot (*L. pardalis*) populations, the number of *L. tigrinus* individuals tends to be higher (estimated at 5-20 ind./100 km²). The total population density is estimated at 0.01 ind./km² (between 8,932 and 10,208 ind. adults throughout its EOO). In the project region it was recorded only by secondary data.	0.01 ind/ha	13,406,366.00	3.12	1,340.64	0.0003	0.002%	The population estimate in the AAEA is 0.002% of the global population. Thus, the impact of vegetation cover reduction in the ADA will not impact the species population so as to meet the criteria for change in threat category (≥50% or ≥70% reduction).	IUCN, GBIFF
Mammalia	*Tapirus terrestris*	Mborevi	Secondary	VU (IUCN)	2	It inhabits humid tropical forests, jungles, savannahs and areas of dense vegetation.	It is distributed in countries such as Argentina, Bolivia, Brazil, Colombia, Paraguay, Peru and Venezuela. Little is known about the population of this species. Although it is usually rare, it can also be locally abundant. Very preliminary estimates point to values of between 0.20 and 3.7 ind./km² . These variations are attributed, among other factors, to the high adaptability of the species to different types of environments. According to GBIF data, the species has been widely recorded in South America. In Paraguay, most of the records are in the western region and on the border with Brazil, in the eastern region. In the project region it was recorded only from secondary data.	between 0.20 and 3.7 ind./km²	8,982,548.81	3.12	1,796,509.76	0.62	0.003%	The population estimate in the AAEA is 0.003% of the global population. Thus, the impact of vegetation cover reduction in the ADA will not impact the species population so as to meet the criteria for change in threat category (≥50% or ≥70% reduction).	IUCN, GBIFF
Mammalia	*Tayassu pecari*	Tañykati	Secondary	VU (IUCN)	2	They inhabit tropical rainforests, jungles, savannahs, grasslands and scrub areas. They are common in areas near rivers, lakes and swamps.	Tañykati densities vary throughout its distribution in different habitats. In the southern Brazilian Pantanal, Desbiez *et al*. (2004) found 7.5 ind/km² and 9.6 ind/km². Desbiez *et al*. (2010) documented densities of 13.7 ind/km² in forested areas, and 3.0 ind/km² in open Cerrado habitat. Lower densities have been found in dry forests of the Gran Chaco in Argentina, of 0.33 ind/km² in hunted sites and 1.04 ind/km² in non-hunted sites (ALTRICHTER, 2005). In the project region it was recorded only by secondary data.	Estimates of 7.5 ind./km² and 9.6 ind./km² in the southern Brazilian Pantanal.	13,874,006.00	3.12	104,055,045.03	23.43	0.002%	The population estimate in the AAEA is 0.002% of the global population. Thus, the impact of vegetation cover reduction in the ADA will not impact the species population so as to meet the criteria for change in threat category (≥50% or ≥70% reduction).	IUCN, GBIFF

Table 5.3.5.1.b
Criterion 1 critical habitat activation analysis according to Guidance Note 72 item "b".

Group	Species	Popular name	Type of registration	State of threat	Agrup.	Habitat	Analysis	Global abundance	EOO (km)²	AAEA (km)²	Estimated global population (in ind.)	Estimated population in the AAEA (in ind.)	Representativeness of the AAEA in the overall population (%)	Conclusion HC	Source
Mammalia	*Blastocerus dichotomus*	Marsh Deer	Secondary	VU (IUCN)	2	They inhabit tropical forest areas, wet and enclosed fields. They are especially adapted to live in wet habitats, such as flooded areas and swamps.	The main population in Paraguay is in the Yacyretá region, where density is low. Most populations in Paraguay were declining in the 1970s (JUNGIUS 1974, 1976). In Argentina, population estimates are around 2,000 animals in the Iberá marshes (near the southern border of Paraguay). Duarte *et al*. (2012) estimate an abundance of 1 to 10 individuals/km² . According to the IUCN distribution, the species is probably extinct in the project region.	1 to 10 individuals/km²	20,000.00	3.12	25,000.00	3.12	1.6%	The population estimate in the AAEA is 1.6% of the global population. Thus, the impact of vegetation cover reduction in the ADA will not impact the species population so as to meet the criteria for change in threat category (≥50% or ≥70% reduction).	IUCN, GBIFF, Duarte *et al*. (2012)

5.3.5.2
Criterion 2

Criterion 2 determines that there are significant local HCs for restricted action species. NO74 defines restricted-action species as those with a limited EOO, restricted to up to 50 thousand km² for terrestrial vertebrates and plants. For aquatic (coastal or riverine) species, this criterion applies to those living in habitats that do not exceed 200 km in width at any point (e.g. rivers), and a limited EOO is defined as an overall action less than or equal to 500 km linear geographic range (the distance between the furthest occupied sites).

For species meeting these criteria, HC is triggered in areas regularly hosting ≥ 10% of the global population size and ≥ 10 breeding units of a species (GN75). The same concept of AAEA as explained in the previous Section was applied in this case.

Among the terrestrial and aquatic flora and fauna species identified in the ADA, there are 6 endemic bird species (*Trogon surrucura, Pyrrhura frontalis, Campephilus leucopogon and Myiothlypis leucoblephara, Xiphocolaptes major* and *Ortalis canicollis*) but all have a wide distribution. Among amphibians and reptiles, 4 endemic species were found (*Lysapsus limellum, Adenomera diptyx, Physalaemus biligonigerus* and *Dryophylax chaquensis*), but all with wide distribution occurring in several South American countries. Finally, among the mammals, 4 species (*Myrmecophaga tridactyla, Aotus azarae, Myotis simus* and *Eumops dabbenei*) were also found to be endemic, but all also widely distributed. Among the flora and fauna species identified in the ADA, none meet the definition of restricted action according to NO74.

5.3.5.3
Criterion 3

Criterion 3 determines that HCs are those that harbour significant concentrations of migratory and/or congregating species on a regular or predictable basis. According to ND 06, migratory species are defined as any species with a significant proportion of its members moving in a cyclical and predictable manner from one geographic area to another (NO76). Congregating species are those whose individuals gather in large groups on a cyclical or regular and/or predictable basis (NO77).

The limits set by ND 06 for this criterion are 2 (NO78):

- Areas that support, on a cyclical or regular basis, ≥1% of the global population of a migratory or congregating species at any stage of its life cycle.
- Areas expected to support ≥10% of the global population of a species during periods of stress.

According to a survey of biodiversity values, there are 27 species of birds with migratory behaviour in the region (see **Section 5.3.2**). However, all species are widely distributed and no concentrations of individuals of migratory species were found in the Project's ADA.

5.3.5.4
Criterion 4

Criterion 4 is the presence of unique or highly threatened ecosystems. NO79 ND 06 guides the use of the red list of ecosystems, developed by IUCN[9] .

GN80 defines the boundaries of the framework as HC under Criterion 4: (a) areas representing ≥ 5% of the global extent of an ecosystem type that meets the criteria for IUCN CR or EN status, or (b) other areas not yet assessed but determined to be of high priority for conservation.

The natural communities present on the site are hydromorphic *Copernicia alba* savanna and semi-deciduous sub-humid forest. According to the IUCN Ecosystem Red List the *Copernicia alba* Savanna is classified as Endangered (EN)[10] and the semi-deciduous sub-humid forest is classified as Critically Endangered (CR)[11] .

The mapping of the vegetation cover of the Chaco and Atlantic Forest ecosystems, developed by the MapBiomas project, was used to analyse the HC activation thresholds.

According to the latest surveys carried out by the MapBiomas Chaco project[12] , in 2022 the native vegetation cover in the entire Chaco (including all native formations) is 846,056.26 km^2 , and in Paraguay the total is 230,136.76 km^2 .

In the Atlantic Forest, mapping carried out in 2022 by the MapBiomas Atlantic Forest project[13] indicated a total native vegetation cover of 548,988.69 km^2 in the whole ecosystem (including all native formations) and 40,636.63 km^2 in Paraguay.

For the HC activation assessment, the AAEA delimited for Forest and Savannah environments (used in grouping 2 of criterion 1) was used, as the phytophysiognomies of the region are composed of environments with characteristics of both ecosystems.

As shown in **Table 5.3.5.4.a**, the AAEA represents less than 0.001% of the ecosystems both in its global distribution and at regional (country) level. Therefore, the threshold for classification as HC is not met.

9 IUCN Ecosystems (iucnrle.org)

10 Ecosystem belonging to the group M649. Northern Chaco Palm Swamp (Northern Chaco Palm Swamp | NatureServe Explorer)

11 Ecosystem belonging to the M596 group. Parana Humid Forest (Parana Humid Forest | NatureServe Explorer)

12 MapBiomas Chaco

13 MapBiomas Atlantic Forest

Table 5.3.5.4.a
Comparison of the area of native vegetation in the Chaco and Atlantic Forest ecosystems in the AAEA and in the Project's ADA.

Comparative bases		AAEA	Savannah in the Project ADA (land+easement strip)	Forest in the Project ADA (land+easement strip)
		5.67 km^2	0.2797 km^2	0.0616 km^2
Total native vegetation in the Chaco Biome	846,056.26 km^2	0.00067%	0.00003%	-
Total native vegetation of the Chaco Biome in Paraguay	230,136.76 km^2	0.0025%	0.0001%	-
Total native vegetation in the Atlantic Forest Biome	548,988.69 km^2	0.0010%	-	0.00001%
Total native vegetation of the Atlantic Forest Biome in Paraguay	40,636.63 km^2	0.014%	-	0.0002%

5.3.5.5.5
Criterion 5

Criterion 5 is the presence of key evolutionary processes in the Project region. According to NO81 and NO83 of ND 06 (IFC, 2019), the structural attributes of a region (topography, geology, soil, temperature, vegetation and their combinations) can influence the evolutionary processes that generate regional species configurations and ecological properties.

In some cases, spatial features have been associated with genetically unique populations or subpopulations of plant and animal species. These physical or spatial features have been described as surrogates or spatial catalysts of ecological and evolutionary processes, and are commonly associated with species diversification. Maintaining these key evolutionary processes inherent to a terrestrial landscape, as well as the resulting species (or subpopulations of species), has become an important focus of biodiversity conservation in recent decades, particularly the conservation of genetic diversity. By conserving species diversity in a terrestrial landscape, the processes that drive speciation, as well as the genetic diversity of species, ensure the evolutionary flexibility of a system, which is especially important in scenarios of rapid climate change.

NO81 defines this criterion as: (i) physical features of a landscape that may be associated with specific evolutionary processes; and/or (ii) subpopulations of species that are phylogenetically or morphogenetically distinct and may be of special conservation concern, considering their distinct evolutionary history. Possible examples of spatial features associated with evolutionary processes include:

a) *Isolated areas* (e.g. islands, mountains, lakes) are associated with phylogenetically distinct populations.
b) Areas of high *endemism* usually contain flora and/or fauna with unique evolutionary histories (note overlap with Criterion 2, endemic and restricted distribution species).

c) Terrestrial landscapes with high spatial *heterogeneity* are a driving force in speciation, as species are naturally selected for their ability to adapt and diversify.
d) *Environmental gradients*, also known as *ecotones*, produce the transient habitat that has been associated with the process of speciation and with high genetic and species diversity.
e) *Edaphic interfaces* are specific juxtapositions of soil types (e.g. sinuous outcrops, calcium and gypsum deposits), which have led to the formation of unique plant communities characterised by rarity and endemism.
f) *Connectivity* between habitats (e.g. ecological corridors) ensures species migration and gene flow, which is especially important in fragmented habitats and for the conservation of metapopulations. This also includes ecological corridors across all different altitudinal and climatic gradients and ranging from "mountainous to coastal" regions.
g) Sites of proven importance for *climate change adaptation* for species or ecosystems are also included in this criterion.

It is noted that the determination of the occurrence of a key evolutionary process is complex and involves a detailed literature and field study, including an integrated analysis of the physical and biotic environments of the region. The relevance of structural attributes in a terrestrial landscape that could influence evolutionary processes is usually determined on a case-by-case basis, and the determination of the habitat that triggers this criterion is highly dependent on scientific knowledge. In most cases, this criterion is triggered in areas that have been previously investigated and are already known or suspected to be associated with unique evolutionary processes.

In this sense, it is understood that the Project region is not included in the examples given in NO81 and no scientific evidence was found that the region could be a relevant location for the occurrence of key evolutionary processes.

5.3.5.6
Conclusion of the analysis

Based on the analysis in the previous Sections, HC boundaries have not been triggered for the Project region. However, there are priority biodiversity values in the region, such as threatened species and ecosystems, which require impact mitigation actions. The analysis of Project impacts is presented in **Chapter 6.0**, and the proposed mitigation measures are presented in the Environmental and Social Management Plan (**Chapter 7.0**).

5.4
Socio-economic environment

This section of the ESIA describes the socio-economic conditions of the study area defined for the Project, prior to the start of construction works. This information allows the social and economic characteristics of this area to be known, so that the potential impacts of the project and the management plans and prevention, mitigation and compensation measures to be carried out can be adequately determined.

Methodology

For the elaboration of the socio-economic baseline, primary and secondary information has been collected for the study area, which consists of the municipality of Villeta, as defined in Section 5.1. The review of secondary sources available at INE - Instituto Nacional de Estadística, formerly DGEEC - Dirección General de Estadísticas, Encuestas y Censos, MSPyBS - Ministerio de Salud Pública y Bienestar Social, MEC - Ministerio de Educación y Ciencias, Conacyt - Consejo Nacional de Ciencia y Tecnología, MOPC - Ministry of Public Works and Communications, Instituto Paraguayo del Indígena (INDI) and the Federación por la Autodeterminación de los Pueblos Indígenas (FAPI), in addition to other publications and studies, also tried to collect data from the Central Department, where Villeta is located, for comparison and because district level data is not always available.

Primary information has been collected using qualitative methods consisting of semi-structured interviews with authorities and other stakeholders in Villeta. For the application of these instruments, field surveys were carried out between 06 and 17 March 2023. During these visits, the mapping of Project stakeholders and interviews with some key actors were carried out (**Table 5.4.a**). This list of stakeholders potentially affected by the Project was subsequently expanded and updated by ATOME's social specialist, and the result is the Expanded Stakeholder Map shown in **Annex 11**.

Table 5.4.a
Interviews conducted for the social baseline

Type	Interview	Role of the interviewee
Authorities / residents of Villeta	Municipality of Villeta	Secretary General of the Municipality. Representative of the Directorate of Works of the Municipality.
	Resident	Former resident of Guasu Kora.
Project implemented or planned in the region	Fertiliser factory FERTIMAX	Ypeka'e interviewee who worked at the company. Company website.
Potentially affected	Neighbouring resident	Person residing and working on the farm adjacent to the Plant site.
	Puerto Lobato (Ype ka'e)	Vice President of the Ypekaʾe Fishermen's Association and other representatives of the association.

Information was also collected on other projects in operation or planned for the region, for which it was not possible to obtain data through interviews. For the Fuel Terminal (PTP), information was obtained from public company documents, while for the Omega Green

Biodiesel Plant, the BCE Paraguay Environmental Impact Report and documents from the Ministry of Industry and Commerce were consulted.

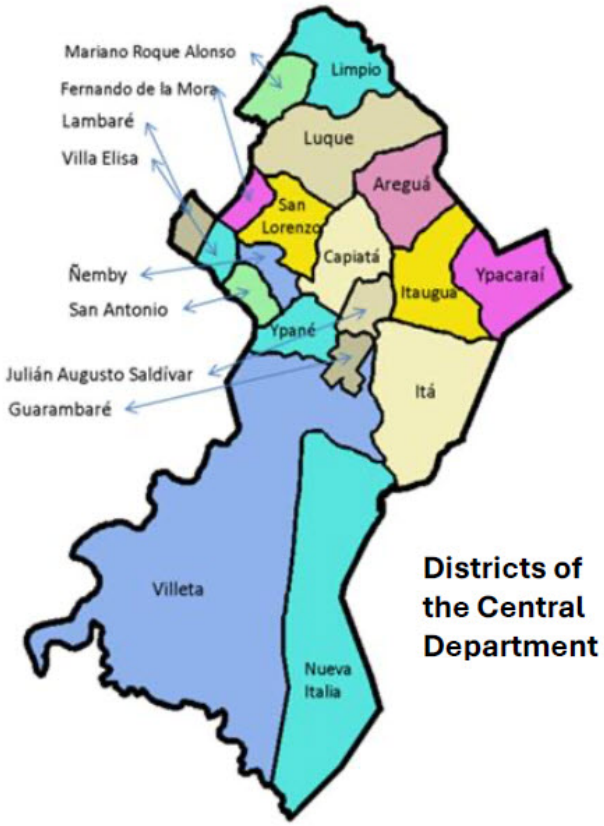
5.4.1
Area of Indirect Influence

5.4.1.1
General Data of the Municipality

The municipality of Villeta covers an area of 950 km^2 . It is located in the Central Department, bordered to the north by Ypané and Guarambaré, to the east by Nueva Italia and Itá, and to the south and west by the Paraguay River (see **Figure 5.4.1.1.a**). The city of Villeta is about 33 kilometres from the capital of the country, Asunción.

Founded in 1714, Villeta is known as the industrial city, as it has more than 70 industries; bordering the Paraguay River, this is its largest generator of jobs.

Figure 5.4.1.1.a
Location of Villeta in the Central Department



Villeta is divided into 12 companies: Naranjaisy, Valle Po'i, Senda, Tacuaty, Guazú Korá, Tacuruty, Ypeka'e, Surubi'y, Cumbarity, Ita Ybaté, Guyratï and Puerto Santa Rosa.

According to the interviews conducted for the ESIA, the vector of growth of the city is towards the East. In the municipality, there are several real estate companies that develop plots of land without adequate planning, without adequate provision for streets and squares.

In the interviews, it was also mentioned that in both the urban and rural sectors, conflicts are growing over the occupation of municipal land. In the settlements, conflicts arise between the neighbourhood commissions that claim to be able to allocate plots of land and those affected by eviction attempts.

In terms of the organisational structure of the municipality, the Mayor and the Municipal Council occupy the same level in the organisational chart. The legislative function is the responsibility of the Municipal Council, and the Mayor is responsible for the directorates.

5.4.1.2
Demographics

Table 5.4.1.2.a presents the total populations in the municipality of Villeta (social study area) for the 2002 and 2012 censuses and the projection for 2023, and also in the Central Department.

As the 2012 census data and the projection for 2023 do not break down the population into urban and rural, there is no way to calculate the urbanisation rate for these years. Companies or localities located in rural areas are urbanising at an accelerated rate due to real estate companies that generate developments in rural areas; also settlements adjacent to the city have been growing. It has been calculated for 2002, as shown in the Table, which also includes population density and geometric annual growth rates by period.

Table 5.4.1.2.a
Total and urban population, urbanisation rate and annual geometric growth rate in the study area

Department /District	Total population		Urban Population	Estimated population 2023	Urbanisation fee	Population density Inhab/km²	Annual geometric growth rates (% per year)	
	2002	2012	2002*		2002	2012	2002-2012	2012-2023
Villeta	22,429	32,880	10,106	44,488	45.1	34.6	3.9	2.79
Central Department	1,362,893	1,855,240	1,177,738	2,328,453	86.4	752.6	3.1	2.09

* DGEEC. Census Atlas of Paraguay. Central Department.
Source: National Institute of Statistics (INE), censuses 2002, 2012 and projections 2023.

As noted in **Section 5.4.1.1**, Villeta is part of the Central Department along with 18 other municipalities. In number of inhabitants, it ranks 15th, with only Guarambaré, Ypacaraí and Nueva Italia having a smaller population than Villeta. Considering population projections for 2023, Villeta's population represents 1.9% of the total of the Central Department. In 2012 it represented 1.77% and in 2002, 1.65%.

Considering the 2002 urban population data, it can be observed that in that year the urbanisation rate of Villeta was 45.1%, much lower than that of the Central Department as a

whole, which was 86.4%. Despite being the 15th municipality in terms of population, as mentioned above, Villeta has the largest surface area of any municipality in the Department (see **Figure 5.4.1.1.a**). This contributes to the low values of its urbanisation rate and especially its population density. Nevertheless, the urbanisation rate of the Central department was quite high in 2002, much higher than the country's rate in the same year, which was 55%. By 2023, Paraguay's rate has already risen to 64%.

The municipality of Villeta has urban neighbourhoods, settlements and rural populations, which have been established for centuries and constitute cohesive communities, with control and social protection mechanisms. Such is the case of Guasu Kora, Kumbarity, Valle Poʾi, Takuruty, Ypekaʾe, Surubiʾy, Ita Yvate and Yryvu Keha.

The municipality of Villeta is made up of the historic centre and the surrounding neighbourhoods with new constructions.

It is observed that both Villeta and the Central Department presented positive growth rates, with the municipality's being slightly higher than that of the department. Considering the two periods evaluated, it is observed that both the municipal and departmental populations grew more in the period 2002-2012 than in the period 2012-2023.

According to information from an interview with a former resident of Guasu Kora (**Photos 01 and 02**), Villeta is a centre of population attraction, and its growth, which is quite disorderly, is taking place both in the new urban neighbourhoods and in the settlements. Immigrants come from different regions of the country and are thus in the process of forming communities, with internal social relations that can become relatively dense.





Photos 01 and 02: Interview with former resident of Guasu Kora.

Considering the composition of the population in relation to gender, **Table 5.4.1.2.b** shows that, in 2012, Villeta had a larger male than female population, resulting in a sex ratio of 97.6%, different from the situation in the Central Department, whose sex ratio was 103.8%, reflecting that there were more females than males in the municipalities as a whole. The population projection for 2023 shows that this situation has been maintained, with a predominance of men in Villeta (sex ratio 96.9%), and a higher female population in the department as a whole (sex ratio 103.1%).

Table 5.4.1.2.b
Distribution of the population by sex

Municipality and Department	Men	Women	Sex ratio (%)	Men	Women	Sex ratio (%)
	2012			Projection 2023		
Villeta	16,747	16,133	97.6	22,585	21,902	96.9
Central Department	916,359	938,881	103.8	1,146,165	1,182,288	103.1

*Total men / Women.
Source: National Institute of Statistics (INE), 2012 census and projections 2023.

Assessing the population in relation to age groups (**Table 5.4.1.2.c**), it can be seen that the young population (up to 19 years old) of Villeta in 2012 represented 40% of the total, while adults (between 20 and 59 years old) accounted for 52.5% and the elderly for 7.5%. In 2023, the percentages of elderly and adults in Villeta's population increase to 10% and 55% respectively, while that of youth decreases to 35%. In both 2012 and 2023, Villeta's age groups reflect exactly the same percentages as in the Central Department.

Table 5.4.1.2.c
Age group distribution

Age group	Villeta		Central Department	
	2012	Projection 2023	2012	Projection 2023
0-4	3,379	4,000	190,455	209,122
5-9	3,242	3,915	182,751	204,674
10-14	3,219	3,861	181,468	201,911
15-19	3,253	3,825	183,437	200,058
20-24	3,146	3,829	177,455	200,357
25-29	2,974	3,857	167,875	201,811
30-34	2,596	3,685	146,627	192,899
35-39	2,243	3,423	126,658	179,208
40-44	2,013	3,006	113,618	157,443
45-49	1,728	2,509	97,518	131,419
50-54	1,448	2,196	81,713	115,008
55-59	1,166	1,854	65,777	97,062
60-64	842	1,501	47,504	78,583
65-69	588	1,165	33,224	61,035
70-74	417	805	23,610	42,169
75-79	288	502	16,302	26,325
80+	339	557	19,249	29,372
Total	**32,880**	**44,487**	**1,855,240**	**2,328,453**

Source: National Institute of Statistics (INE), 2012 census and projections 2023.

5.4.1.3
Socio-economic Level of the Population

As shown in **Table 5.4.1.3.a**, total and extreme poverty levels have decreased in the Central Department between 2002 and 2021. Total poverty decreased by 43% and extreme poverty by 69%.

Table 5.4.1.3.a
Population of the Central Department according to the main poverty indicators. Period 2002, 2012 and 2021

	2002	2012	2021
Percentage			
Population in total poverty (%)[1]	51.5	18.2	18.6
Population in extreme poverty (%) [2]	6.3	0.7	1.2
Absolute value			
Population in total poverty[1]	731,747	336,798	415,869
Population in extreme poverty[2]	90,163	12,550	27,981

Source: INE. Continuous Permanent Household Survey 2017 - 2021. Fourth quarter. Comparable series.
1- Corresponds to the population with an income below the Total Line (Basic Food and Non-Food Basket), therefore, it includes the extreme poor and the non-extreme poor.
2- Corresponds to the population with an income below the Extreme Poverty Line (Basic Food Basket).

Table 5.4.1.3.b, in turn, shows the food insecurity data for the different departments of Paraguay. As can be seen, Asunción has the lowest levels, while the worst situation is observed in the Departments of Caazapá and Itapúa, for moderate to severe food insecurity, and Caazapá and Alto Paraná, for severe cases. The Central Department, where Villeta is located, presents values below the average of the other departments for both moderate to severe food insecurity and severe cases.

Table 5.4.1.3.b
Prevalence of food insecurity in households, according to representative department (%). Year 2021

Representative department	Prevalence of food insecurity	
	Mod grave	Serious
Asunción	13,25 (±7,3)	2,67 (±2,9)
San Pedro	26,88 (±9,8)	5,13 (±4,2)
Caaguazú	25,79 (±10,8)	4,61 (±4,7)
Caazapá	37,55 (±11,2)	7,95 (±5,8)
Itapua	33,63 (±8,5)	6,55 (±4,4)
Upper Paraná	23,93 (±6,6)	7,85 (±3,9)
Central	23,06 (±6,1)	4,51 (±2,6)
Rest	24,78 (±4,2)	5,20 (±2,0)

Source: INE, Encuesta Permanente de hogares Continua third quarter 2021.
Note: Does not include Boquerón and Alto Paraguay.

For Villeta, the 2012 census data show that of the 55 segments (Census Work Areas) assessed in the urban area of the municipality, about 76% were in the medium socio-economic level, with the high level having the lowest proportion (see **Table 5.4.1.3.c**). Although the socio-economic division in the rural area segments was somewhat less discrepant, the majority, 44%, remained in the middle socio-economic level. However, the percentages in the low and high levels were similar in this case.

Table 5.4.1.3.c
Stratification of Villeta according to socio-economic level, 2012

Urban Area (%)				Rural Area (%)			
Total	**Under**	**Medium**	**High**	**Total**	**Under**	**Medium**	**High**
55	14.5	76.4	9.1	113	27.4	44.2	28.3

Source: DGEEC. Socio-economic stratification of segments. Census 2012.

Like Villeta, most of the other districts of the Central Department also had most of the segments of the urban area in the middle socio-economic level. Only in Villa Elisa, Lambaré and Fernando de la Mora were the segments mostly distributed in the high socio-economic level. On the contrary, Limpio, Guarambaré, San Antonio, Areguá and Ñemby had their segments mostly in the low socio-economic level.

In rural areas, Nueva Italia, Itá, Luque, Itauguá and Guarambaré, as well as Villeta, had their segments in higher proportions at the middle level, and the districts Ypacaraí, Areguá, Ypané and J. Augusto Saldívar were distributed in higher proportions at the high level.

According to one of the interviews conducted for the ESIA, among the social problems faced by the municipality is the fact that five of the ten settlements in Villeta are established in flood zones. In addition to this, in Villeta there are conflicts over access to plots of land and their conservation, weaknesses of social integration processes in the newly established settlements, unemployment, drug addiction, alcoholism and theft, as mentioned above.

5.4.1.4
Housing and Basic Services

The situation of the study area in relation to housing characteristics and basic services infrastructure is shown in the following tables.

Table 5.4.1.4.a below shows that, in the Central Department, about 80% of the population owned their homes in 2021. The situation regarding the availability of transport and telephone access improved considerably between 2002 and 2021. As for the availability of a refrigerator, already in 2002 more than 80% of households had a refrigerator, and in 2021 this percentage was already above 96%. In contrast to the other goods, households with television reception decreased between 2002 and 2021, from 92% to 56%.

With respect to water, **Table 5.4.1.4.b** shows the forms of supply that occurred in the Central Department in 2017 and 2018. As can be seen, the majority of households in 2017, 34.6%, were supplied by mains or private supplier. This percentage dropped to 31% in 2018, while the other two most common forms of supply, which are by SENASA - Servicio Nacional de Saneamiento Ambiental or Junta de Saneamiento and by ESSAP - Empresa de Servicios Sanitarios del Paraguay S.A. (ex-Corposana), increased slightly.

Table 5.4.1.4.a
Households in the Central Department according to housing tenure and durable goods. Period 2002, 2012 and 2021

	2002	2012	2021
Percentage			
Households with their own dwelling[1]	80.7	76.7	80.4

Table 5.4.1.4.a
Households in the Central Department according to housing tenure and durable goods. Period 2002, 2012 and 2021

	2002	2012	2021
Households with access to telephone communication[2]	51.0	97.3	98.5
Households with own transport[3]	24.5	58.9	73.4
Households with refrigerator	80.2	92.3	96.9
Households with television reception[4]	92.0	31.0	56.1
Absolute value			
Households with their own dwelling[1]	249,225	331,363	454,667
Households with access to telephone communication[2]	157,546	420,529	557,345
Households with own transport[3]	75,549	254,644	415,430
Households with refrigerator	247,919	399,021	548,135
Households with television reception[4]	284,158	133,843	317,284

Source: INE. Permanent Household Survey. Comparable series.
1- Includes home ownership, paying in instalments and condominium ownership.
2- Includes fixed and/or mobile telephony.
3- Includes motorbike and/or car.
4- Includes Cable TV and/or satellite dish.

According to the interview conducted for this ESIA, there are rental houses available in the municipality, which can be used by temporary workers from outside the region.

Table 5.4.1.4.b
Percentage of households in the Central Department according to types of water source (%). Period 2017 - 2018

Water source	Year	
	2017	2018
Number of households	**516,793**	**536,994**
ESSAP (ex-Corposana)	24.7	26.3
SENASA or Sanitation Board	26.5	28.4
Community network	8.1	8.2
Network or private provider	34.6	31.0
Other	6.0	6.1

Source: DGEEC Encuesta Permanente de Hogares Continua 2017 - 2018. Annual average.

In Villeta, according to the ESIA interview, the Junta de Saneamiento de Villeta, under the supervision of SENASA, is responsible for drinking water supply. Currently, the Junta de Saneamiento has 4,300 users. Each company or locality has drinking water services managed by local sanitation boards; private aguaterias also operate.

With regard to effluent disposal and treatment in the Central Department as a whole, **Table 5.4.1.4.c** shows that the percentage of households that were connected to the sewerage network in 2018 was minimal, not reaching 5.5%. The majority of households (60%) disposed of wastewater in septic tanks and 32.5% had a cesspool without a septic tank.

Table 5.4.1.4.c
Percentage of households in the Central Department by type of sanitary sewerage (%). Period 2017 - 2018

Type of sanitary sewer	Year	
	2017	2018
Number of households	**516,793**	**536,994**
With water entrainment, septic tank and cesspit (absorber)	60.9	60.0
With cesspit water haulage, without septic tank	30.6	31.5
With water conveyance, sanitary sewerage network (sewer)	4.4	5.4
Other	2.8	2.3

Source: DGEEC Encuesta Permanente de Hogares Continua 2017 - 2018. Annual average.

According to the interview, in Villeta the sanitary sewerage service is also provided by the Junta de Saneamiento de Villeta, under the supervision of SENASA. The sewerage system covers the entire urban area and there are currently projects to extend the network to the settlements bordering the urban centre.

There is a wastewater treatment plant that treats effluent from the urban area of Villeta.

In terms of solid waste collection and disposal, the situation in the Central Department is as shown in **Table 5.4.1.4.d** below. As can be seen, in 2018 a public or private company collected solid waste from about 65.5% of households, a percentage that increased compared to 2017. About 30% of households disposed of their waste by burning in 2018, a percentage that decreased compared to the situation in 2017. There is a small share that buries waste, and this percentage also decreased between 2017 and 2018.

Table 5.4.1.4.d
Percentage of households in the Central Department by mode of rubbish disposal (%). Period 2017 - 2018

Mode of waste disposal	Year	
	2017	2018
Number of households	**516,793**	**536,994**
Burn	32.1	30.2
Public/private collection	60.9	65.6
Throw in a hole	4.7	3.0
Other[1]	2.4	1.3

Source: DGEEC Encuesta Permanente de Hogares Continua 2017 - 2018. Annual average.
1- Dump in municipal landfill, yard, vacant lot, ditch or street, farm, stream and river, pond.

According to the interview data, rubbish collection in Villeta is carried out by the company EMMASA, which takes it outside the municipality. The municipality does not have a sanitary landfill or open industrial landfill, nor does it have a landfill for hazardous waste. These are covered by the companies themselves.

The waste and solid waste is removed by the company El Farol, which is in charge of taking the waste to Villa Hayes, where it has its sanitary landfill.

In the interview it was also mentioned that the inhabitants of Guazu Korá confronted years ago with the company El Farol, which wanted to install its landfill in the locality.

Table 5.4.1.4.e shows that almost all households had electricity from ANDE in 2018.

Table 5.4.1.4.e
Percentage of households in the Central Department according to ownership of electricity (%). Period 2017 - 2018

Electricity supply	Year	
	2017	2018
	516,793	536,994
If you have	99.7	99.8
It does not have	(0.3)	(0.2)

Source: DGEEC Encuesta Permanente de Hogares Continua 2017 - 2018. Annual average.

In terms of citizen security, data from the General Directorate of Order and Security of the National Police of Paraguay for the first half of 2017 (**Table 5.4.1.4.f**) show that most of the cases reported in the country are injuries in traffic accidents and motorbike thefts, followed by robberies and injuries.

Table 5.4.1.4.f
Most relevant punishable offences, reported throughout the country, 2017

	Nº of facts reported					
	January	February	March	April	May	June
Abigeato	71	58	41	59	74	67
Sexual coercion	49	39	61	34	46	40
Theft	177	156	134	139	163	108
Aggravated theft	110	94	138	105	121	93
Homicide in road traffic accidents	102	79	56	92	81	51
Intentional homicide	57	59	35	41	35	39
Road traffic injuries	407	316	286	342	347	282
Injury	161	136	152	151	136	124
Theft of objects	47	36	45	42	38	36
Aggravated theft of objects	157	133	129	115	141	100
Vehicle theft	72	66	61	55	66	45
Aggravated vehicle theft	10	9	9	10	16	17
Motorbike theft	245	201	225	245	345	185
Aggravated motorbike theft	26	33	41	38	39	21
Total	**1691**	**1415**	**1413**	**1468**	**1648**	**1208**

Specifically for the Central Department, the evolution of homicide and punishable offences rates between 2010 and 2017 is shown in **Table 5.4.1.4.g**. As can be seen, homicide rates fluctuate each year, oscillating between 5 and 3.5 per 100,000 inhabitants. As for the rate of punishable acts against property, with the exception of 2013, they always follow an increasing trend, with an increase of 68% between 2010 and 2017.

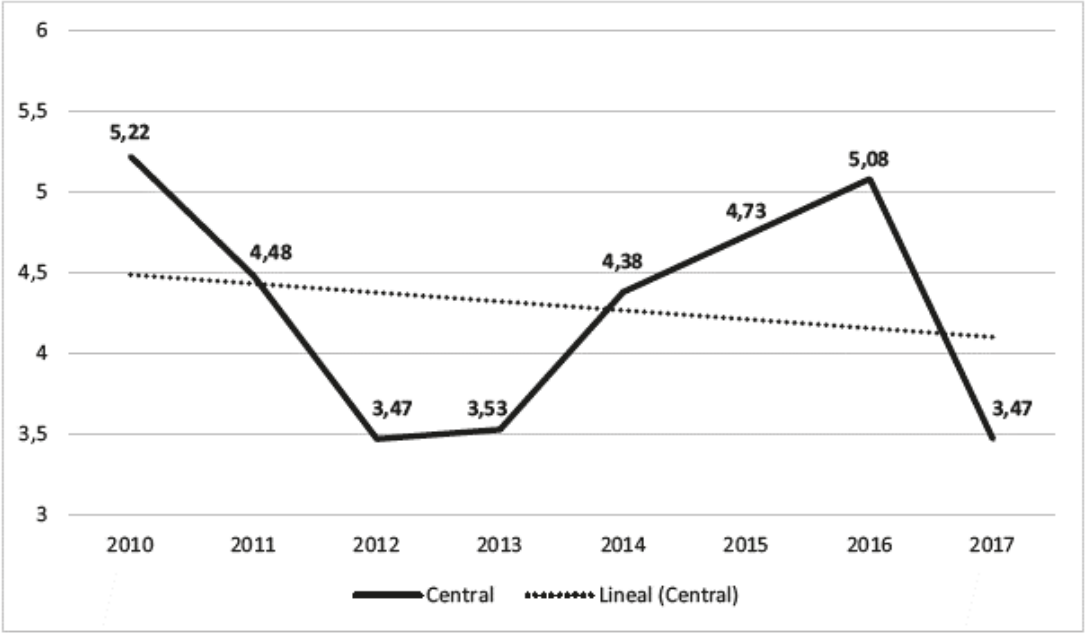
Table 5.4.1.4.g
Evolution of the rates of homicides and punishable acts against property /100 thousand inhabitants in the Central Department. Period 2010 and 2017

	2010	2011	2012	2013	2014	2015	2016	2017
Homicide rate	5,22	4,48	3,47	3,53	4,38	4,73	5,08	3,47
Rate of punishable acts against property	124,95	149,54	143,8	128,87	148,25	174,42	218,37	210,03

Source: Atlas of Violence and Insecurity in Paraguay. National Council of Science and Technology. 2017.

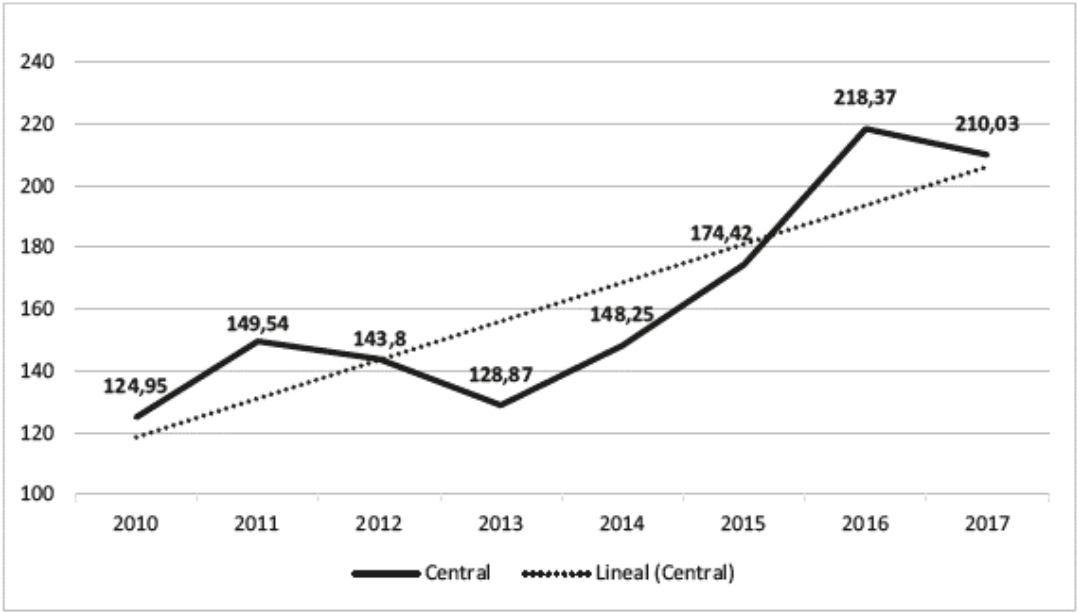
These trends are also demonstrated by data from the Atlas of Violence and Insecurity in Paraguay. The data from 2010 to 2017 show that the evolution of the criminal record in the Central Department is different, depending on whether it is homicides or punishable acts against property, since in the case of violent deaths there was a decrease of 33.5%, while in relation to the affectation of people's property there was an increase of 69.3%, as shown in **Figures 5.4.1.1.4.a** and **5.4.1.1.4.b**.

Figure 5.4.1.4.a
Intentional homicide rate in the Central Department per 100,000 inhabitants



Source: Atlas of Violence and Insecurity in Paraguay. National Council of Science and Technology. 2017.

Figure 5.4.1.4.b
Property crime rate in the Central Department per 100,000 inhabitants



Source: Atlas of Violence and Insecurity in Paraguay. National Council of Science and Technology. 2017.

According to the interview conducted for this ESIA, there are reports of assaults and robberies in the municipality, as well as drug addiction problems, basically with crack, and also alcoholism. However, interviewees were unable to report whether there are cases of sexual abuse, child prostitution and teenage pregnancy.

The public security service is assigned to the municipality. There are four police stations in Villeta, including Ypeka'e, Surubi'y and the one that covers the city. Villeta also has the headquarters of the Municipal Council for the Rights of Children and Adolescents - Codeni. Police patrols are carried out in the municipality, but only in the city or urban centre.

5.4.1.5
Economic Aspects

5.4.1.5.1
Activity, Employment and Unemployment Rates of the Labour Force

The EAP - Economically Active Population (population aged 15 to 65) is the portion of the Working Age Population (population aged 10 years and over) that is employed or unemployed. In other words, it represents the contingent of persons able to work. The Employed Population (OP), in turn, is that which has a regularly exercised paid job or which has an irregularly exercised paid job, provided that it is not looking for a job other than its current job.

Table 5.4.1.5.1.a shows the number of persons of working age, economically active (EAP) and employed (PO) and the employment and unemployment rates in Villeta and in the Central Department, which allows characterising the current profiles of the level of activity and occupation of the available labour force.

The 2012 census data are not disaggregated by district, so the EAP, OP and unemployed population (OP) figures for Villeta were only obtained for 2002. Thus, data for the Central Department for 2002 have also been included in the Table for comparative purposes.

As shown in **Table 5.4.1.5.1.a**, the EAP in Villeta in 2002 totalled 8,763 persons, resulting in an activity rate (EAP / working age population) of 50.6%, lower than the Central Department average in the same year. This rate in the Department had a small increase in 2012, from 60 to 61.6%. Despite the lower activity rate, the proportion of employed persons (employment rate) in Villeta was 94.4% in 2002, well above that of the Central Department this year. The Department's employment rate improved in 2012, reaching 93.9% and approaching that of Villeta.

Table 5.4.1.5.1.a
Information on the occupation of the population

	Total working age population	Economically Active Population - EAP	Activity rate (%)	Employed Population - PO	Employment rate (%) PO/EAP	Unoccupied population - PD	Unemployment rate (%) PD / ADP
Villeta 2002	17,319	8,763	50.6	8,275	94.4	488	5.6
Central Department 2002	1,060,626	636,495	60.0	523,348	82.2	113,147	17.8
Central Department 2012	1,483,457	914,122	61.6	858,179	93.9	55,943	6.1

Source: National Statistics Institute (INE), 2002 and 2012 censuses.

Considering the unemployment rate (open unemployment), the value in the Central Department in 2002 was quite high at 17.8%, reflecting the lower employment rate mentioned above. In that year, Villeta had only 5.6% of the population unemployed. In 2012, the Central Department's unemployment rate fell considerably, with the number of unemployed falling to almost half the value of the previous decade.

For the Central Department there is gender-segregated population employment data for 2017 and 2018 (**Table 5.4.1.5.1.1.b**). As can be seen, the employment rate fell again in 2017, from around 94% in 2012 to around 66%. The unemployment rate, meanwhile, has risen from 6.1% to 7.2-8.2%. The employment rate is higher for men, at around 78%, while for women it is around 55%, which contributes to lowering the overall rate. Unemployment among men is between 6.4 and 7%, while among women it is between 8.3% and 9.8%.

Table 5.4.1.5.1.b
Population aged 15 and over by year in the Central Department, by sex and labour market indicators. Period 2017 - 2018

Department, gender and labour market indicators	Year	
	2017	2018
Total	**2,072,035**	**2,115,204**
Working Age Population (WAP)	1,483,637	1,537,214
Workforce	1,058,527	1,112,095
Population outside the labour force	425,110	425,119
Employed population	982,302	1,020,910
Unemployed population	76,225	91,185
Under-occupation due to insufficient working time	42,705	39,823
Labour Force Rate	71.3	72.3
Occupancy rate	66.2	66.4
Unemployment rate	7.2	8.2
Underemployment rate due to insufficient working time	4.0	3.6
Men	**1,027,614**	**1,051,630**
Working Age Population (WAP)	723,900	750,405
Workforce	603,011	627,177
Population outside the labour force	120,889	123,228
Employed population	564,540	583,581
Unemployed population	38,471	43,596
Under-occupation due to insufficient working time	13,526	16,132
Labour Force Rate	83.3	83.6
Occupancy rate	78.0	77.8
Unemployment rate	6.4	7.0
Underemployment rate due to insufficient working time	2.2	2.6
Women	**1,044,421**	**1,063,574**
Working Age Population (WAP)	759,737	786,809
Workforce	455,516	484,918
Population outside the labour force	304,221	301,891
Employed population	417,762	437,329
Unemployed population	37,754	47,589
Under-occupation due to insufficient working time	29,179	23,691
Labour Force Rate	60.0	61.6
Occupancy rate	55.0	55.6
Unemployment rate	8.3	9.8
Underemployment rate due to insufficient working time	6.4	4.9

Table 5.4.1.1.5.1.c, below, shows the percentage of employed persons by category in occupation, for the Central Department in the years 2017 to 2019. As can be seen, almost half of the population are private employees/workers, followed by about 21-22% self-employed and about 11% public employees/workers. Employers or employers account for only 5-6%.

Table 5.4.1.5.1.c
Population aged 15 and over employed by year in the Central Department, by occupational category (%), 2017 to 2019. Annual average

Department, gender and occupational category	Year		
	2017	2018	2019
Total	**982,302**	**1,020,910**	**1,059,949**
Public employee/worker	11.4	11.3	11.2
Private employee/worker	51.2	50.8	49.8
Employer or employer	5.0	5.3	6.2
Self-employed	21.1	21.4	22.3

Table 5.4.1.5.1.c
Population aged 15 and over employed by year in the Central Department, by occupational category (%), 2017 to 2019. Annual average

Department, gender and occupational category	Year		
	2017	2018	2019
Unpaid family worker	2.8	2.7	2.3
Domestic worker	8.3	8.5	8.1
Not available	0.1	0.0	0.1

Source: DGEEC. Continuous Permanent Household Survey 2017 - 2019. Annual average.

The 2012 census also collected data on the phenomenon of pendular migration and the need to move a considerable distance from their residence to their place of occupation. According to the data for Paraguay as a whole, about 54% or 255 thousand people worked in 2012 in a department other than the one where they lived, the latter being an interdepartmental pendular migration.

Table 5.4.1.1.5.1.d below shows the data on Population aged 10 years and above migrant pendulous by place of occupation in 2012, for the Central Department. As can be seen, of the population aged 10 years and above in the Central Department in 2012, which amounted to 347,930 persons, 87,115 (25%) worked in the department itself. The majority, 59%, worked in Asunción, and 13% had no fixed district.

Table 5.4.1.5.1.d
Population aged 10 years and over subject to out-migration from the Central Department, by place of occupation, 2012

Place of occupation										
Asunción	Concepción	San Pedro	Cordillera	Guairá	Caaguazú	Caazapá	Itapua	Missions	Paraguarí	Upper Paraná
204,903	487	506	1.821	256	530	140	468	256	756	1,465
Central	Ñeembucú	Amambay	Canindeyú	President Hayes	Anchovy	Upper Paraguay	Other country	It does not have fixed	Population migrant pendulum	
87,115	242	198	403	1.844	575	336	1,788	43,841	347,930	

Source: Census 2012. Pendular Migration in Paraguay, 2012.

5.4.1.5.2
Economic Activities Predominant in the Study Area

The 2011 Economic Census collected data on the employed population of the district of Villeta by sector and branch of economic activity (**Table 5.4.1.5.2.a**). As can be seen, of the 3,638 people employed in 2010, 56% were employed in industry, mainly in food processing, manufacture of chemical substances and products and other industry activities. A further 26% were in commerce, the vast majority (85%) in the retail trade branch, except motor vehicles and motorbikes. Finally, 18% were in the services sector, most of them in the branches of food and beverage services, land and pipeline transport, education and other service activities.

Table 5.4.1.5.2.a
Total employed personnel in Villeta by branch of economic activity. Year 2010

	Employed staff	%
Total	**3,638**	
Industry	**2,021**	
Food processing	568	28.10
Manufacture of chemicals and chemical products	531	26.27
Other industrial activities	426	21.08
Manufacture of fabricated metal products, except machinery and equipment	131	6.48
Furniture manufacture	120	5.94
Manufacture of rubber and plastic products	75	3.71
Manufacture of non-metallic mineral products	70	3.46
Wood products and manufacture of wood and cork products, except furniture. Manufacture of articles of straw and articles of other materials.	54	2.67
Garment manufacturing	29	1.43
Maintenance, repair and installation of machinery and equipment	17	0.84
Trade	**950**	
Retail trade, except of motor vehicles and motorbikes	811	85.37
Trade and repair of motor vehicles and motorbikes	105	11.05
Wholesale trade, except of motor vehicles and motorbikes	34	3.58
Services	**667**	
Food and beverage services	147	22.04
Land and pipeline transport	112	16.79
Teaching	74	11.09
Other service activities	68	10.19
Other personal service activities	59	8.85
Financial intermediation and other financial services, except insurance and pension fund management	46	6.90
Water collection, treatment and supply	39	5.85
Repair of computer and communication equipment; personal and household goods	37	5.55
Sports and entertainment activities	22	3.30
Telecommunications	18	2.70
Human health care activities	18	2.70
Legal and accounting activities	9	1.35
Other professional, scientific and technical activities	7	1.05
Gambling and betting activities	7	1.05
Rental and leasing activities, except real estate, and management of non-financial intangible assets	4	0.60

Source: National Economic Census 2011 - Paraguay. Final District Results.

According to interviews conducted for the ESIA, there are three hotels in Villeta, one of which has a good reception capacity, and four restaurants.

Unlike Villeta, the Central Department as a whole had in 2010 the highest proportion of the employed population (total of 220,635 persons) in the commerce sector, with 41% of the total, followed by the services sector, with 32% and finally industry, with 27%. In departmental

commerce, the branch with the greatest weight (39% of this portion) was retail trade in non-specialised shops. In services, the branches with the largest share of the labour force were restaurants, bars and the like and other land transport (both 29.5%). In industry, the most important branches, with better distributed percentages, were meat processing and preserving, manufacture of garments, except fur garments, and manufacture of furniture.

According to an interview conducted for the ESIA, livestock production in Villeta is being displaced by irrigated rice production with canalised water, which extends downstream. In the municipality there is large-scale production, which according to local interviewees reaches thousands of hectares and uses suction machines that are supplied from the river.

One of the main employers in the municipality is Archer Daniels Midland (ADM), which produces and exports unrefined soybean oil. This company reportedly employs more than 300 workers, some of whom work with outsourced subcontractors.

In addition to the firm Eladia, which collects, processes and exports rice and employs workers from Ypeka'e, Villeta is home to the Complejo Agroindustrial Angostura SA (CAIASA), located within the Villeta industrial park, 45 km from Asunción and some 22 km from the planned site of the ATOME power plant.

CAIASA has been operating in Paraguay since 2013, producing soybean meal, leguminous oils and soybean hull pellets. It has a capacity to process 4,500 tonnes of oilseed per day. Within its facilities it has a port terminal with two docks, with an operational loading and unloading capacity of 1,500 tonnes per hour; in addition to an oilseed crushing plant, it also has differentiated silos for storing cereals and oilseeds, flours and tanks for storing oils of twenty-five thousand tonnes[14] .

An industrial plant for the production of biodiesel is in the process of being installed next to CAIASA. Cremer Oleo Paraguay S.A. is being implemented by the German global company CREMER.

Four fertiliser processing plants operate in Villeta, including Organitec Fertilizantes S.A., Tecnomyl, the FERTIMAX Industrial Complex and Mosaic Fertilizantes Paraguay, the latter two about 5 km from the planned ATOME plant site. At peak times, the largest of these industries transports its production using up to 300 trucks with a load capacity of 36 tonnes each.

According to an interview with a former employee of FERTIMAX and data obtained from its website, the company manufactures and markets fertilisers, urea being one of its products. Some of its inputs come from Russia and are processed at the Villeta plant. The supply of this raw material suffered restrictions as a result of the war with Ukraine.
In terms of logistics, the factory has its own port, and uses both inland and inland waterways for the movement of inputs and production.

For river transport, they use 20 barges (chatas) per tugboat, with a capacity of 2,000 tonnes for the large barges and 1,600 tonnes for the small barges. In relation to land transport of the

14 https://www.ip.gov.py/ip/jefe-de-estado-visita-la-mayor-planta-de-procesamiento-de-soja-ubicada-en-villeta/

production, the interviewee points out that at peak times some 300 trucks per day usually leave the factory with a capacity to transport 53,000 kg each.

FERTIMAX has two 12-hour shifts, with 100 workers working on each shift. It uses private transport to transport its workers, and those who do not live on all-weather roads use motorbikes to get around.

Villeta also has a multipurpose terminal managed by PTP Paraguay through an operational alliance in usufruct with the National Administration of Navigation and Ports (ANNP). The concession rights extend for 20 years from 2014, with the possibility of extending this term for a further five years. PTP Paraguay is part of PTP Group, an Argentinean-owned *holding company* with a presence along the Paraguay-Parana Waterway. It has infrastructure in Uruguay, Argentina and Paraguay, through eight port terminals, covering nearly 1,500 km of route.

The Villeta terminal is located in the vicinity of the urban centre, at km 1539 of the Paraguay-Parana waterway. Its position on the waterway is particularly attractive because it is the furthest point on the waterway where it can be accessed by full-cargo barges all year round.

According to available public documents, this terminal offers transhipment, stevedoring, unstowage, cargo consolidation/deconsolidation, fractionation and *blending* operations; serving *feeder* vessels and river barges with solid bulk, liquid bulk, general cargo, containers and RO-RO. The draft is 13 feet (full cargo 365 days a year). The terminal has equipment such as Liebherr FCC 320 WL crane and Terex MHL 380 crane.

The facilities have more than 10,000 m² covered for storage of solid bulk and general cargoes, more than 10,000 m³ for storage of liquid bulk (fuels, bio fuels, vegetable oils, liquid fertilisers, etc.) and a 5-hectare yard suitable for containers and steel products.

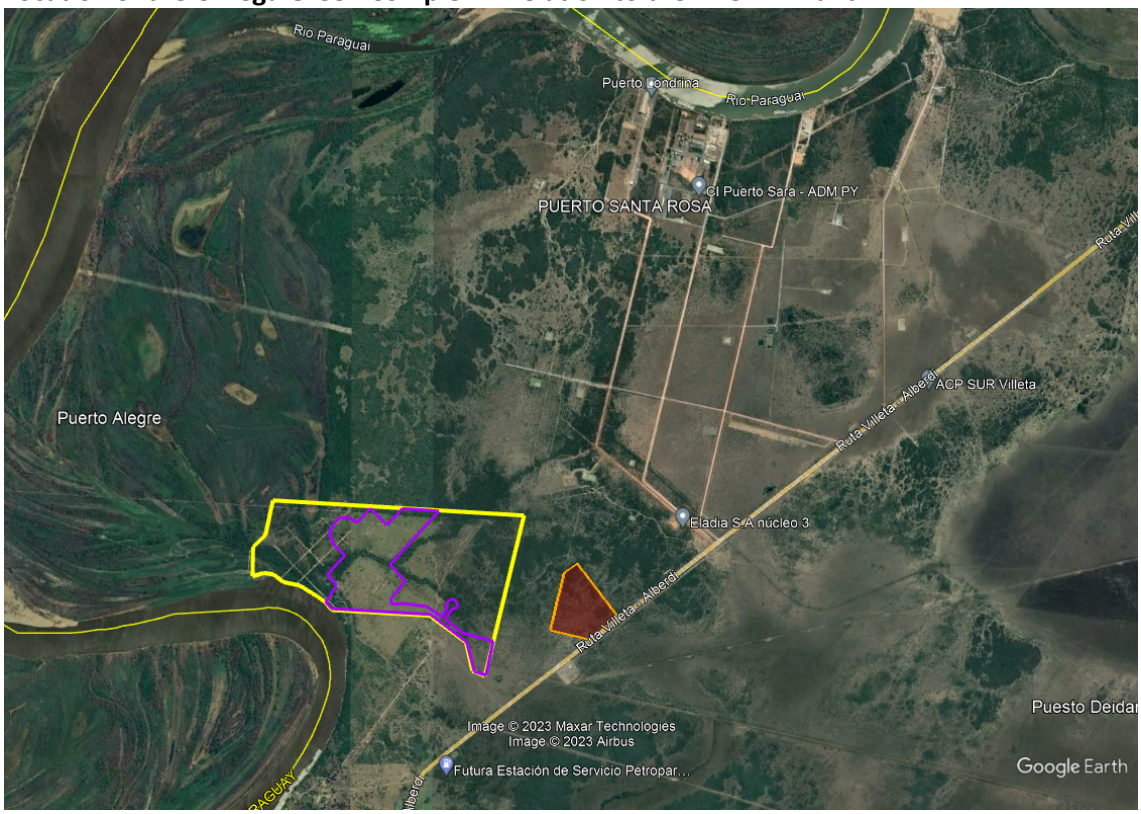
The fuels and oils transported through this terminal are basically of European origin, of different emblems. They are unloaded and stored at the terminal, to be redistributed by river and overland to the final places of sale.

The company specialises in the unloading of fertilisers, related to the operation of its main client, Abonos del Paraguay S.A., with whom it has a long-term contract with a guaranteed annual transfer level (180,000 tonnes). More than 65% of PTP Paraguay's ordinary revenues are linked to it, showing a strong concentration.

Closer to the ATOME Plant site (see **Figure 5.4.1.5.2.a**) there is a project to build the Omega Green Biofuel Production Industrial Complex. The industrial complex will also be located close to ADM's grain processing plant, as shown in **Figure 5.4.1.5.2.a.**

The land where the project will be implemented is accessed by the National Route PY19 Villeta - Alberdi, and then by a 4.6 km gravel road. The project will be integrated with logistics terminals and extraction, pre-treatment, electrolysis and hydro-treatment plants. The Villeta - Alberdi road will be high flow after implementation.

Figure 5.4.1.5.2.a
Location of the Omega Green Complex in relation to the ATOME Plant



Omega Green Complex Limit

Land boundary

Source: *Omega Green Project. General Plant Layout*.

According to the Environmental Impact Report of the project, prepared to obtain the permit from MADES, the project proponent, ECB Paraguay S.A., is a group established in 2011 and has an investment portfolio with stakes in companies that generate fuels from renewable raw materials, such as BSBIOS Paraguay S.A. BIO SWITZERLAND SA, ECB GROUP PARAGUAY and ECB GROUP BRASIL.

The Free Trade Zone Concession Contract between the Government of the Republic of Paraguay and ECB Paraguay S.A. establishes that the concessionaire will install an industry for the production of biofuel for export, processing raw materials and/or semi-finished products of national or imported origin. This activity will be developed in the concessionaire's facilities.

The concessionaire may install a port terminal for the reception of raw materials, machinery and other goods necessary for the development of its activities, and the subsequent exploitation of the final or residual products, in accordance with the free trade zone concession contract and the signing of its amending addendum. In this addendum it is mentioned that in September 2020 the free zone concession contract was signed between the government of Paraguay and the company ECB Paraguay S.A. in which it is established that the free zone granted will be located in a 70 hectares property located in Villeta, whose purchase and sale operation was carried out with EL ARREGLO S.A.

On 30 April 2021, an addendum to the aforementioned contract was requested, accompanying the purchase and sale of a 388 ha property located in Puerto Sara, district of Villeta. In August 2022 the company BSBIOS Paraguay S.A. was renamed Omega Green S.A. The addendum was agreed on 2 February 2023. For this ESIA it was possible to access the addendum amending the Free Trade Zone concession contract between the government of the Republic of Paraguay and Omega Green S.A.

The industrial complex will produce 20,000 barrels per day of renewable diesel, jet fuel and by-products. It is estimated to produce 2,700,000 litres of renewable fuels per day; 1,200 metric tons of degummed oil plus another 1,200 metric tons of oils purchased from local and international markets.

The raw materials to be used by Omega Green are oilseeds, grains, animal fats, vegetable oils, recycled vegetable oils of domestic or imported origin, and biodiesel residues. It is estimated to process 6,250 tonnes of grain per day.

According to the Environmental Impact Assessment, the estimate of the number of staff to be required comprises:

- 400 direct jobs
- 2,000 indirect jobs
- 3,000 temporary jobs

5.4.1.5.3
Fishing Activity

About 8 km as the crow flies from the ATOME plant site, and about 11 km by road, is the Ypeka'e company (**Figure 5.4.1.5.3.a**), where subsistence and sport fishing activities are carried out. The fishing village of Puerto Lobato or YpeKa'e is located on the banks of the Paraguay River, about 3 km from the Villeta Alberdi Route (PY19), which is accessed by a precarious road.

Figure 5.4.1.5.3.a
Location of Puerto Lobato / Ypeka'e in relation to the plant site



The fishermen in this community are associated with the Ypeka'e Fishermen's Association, whose vice-president and one of the members were interviewed as part of the baseline for this ESIA.

According to the interview, the locality is an old settlement and the first settlers refer to the initial settlement as early as 60 years ago. At present, the local population itself consists of about 200 households.

The locality has a chapel with San Antonio de Padua as patron saint, and a school (San Juan Bautista) that covers up to 9th grade. Those who want to finish high school must go to the centre of Villeta. The local population is not served by public transport. To go to the centre of Villeta they have to take the Villeta - Alberdi route and wait for the Lago Ypo'a bus which runs three times a day.

The community has neither a sanitation board nor a water treatment plant. The inhabitants buy jerry cans of water for drinking, each family buys around five jerry cans of water per week, which is equivalent to 200,000 guaraníes per month. For cleaning and other needs, they draw water directly from the Paraguay River, some houses have a motor pump and others carry water in buckets. The community does not have a rubbish collection service, so the villagers burn or bury the rubbish in their backyards. Firewood is used to cook food. There are no cases of robbery or theft; the police patrol does not usually enter the community.

Most heads of households are engaged in commercial or subsistence fishing while others work in agro-industrial establishments in Villeta. The temporary population of weekend sport fishermen is difficult to estimate as not all of them have their residences in the locality and are limited to using the facilities of the fishing clubs.

There are just over 100 permanent commercial or subsistence fishermen, 60 of whom are registered with the Ministry of Social Development who receive subsidies during the closed season, but only one member of the household is eligible for compensation.

According to MADES records, the association does not have any canchadas registered with the ministry, which are areas allocated for fishing, subject to monitoring and evaluation by the institution.

Most of the fishermen are spinners, since they catch relatively large black fish (basically surubí) with spinels, and in the low season of this harvest they catch smaller white fish with liñadas, which they basically use for their own consumption. The bait they use depends on the type of fish they want to catch. The fishermen use worms that they buy from the centre of Villeta. They also use small fish as bait.

Due to the proximity of the river the villagers of Ypekaʾe walk to fish.

The profile of these fishermen can be deduced from an interview with one of them:

> *I am a fisherman. I sell the fish, I take them out with a spinel. I have my skipper ..... I fish every day, including Saturdays and Sundays. Most of the villagers are fishermen, some, very few, work with the Pasiva rice company, which is actually a silo. There are five of us living in my house.*

As far as sport fishing is concerned, three sport fishing clubs are established in the locality with berths and other facilities. The APTV would have more than 200 members, Guyrati would have about a hundred members and the San Lorenzo Club would have approximately 50 members. These fishermen have little interaction with the local population. Some of them have luxurious residences that contrast with the modest dwellings in the surrounding area.

5.4.1.6
Public services

5.4.1.6.1
Health

This section presents some indicators to assess the profile of Villeta and the Central Department in relation to the existence of basic resources for health care.

According to the division of the country into health regions, the Central Department constitutes Health Region XI - Central.
Table 5.4.1.1.6.1.a presents the data on health facilities in the Central Department for 2018. As can be seen, in this year there were a total of 173 health facilities, most of which were Family Health Units - FHUs (108). Despite having 19 districts, the department had only 16 regional

hospitals, which shows that there were districts without a hospital. This is the case of Villeta, which, according to the interview conducted for this ESIA, has one district hospital (HD), the regional IPS unit and the USF Cumbarity, Tacuaty Rugua, Naranjaisy and Naranjaisy II.

Table 5.4.1.6.1.a
Total health facilities - Central Department 2018

Types	Nº of establishments
Regional hospitals	**16**
Health centres	8
Health posts	16
District hospitals	7
Specialised hospitals	5
Specialised centres	7
Dispensaries	-
Family health unit	108
Maternity and Children's Hospital	4
General Maternity and Children's Hospital	-
General Hospital	2
Total	**173**

Source: Ministry of Public Health and Social Welfare. General Directorate of Strategic Health Information.

Among other data from the Ministry of Public Health and Social Welfare on the Villeta HD, it can be seen in **Table 5.4.1.6.1.b** that in 2015 this hospital had 20 beds and performed 34,331 outpatient consultations and 17,084 emergency consultations.

Table 5.4.1.6.1.1.b
Statistical data year 2015 HD Villeta

	Outpatient Consultations	Emergency Consultations	Number of beds	Hospital discharges	Days Beds Available	Days Beds Occupied	% Bed Occupancy
HD Villeta	34,331	17,084	20	1,082	7,300	2,870	39.3

Source: Health Investment Department - Directorate of Health Economics. Central Costing Workshop. Ministry of Public Health and Social Welfare.

Table 5.4.1.1.6.1.c shows some health indicators for the Central Department. As can be seen, the percentage of the population with access to health and health insurance coverage decreased in 2021 compared to the situation in 2012.

Table 5.4.1.6.1.c
Main health indicators of the population of the Central Department. 2012 y 2021

	2012	2021
Population with health insurance coverage[1]	693,961 (37.4%)	796,536 (35.5%)
Access to health [2]	477,363 (78.9%)	267,663 (66.6%)

1- Includes IPS and other insurance.
2- Includes the sick or injured population.
Source: DGEEC. Permanent Household Survey.

According to data from the Ministry of Public Health and Social Welfare on notifiable communicable diseases in Paraguay, for the period 2018-2020, dengue is the disease with the highest occurrence, with percentages of 84%, 72% and 98% of total notifications in 2018, 2019 and 2020, in a set of 24 diseases. The second most reported were, in 2018, Mumps, with only 4% of the total, and Varicella in 2019 and 2020, with 12% and 0.5% of the total, respectively.

Data from the National Disease Surveillance and Control Guide of the National Epidemiological Surveillance System (Ministry of Public Health and Social Welfare, 2022), show that the Central Department is among those that were involved in almost all disease outbreaks and among the departments with the highest number of reported cases of certain diseases, as shown in the examples below:

- The outbreak of autochthonous circulation of **Chikungunya** in January 2015 started in the district of Fernando de la Mora, Central Department, and spread to neighbouring districts as well as to other departments of the country;
- The outbreak of **diphtheria** between 2002 and 2003, with a total of 50 cases and a case fatality rate of 18%, particularly affected the Central Department and to a lesser extent Asunción and the Departments of Presidente Hayes, Caaguazú and San Pedro;
- Cases of **poisoning by scorpions** of the species *T. trivittatus*, of medical importance, have been reported in the Departments of Concepción, Amambay, Guairá, Cordillera, Paraguarí, Central and the city of Asunción;
- **Viral Hepatitis B** is distributed throughout the country, but the health regions with the highest notification are Central, Capital and Alto Paraná;
- More than 90% of the cases of **Visceral Leishmaniasis** come from the district of Asunción and the Departments of Central, Paraguarí and Cordillera;
- In Paraguay, the highest incidence rates of **syphilis and neonatal syphilis** are found in Boquerón, Asunción, Alto Paraná, Alto Paraguay, Central, Pte. Hayes and San Pedro;
- Asunción, Central and Alto Paraná have cases of **tuberculosis**, with the highest incidence of active disease in young men aged 15-44 years in areas of high population density;
- In Paraguay, 56% of people with **HIV infection** registered in 2020 reside in the Central and Capital Departments, followed by border areas such as Alto Paraná (13%) and Itapúa (3%).

In terms of dengue, the 2017-2018 Report of the Ministry of Public Health and Social Welfare indicates that the cases reported in 2018 came mainly from the Central Department (52.5%) and Asunción (30.3%). Of the 15 cases of dengue deaths during the year, 7 were in Asunción, 5 in the Central Department, and 1 each in the departments of Guairá, Boquerón and Alto Paraná.

This report also reports only three cases of malaria, one from the Central Department and two from Misiones. With regard to meningoencephalitis, although there are cases in all other departments of the country, most of the cases reported were from the Central Department (44%), Asunción (12%), Alto Paraná (11%) and Cordillera (5%).

5.4.1.6.2
Education

The data in this section are presented in order to characterise the conditions of education in Villeta and in the Central Department, where the project is located.

The data in **Table 5.4.1.6.2.a** for the Central Department show that almost all (98.9 to 99.1%) of the population aged 6 to 14 years studied in a formal education institution between 2017 and 2019, with a balanced situation between males and females. The next group, aged 15-17 years, shows a decrease in the percentages, ranging from 85.6% to 90.8%. In this case, the percentages are lower for males, with 82.1% to 88.5% versus 89.3% to 93.4% for females.

Table 5.4.1.6.2.a
Population aged 6-14 and 15-17 years in the Central Department, by attendance at a formal education institution and sex (%), in the period 2017 to 2019. Annual average

Attendance / gender	Year					
	2017		2018		2019	
	6 to 14 years	15 to 17 years	6 to 14 years	15 to 17 years	6 to 14 years	15 to 17 years
Total	**343,784**	**122,438**	**335,198**	**119,069**	**345,134**	**111,645**
Attends	98.9	85.6	99.1	88.5	98.9	90.8
Not in attendance	(1.1)	14.2	(0.9)	11.5	(1.1)	9.2
Men	**176,370**	**64,788**	**177,951**	**56,555**	**185,215**	**58,864**
Attends	98.3	82.1	99.3	87.7	99.1	88.5
Not in attendance	(1.7)	17.9	(0.7)	12.3	(0.9)	11.5
Women	**167,414**	**57,650**	**157,247**	**62,514**	**159,919**	**52,781**
Attends	99.5	89.6	98.9	89.3	98.7	93.4
Not in attendance	(0.5)	10.1	(1.1)	10.7	(1.3)	(6.6)

Source: DGEEC Continuous Permanent Household Survey 2017 - 2019. Annual average.
Note: ( ) estimate based on less than 30 sample cases, which may be considered as under-sampling.

Regarding the type of institution attended by this population aged 6 to 17 years in the period 2017 to 2019, it is observed in **Table 5.4.1.6.2.b** that the vast majority of the population in this age group (73 to 77%) attended public schools. However, the percentages attending public institutions decreased from 2017 to 2019, with the percentages attending public schools increasing in this period. There is a higher percentage of males who attended public schools, and a higher percentage of females in private/subsidised schools.

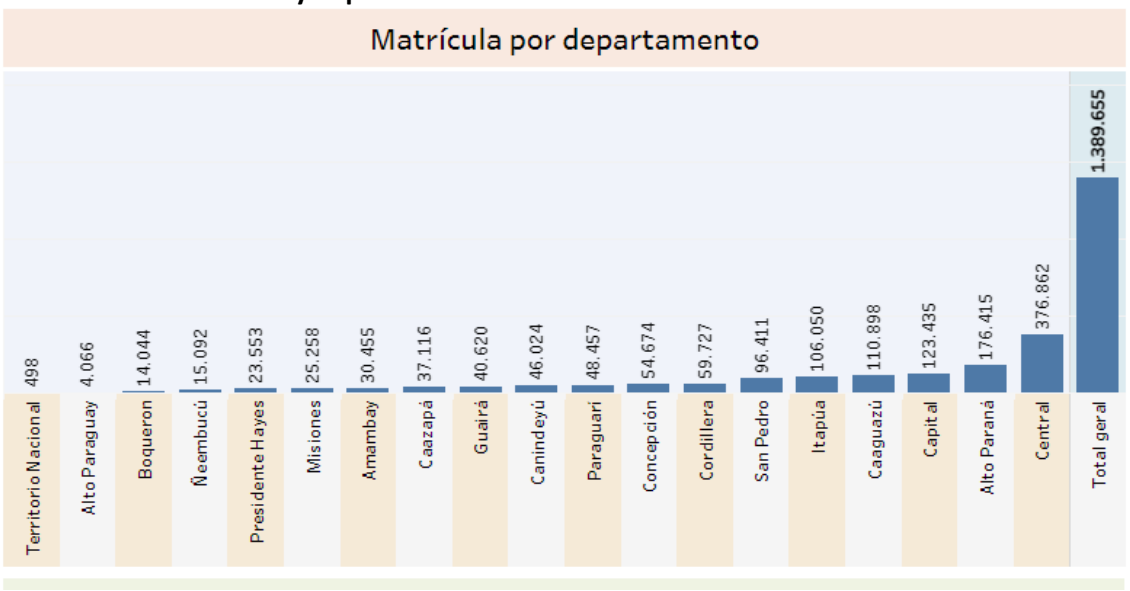
Table 5.4.1.6.2.b
Population aged 6-17 years attending a formal education institution by year, for the Central Department, by sex and type of institution attended (%), 2017 to 2019. Annual average

Type of institution / gender	Year		
	2017	2018	2019
Total	**444,713**	**437,683**	**442,696**
Public	77.0	73.3	73.9
Private	14.7	18.0	16.6
Private/ Subsidised	8.2	8.7	9.5
Men	**226,491**	**226,280**	**235,574**
Public	77.9	74.7	75.6
Private	14.9	18.0	16.1
Private/Subsidised	7.2	7.3	8.3
Women	**218,222**	**211,403**	**207,122**
Public	76.1	71.8	72.0
Private	14.5	17.9	17.1
Private/ Subsidised	9.4	10.3	11.0

Source: DGEEC Continuous Permanent Household Survey 2017 - 2019. Annual average
Note: ( ) estimate based on less than 30 sample cases, which may be considered as under-sampling.

Figure 5.4.1.6.2.a below shows the total enrolments in 2018 according to the Ministry of Education and Science, and the distribution in the different Departments of Paraguay. As can be seen, of the total enrolments for the Departments as a whole, the majority, 27%, were in the Central Department.

Figure 5.4.1.6.2.a
Number of enrolments by department



Source: https://datos.mec.gov.py/app/grafico_matriculaciones_2018.

As for Villeta, the interview data show that the municipality has 45 schools, of which 20 are urban and 25 are rural. According to the School Map of the Ministry of Education and Science[1] , the closest educational centre to the project is the Basic School N° 2872 San Juan Bautista, located in the locality of Buey Rodeo, a rural area of the municipality.

[1] https://mapaescolar.mec.gov.py/mapa_escolar/maps/index

In terms of higher education, there are the UTCD - Villeta branch and UPAP - Villeta.

A Departmental Technical College offers Technical Baccalaureate in Civil Construction, Technical Baccalaureate in Electricity, Technical Baccalaureate in Industrial Chemistry, Secondary Vocational Training in Mechatronics and Business Council.

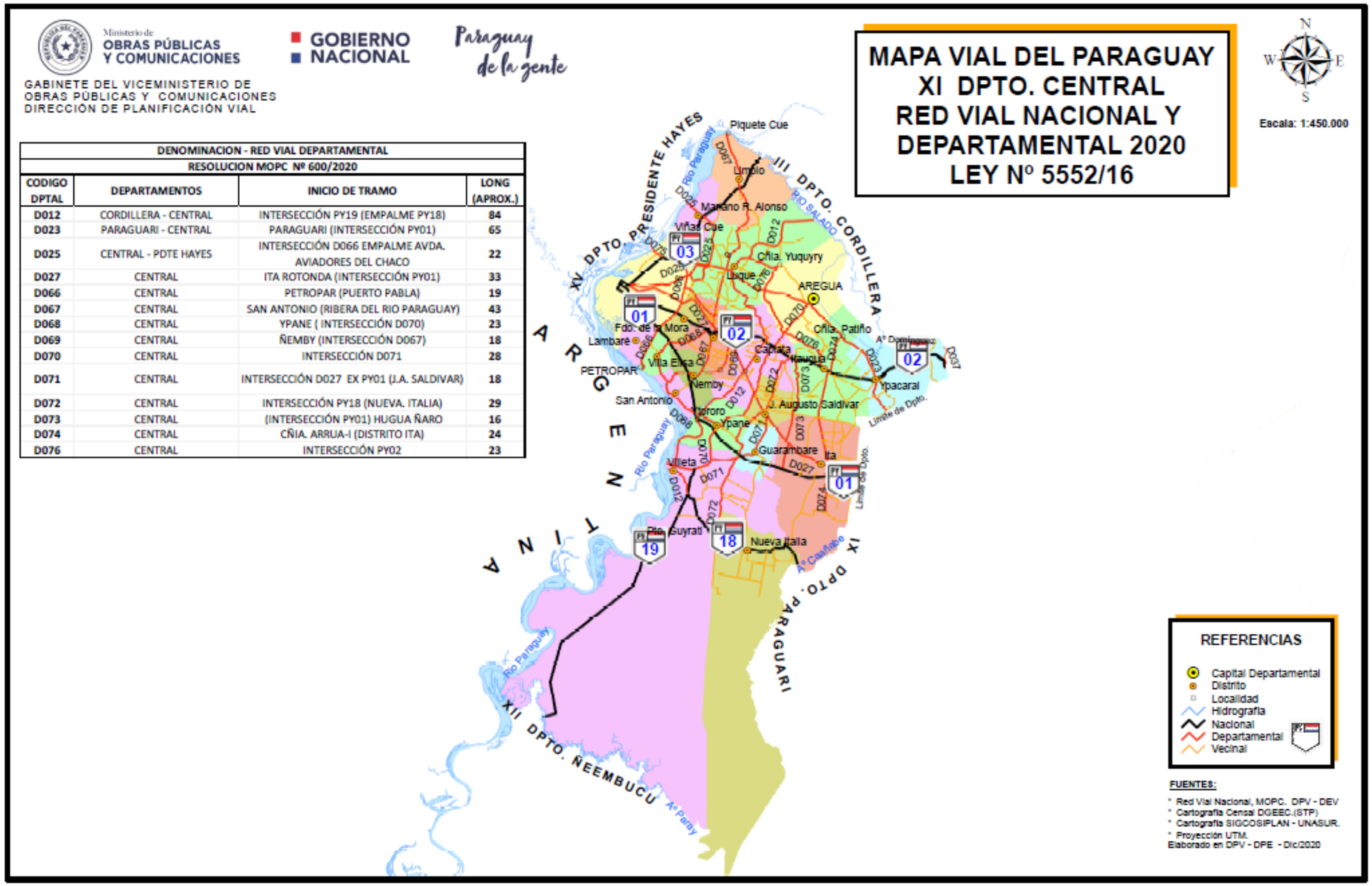
5.4.1.6.3
Transport

5.4.1.6.3.1
Road Transport

The road network of the Central Department is shown in **Figure 5.4.1.1.6.3.1.a below**.

The two main roads leading to the municipality of Villeta are National Routes PY18 and PY19.

Figure 5.4.1.6.3.1.a
Road Network Map of the Central Department - 2020



DENOMINACION - RED VIAL DEPARTAMENTAL RESOLUCION MOPC Nº 600/2020			
CODIGO DPTAL	DEPARTAMENTOS	INICIO DE TRAMO	LONG (APROX.)
D012	CORDILLERA - CENTRAL	INTERSECCIÓN PY19 (EMPALME PY18)	84
D023	PARAGUARI - CENTRAL	PARAGUARI (INTERSECCIÓN PY01)	65
D025	CENTRAL - PDTE HAYES	INTERSECCIÓN D066 EMPALME AVDA. AVIADORES DEL CHACO	22
D027	CENTRAL	ITA ROTONDA (INTERSECCIÓN PY01)	33
D066	CENTRAL	PETROPAR (PUERTO PABLA)	19
D067	CENTRAL	SAN ANTONIO (RIBERA DEL RIO PARAGUAY)	43
D068	CENTRAL	YPANE (INTERSECCIÓN D070)	23
D069	CENTRAL	ÑEMBY (INTERSECCIÓN D067)	18
D070	CENTRAL	INTERSECCIÓN D071	28
D071	CENTRAL	INTERSECCIÓN D027 EX PY01 (J.A. SALDIVAR)	18
D072	CENTRAL	INTERSECCIÓN PY18 (NUEVA. ITALIA)	29
D073	CENTRAL	(INTERSECCIÓN PY01) HUGUA ÑARO	16
D074	CENTRAL	CÑIA. ARRUA-I (DISTRITO ITA)	24
D076	CENTRAL	INTERSECCIÓN PY02	23

Source: https://www.mopc.gov.py/application/files/7116/3007/2544/11_central_mapa_vial_py-2020.pdf.

The National Route PY18 starts in Villeta and ends in the locality of Mayor Otaño. It crosses from west to east along the southern part of the Eastern Region. It has an approximate extension of 358 km and passes through 5 departments. This road connects Villeta to Nueva Italia.

National Route PY19 starts in the city of Villeta and ends in the city of Pilar, passing through Alberdi. It is a road adjacent to the Paraguay River, with an approximate length of 202 km. This is the access route to the ATOME Plant site from Villeta.

According to data from the Ministry of Public Works and Communications - MOPC, improvement works were carried out on PY19 in the Villeta km 40 - Alberdi section (**Photos 01 and 02**), with the placement of horizontal signalling and a new layer of asphalt concrete with polymers, which is a type of material whose resistance withstands deformations due to climatic factors and traffic due to the weight of vehicles. Polymer modified asphalts increase the service life of a pavement and are applied taking into account certain factors such as traffic volume and the magnitude of the loads transiting the site[2] .





Photos 01 and 02: Improvement works on PY19, section Villeta km 40 - Alberdi.

According to data from the Final Report of the Update of the Master Plan for Infrastructure and Transport Services of Paraguay 2018 - 2028, December 2020, a traffic survey carried out in two periods; 2012 and 2018, resulted in the following numbers for the Villeta - Alberdi Road (**Table 5.4.1.6.3.1.a**), in the section to be used for the Project:

Table 5.4.1.6.3.1.a
Traffic survey on the Villeta - Alberdi Route, Villeta - Villa Olivia section.

Vehicle types	Light Vehicle Flow Allocation (TPDA) - vehicles per day
Motorbikes	171
Cars	889
Bus	22
T1 (2 and 3 axles)	105
T2 (4 and 5 axles)	171
T3 (more than 5 axles)	304
Total	1,662

[2] https://www.mopc.gov.py/index.php/noticias/puesta-punto-de-la-ruta-py19-tramo-alberdi-villeta-km-40-tiene-70-de-avance and https://www.mopc.gov.py/index.php/noticias/tramo-villeta-km-40-alberdi-tiene-80-de-avance.

According to the interview data, the transport system to serve the urban and rural areas of Villeta has only the buses that go to the capital, travelling along the main routes. The industrial zone has little public transport coverage.

Motorbikes are the main means of transport for the local population.

Companies in the district have dedicated mobility systems for the movement of staff residing in Villeta and neighbouring municipalities. Workers residing in places without all-weather access, such as those in Ype Ka'e, travel on motorbikes.

The same Master Plan Update Final Report presents traffic counts for the Southern Access for a period in 2018 (**Table 5.4.1.6.3.3.1.b**). The South Access will also be used by the Project, more specifically by buses transporting workers from the Asunción Bus Station on Avenida Fernando de La Mora to the construction site.

Table 5.4.1.6.3.1.b
Traffic survey on the South Access

Vehicle types	Light Vehicle Flow Allocation (TPDA) - vehicles per day
Motorbikes	1,156
Cars	6,826
Bus	116
T1 (2 and 3 axles)	917
T2 (4 and 5 axles)	977
T3 (more than 5 axles)	1,018
Total	11,010

5.4.1.3.6.2
Inland Waterway Transport

Villeta is located on the banks of the Paraguay River, which forms part of the Paraguay-Parana Waterway.

According to Paraguay's National Connectivity Report (ECLAC, 2020), Paraguay is part of the Paraguay-Paraná Waterway Waterway Transport Agreement, which consists of 3,442 km of waterways linking 5 countries and runs from Puerto Cáceres (Brazil) to Nueva Palmira (Uruguay) (**Figure 5.4.1.3.6.2.a**). It passes through Puerto Busch (Bolivia), Asunción (Paraguay) and the ports of the Paraná River (Rosario, Zarate), Buenos Aires, Dock Sud and La Plata (Argentina), up to the maritime access of Recalada.

Paraguay is also a member of the Intergovernmental Committee of the Paraguay-Parana Waterway, the body in charge of managing the River Transport Agreement on the Paraguay-Parana Waterway signed by Argentina, Bolivia, Brazil, Paraguay and Uruguay in 1991.

According to the ECLAC document (2022)[3] , currently the rivers that make up the Paraná-Paraguay river system are transited by a fleet of more than 2000 river barges of all types (for

[3] Paraguay - Paraná Waterway: Santa Fe - Confluencia Section. Analysis of the most relevant characteristics for future decision-making. Technical assistance to the General Administration of Ports of the Argentine Republic. 2022.

bulk, dry, liquid and gaseous cargoes and containers and general cargo), propelled by vessels specially designed for this task.

According to the document "Santa Cruz de la Sierra" Agreement on river transport on the Paraguay-Parana Waterway and its additional protocols, Volume II, Regulations, of the General Secretariat of ALADI (2016), convoys in push navigation on the Waterway may not exceed a maximum length of 290 m, considered from the bow of the first barge to the stern of the last vessel. The maximum beam in this mode of navigation shall be 50 m. The engine power of the tugs must be in accordance with the displacement of the convoys and their safety, with sufficient characteristics to guarantee manoeuvrability in critical sections.

Figure 5.4.1.3.6.2.a
Paraná-Paraguay Waterway in South America



Source: ANTAQ/UFPR (2017). Prepared by UFPR/ITTI.

Conditions of the Paraguay-Paraná Waterway

The report prepared by ANTAQ/UFPR (2017) presents a diagnosis of the river infrastructures available in the Paraguay-Paraná Waterway in terms of morphological, hydrological and structural conditions at the time of the study.

Specifically for the section of the ATOME plant project of interest, i.e. from Villeta to Nueva Palmira in Uruguay, the reported conditions are as follows:

Asunción - Santa Fe section:

With an extension of 1,040 km, the section shares jurisdiction between Paraguay and Argentina, from Asunción (PRY) (km 1,630) to Santa Fe (ARG) (km 590), and contains the confluence of the Paraná River with the Paraguay River, in the vicinity of the Argentinean municipalities of Corrientes and Paso de la Patria (km 1,240).

In the vicinity of Asunción (PRY), the Remanso Castillo Bridge (**Figure 5.4.1.3.6.2.b**) is considered one of the main impediments to boat traffic, according to the Ministry of Transport (BRAZIL, Ministry of Transport, 2014[4]), and overtopping works are needed in its vicinity to improve navigability. In this region, the river has a considerable increase in width and the floodplain reaches a dimension varying between 5 and 15 km (affecting the right bank of the river). The navigation channel is deeper at some isolated points (with depths of up to 8.0 m).

Figure 5.4.1.3.6.2.b
Remanso Castillo Bridge. Obstacle to navigation on the section from Corumbá (BRA) to Asunción (PRY).



Source: ANTAQ/UFPR (2017).

[4] BRAZIL. MINISTÉRIO DOS TRANSPORTES. Bacia do Paraguai. 2014. Available at: http://www.transportes.gov.br/editoria-d/52-sistema-de-transportes/1442-baciado-paraguai.html.

In terms of the hydrological regime, floods occur between June and September, with a more recurrent peak in July, and can vary from year to year. Drought extends from October to February, with extreme levels between December and January (ANA[5] ; CPRM, 2015). [6]

Along this stretch, and already under shared jurisdiction between Brazil and Paraguay, the Paraguay River has a series of sandbanks and rocky outcrops as it approaches Asunción, which makes boat traffic difficult during the dry season. From km 2,050 onwards, the passes known as Arrecifes (km 2,048), Guggiari (km 1,940) and Passo Remanso Castillo (km 1,645) are among the main obstacles to navigation and are considered bottlenecks in the waterway, requiring dredging and overthrow works to ensure navigation (BRASIL. Ministério dos Transportes, 2014).

Regarding maintenance dredging, information was obtained from Terport that the Paraguayan Government currently has 3 contracts in force for different sections for 3 years, through a public tender administered by the MOPC.

Following the description in the ANTAQ/UFPR (2017) report, it is indicated that in the vicinity of Bahía de Asunción in Itá Punta (km 1.626), Cassacia (km 1.619), Medín (1.608), San Antonio (km 1.604), Villeta (km 1.595), Buey Muerto (km 1.591), Itá Pyrú (km 1.585) and Guyrati (km 1.581), the trains have yet to be dismantled, to the equivalent of a 2x4+1 barge composition (CSI Ingenieros, 2010).[7]

In the stretch from Asunción to Santa Fe the river is navigable for most of the time, and the depth of the navigable channel can be divided into two sub-sections. The first concentrates the stretch from km 1.630, in Asunción, to km 1.240, at the confluence of the rivers, in which the depths of the channel can vary between 3.20 and 3.95 m according to information on navigable depths from the Subsecretaría de Puertos y Vías Navegables (ARGENTINA. Secretaría de Transporte de la Nación, 2016[8]) and the technical reports presented by CSI Ingenieros (2010). The second sub-section is located between the confluence of the Paraguay-Paraná river (km 1,200) and the city of Santa Fe (km 590), where the range of depths can vary from four to seven metres.

Therefore, this section is navigated in an approved manner by 4x5 convoys, consisting of barges and pusher craft, with a capacity of up to 30,000 tonnes (**Figure 5.4.1.3.6.2.c**).

To the south of the Asunción alluvial plain (PRY) are the Mesopotamian plains (Ribeira plain, between the Paraguay and Paraná rivers). In addition to being part of the Argentinean plains with small altimetric differences, the Corrientes plains present a special alternation of levels and forms with a notable physiographic impact.

According to the Intergovernmental Committee of the Paraguay-Paraná Waterway (CIH, 2016[9]

[5] ANA. AGÊNCIA NACIONAL DE ÁGUAS. Hidroweb System. Hydrological Information Service. Available at: http://www.snirh.gov.br/hidroweb/.

[6] CPRM. COMPANHIA DE PESQUISA DE RECURSOS MINERAIS - SERVIÇO GEOLÓGICO. Previsão Hidrológica e Alerta de Enchentes Pantanal MatoGrossense. Available at: http://www.cprm.gov.br/.

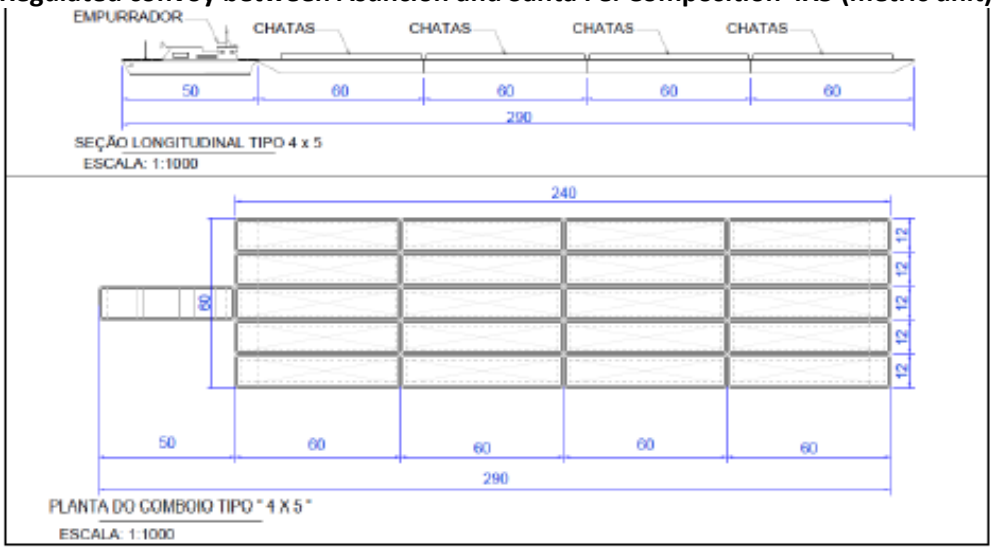
[7] CSI ENGINEERS. IDB/MIF Project. Study of the River Transport System for Grain and Processed Products on the Paraguay - Parana Waterway. 2010. (Final Report).

[8] ARGENTINA, Secretariat of Transport of the Nation. Undersecretary of Ports and Waterways. Information on navigable routes. 2016b. Available at: http://www.sspyvn.gob.ar/sspyvn/.

[9] CIH. COMITÊ GOVERNAMENTAL DA HIDROVIA PARAGUAI-PARANÁ. Available at: http://cicplata.org/?id=hpp_mi.

), dredging of this section is carried out in order to maintain a minimum navigable depth of 3.65 m.

Figure 5.4.1.3.6.2.c
Regulated convoy between Asunción and Santa Fe. Composition 4X5 (metric unit)



Source: ANTAQ/UFPR (2017). Prepared by UFPR/ITTI.

Downstream of the municipality of Corrientes (ARG), the Paraguay-Paraná Waterway increases in number of branches in the main channel, characterising a meandering fluvial evolution. The presence of sand banks formed by its own alluvial deposits and the presence of extensive flood plains are the result of the various lateral contributions of the basin, such as the Porteño River, the San Hilario River, the Komare River, the Cortapik River, the Payagua River, the Bermejo River, the Pilcomayo River, the Río de Oro and the Negro River, predominantly on the right bank of the Waterway.

As for artificial obstacles, the Chaco-Corrientes Bridge (General Manuel Belgrano Bridge) crosses the waterway after the confluence of the Paraguay and Paraná rivers, but without imposing restrictions on vessels during its passage (**Figure 5.4.1.3.6.2.d**). Even so, maritime regulations in this section require that both day and night navigation, in both directions, be carried out through the channel marked between abutments 5 and 6, with crossings and overtaking prohibited in the 1,000 m downstream and upstream of the bridge (BRASIL. Ministério dos Transportes, 2014).

The most recent ECLAC Report (2022) presents the diagnosis of the section "Asunción (km. 1630) - Confluencia (km. 1238), in which it is reported that in this segment navigation is carried out with convoys of up to 20 barges and almost all year round with a maximum draught of 10 feet. The traffic upstream to Asunción has the component of container and general cargo ships and barges, and when the river provides sufficient depth, general cargo ships of greater draught are added. In this section, for which no date has yet been set for dredging and beaconing work, the low seasonal heights of the Paraguay River between October and February are critical, with navigation being interrupted for more than a month at times of high demand for goods destined for year-end consumption.

Figure 5.4.1.3.6.2.d
General Manuel Belgrano Bridge, between the Provinces of Chaco and Corrientes.



Source: IFC (2016).

The Confluencia (km. 1240) - Santa Fe (km. 584) section, in turn, has a series of critical crossings, which, in their current state, force navigation to be interrupted at night, especially for convoys with a larger number of barges. There are no rock formations in its bed, so that groundings are not very burdensome for the vessels, although they punish the main channel and cause less damage to the environment. Its race presents rapid changes in certain passages, with similar instability characteristics to the Asunción - Confluencia section.

According to the ECLAC document (2022)[10] , north of Confluencia (km. 1,244 of the Paraná River) specially designed vessels need to adapt their drafts to the shallow depths provided.

In the case of container traffic, barges have capacities of between 150 and 500 TEUs (TEU *Twentyfoot Equivalent Unit*) and container traffic is increasing in line with the growth of container traffic worldwide. The average draughts used north of Santa Fe are approximately 3.10 m, but these cannot be used all year round due to seasonal lows in the period from October to January, which particularly affect traffic from Confluencia to the north, the area from which the greatest flow of cargoes is generated in the downstream direction.

The main economic activity is associated with primary productions such as grains and minerals. One of the most outstanding qualities of the traffic on the section of the Paraná River extending from Santa Fe (km. 584) to Confluencia (km. 1244), is that most of the goods transported have the characteristics of through cargo, since, although they transit this section in its entirety, they are loaded, transhipped and unloaded in ports of origin and destination located outside the limits of the same. Most of this cargo comes from ports located on the Paraguay and Alto Paraná rivers, and travels by downstream navigation to destination and/or transhipment ports in Argentina and Uruguay. This particularity makes it difficult to obtain statistical data of all kinds, due to the fact that there is no centralising body for information on the activity within the Paraguay-Parana Waterway system.

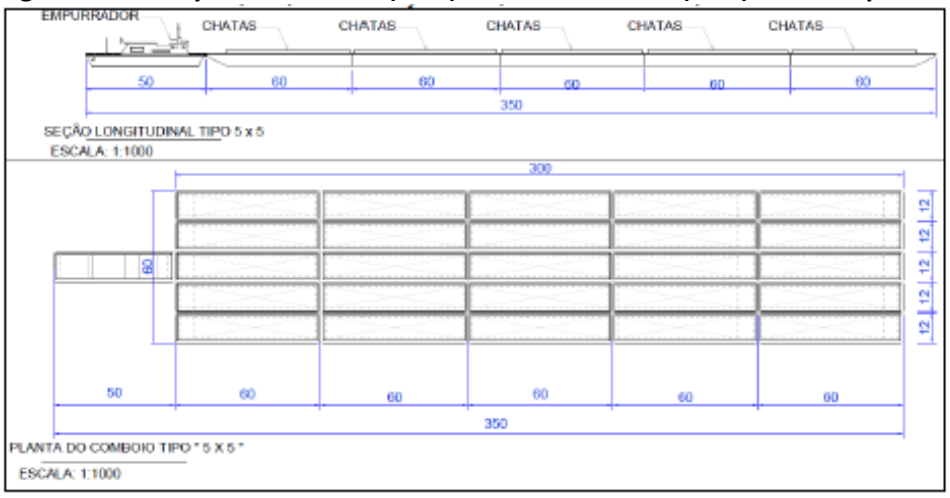
[10] Paraguay - Paraná Waterway: Santa Fe - Confluencia Section. Analysis of the most relevant characteristics for future decision-making. Technical assistance to the General Administration of Ports of the Argentine Republic. 2022.

Santa Fe to Nueva Palmira section:

This section begins the fluvial-maritime portion of the Paraguay-Parana Waterway, starting in the city of Santa Fe (ARG) (km 590) and extending for 590 km to the city of Nueva Palmira (URY) (km 0). Along this route, maritime vessels can enter the different ports located on the Paraná River. The best navigation conditions in relation to the depths of the navigable channel are found along this stretch. According to the daily depth bulletins of the Subsecretaría de Puertos y Vías Navegables (ARGENTINA. Secretaría de Transporte de la Nación, 2016), depths range between 7 and 10 m between Santa Fe and San Martín, and between 10 and 12 m between San Martín and the city of Nueva Palmira (URY).

Due to the port distribution, this section can be subdivided into four sub-sections, namely: Santa Fe - San Martin; San Martin - Ibicuy; Ibicuy - Nueva Palmira; and Nueva Palmira - Montevideo. The best navigation conditions allow the traffic of 5x5 formation convoys with a capacity of up to 40,000 tonnes (**Figure 5.4.1.3.6.2.e**).

Figure 5.4.1.3.6.2.e
Regulated convoy from Santa Fe (ARG) to Nueva Palmira (URY). 5x5 composition (metric unit)



Source: ANTAQ/UFPR (2017). Prepared by UFPR/ITTI.

According to the technical report prepared by CSI Ingenieros (2010), between San Martín (km 447) and Nueva Palmira, navigation is possible on two additional stretches, namely:

- At the mouth of the Paraná Guazú and Paraná Bravo rivers, through which convoys of 50 m wide and 290 m long pass;
- By the Playa Honda canal, with maximum permitted dimensions of 50 m wide and 236 m long.

With regard to the hydrological characteristics of this region, we can observe the incidence of shallow depths due to the aggravation of the sedimentation process and the geomorphological characteristics of the river system. In addition, the Paraná River receives several tributaries and at its mouth in the Atlantic Ocean forms a delta with the following river systems: Paraná das

Palmas, Paraná Pavón, Paraná Ibicuy, Paraná Bravo, Paraná Guazu and Paraná Miní (PRENDES *et al*., 2015). [11]

The Raúl Uganda-Carlos Begnis underwater road tunnel, 7.50 m wide and 3 km long, built in the 1960s, is located in the urban region of Santa Fe. Monthly monitoring campaigns are carried out by means of bathymetric soundings and GPS surveys in the section 500 m upstream and downstream of the tunnel in order to determine the amount of sediment in the vicinity of the construction site and to identify the dynamics of the dunes and the main channel in the region (TÚNEL SUBFLUVIAL, 2016). [12]

As for the structural works present in this section, mention should be made of the Nuestra Señora del Rosario cable-stayed bridge, located at km 420, in the Argentinean municipality of Rosario. Over the Paraná River, it has an approximate length of 4,100 m and a free span of 300 m for the passage of vessels (**Figure 5.4.1.3.6.2.f**).

In the vicinity of the Argentinean municipality of Zárate, in the province of Buenos Aires, is the General Bartolomé Mitre Road and Railway Bridge, over the Paraná-Guazú tributary, which links the provinces of Buenos Aires and Entre Ríos along a construction of approximately 1.7 km in length, with a free span for the passage of convoys of approximately 300 m (**Figure 5.4.1.3.6.2.g**).

According to CEPAL (2022), the Santa Fe (km. 584) - Nueva Palmira (km. 140) section, concessioned for maintenance of beaconing and dredging, is transited by overseas vessels, with drafts exceeding 34 feet, and has almost all the transhipment ports. The Paraná River has no rocky formations that could be dangerous for navigation. One of the important characteristics is that it has a certain instability in its course. At present it has modern beaconing and there has been a notable development of new terminals.

[11] PRENDES, H. H., José; HUESPE, J.; MANGINI, S. P. Navigation channels Design in Argentine Inland Waterway. SMART RIVERS Conference. Buenos Aires, [2015].
[12] SUB-FLUVIAL TUNNEL. Available at: http://www.tunelsubfluvial.gov.ar.

Figure 5.4.1.3.6.2.f
Our Lady of the Rosary Bridge



Source: ARQHYS ARQUITETURA (2016).

Figure 5.4.1.3.6.2.g
General Bartolomé Mitre Bridge



Source: BAFILM (2016)[13] .

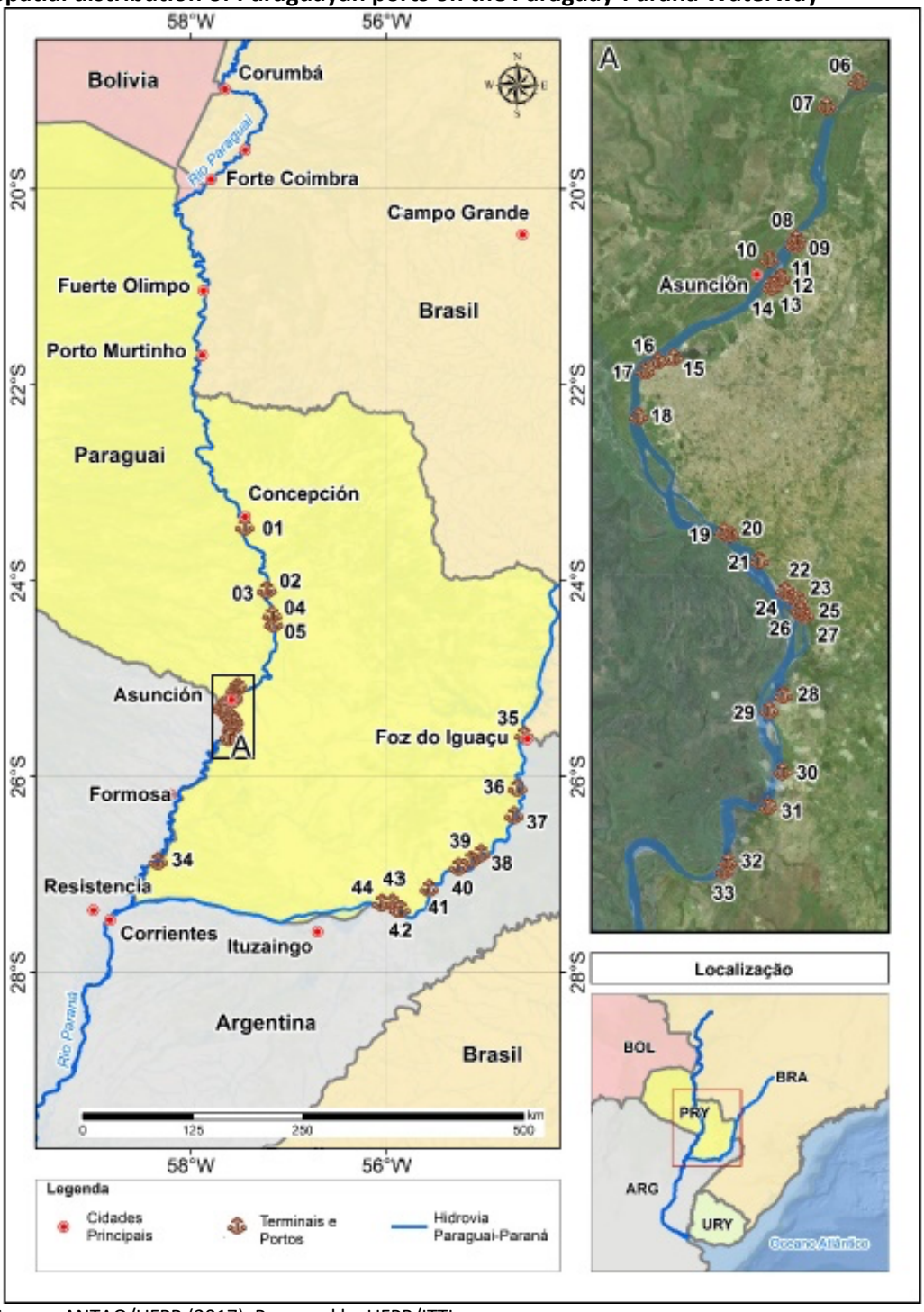
Ports

According to the ANTAQ/UFPR (2017) report[14] , within the 918 km that the Paraguay-Paraná Waterway runs through Paraguayan territory, 44 ports and terminals have been identified, of which 34 are located on the Paraguay River and 10 on the Paraná River (upstream of the

[13] BAFILM. Zarate Brazo Largo Bridge. Available at: http://www.bafilm.com.ar/locacion/zarate/131-puente-zarate-brazo-largo.
[14] ANTAQ/UFPR. Study of the regulatory practice, competitive advantages and supply and demand of cargo between the signatory countries of the Paraguai-Paraná Waterway Agreement. Produto 2 - Diagnóstico da Infraestrutura da Hidrovia Paraguai-Paraná e Base de Dados Georreferenciada. 2017.

Paraguay-Paraná confluence), as shown in **Figure 5.4.1.1.3.6.2.h**. The largest concentration of ports and terminals is in the vicinity of Asunción, with 20 facilities along approximately 40 km.

Figure 5.4.1.3.6.2.h
Spatial distribution of Paraguayan ports on the Paraguay-Paraná Waterway



Source: ANTAQ/UFPR (2017). Prepared by UFPR/ITTI.

The closest to the planned construction site of the ATOME plant are:

Nº in Figure 5.4.1.3.6.2.h	Port
27	Terminal Portuario S.A. (TERPORT S.A.)
28	Porto San Antonio II (Concrete Mix II)
29	Porto Seguro Fluvial S.A.
30	Complexo Agroindustrial Angostura S.A.
31	Port Terminals and Logistics S.A. - TLP
32	Porto Custodia
33	Villeta port region

The production of CAN fertiliser from the ATOME plant will be transported through the TERPORT S.A. Port Terminal, a private port operating mainly with containers, Group 1, Category CG (general cargo).

Terport is the most modern container terminal of the Paraguay-Paraná Waterway, located at km 13.5 of the national route PY19 Villeta - Alberdi and at km 1,578.5 of the waterway, 4 km south of Ita Piru and Guyrati. It has an area of 170 hectares. Terport has been operating since 2002 in San Antonio, but the construction of the Villeta Port Terminal started in 2015 and was completed in 2018. TERPORT offers services as a container port terminal operator, roll-on/roll-off (Ro-Ro) cargo, general cargo on the waterway, including storage, loading and unloading of vessels, inland and multimodal transport, handling of general and containerised goods as well as special cargo operations (Terport's official website[15] ; Mundo Marítimo - All the Maritime Information of Latin America).[16]

In terms of infrastructure, Terport has a 200 m long and 31 m wide quay and a 1,800 m warehouse[2] with 9 m high. In total, it handles 90,000 TEUs of empty and full containers per year. This corresponds to more than 50% of the total container traffic in Paraguay. The port terminal has 20 hectares of 320 m frontage on the Paraguay River, and 150 hectares that will be destined for a future logistics park. The wharf is 200 m of concrete. It has two mooring dolphins. It also has metallic fenders with conical rubber shock absorbers, a container yard with a capacity of 8,500 TEUs, 350 sockets for refrigerated containers, 60 sockets for Pre-Trip of refrigerated containers and emergency generators. The terminal operates under the Customs Warehouse regime, with a customs sub-administration under the Terport Administration.

The equipment available guarantees the smooth and efficient operation of all the operations carried out, including: 2 Liebherr FCC 45/38 cranes, *Reachstackers*, 2 RTG Kone and Forklifts from 2.5. to 10 t.

The Terminal is qualified to store agrochemicals according to the technical standards of the Food and Agriculture Organisation of the United Nations (FAO) (TERPORT, 2016 *apud* ANTAQ/UFPR, 2017).

According to information obtained in consultation with Terport, the travel time by waterway from the port in Villeta to the port in Uruguay is 5-6 days downbound and 7-8 days upbound.

[15] http://www.terport.com.py/es/villeta.
[16] https://www.mundomaritimo.cl/.



Photo 03: View of the TERPORT container yard (Source: Terport official website).

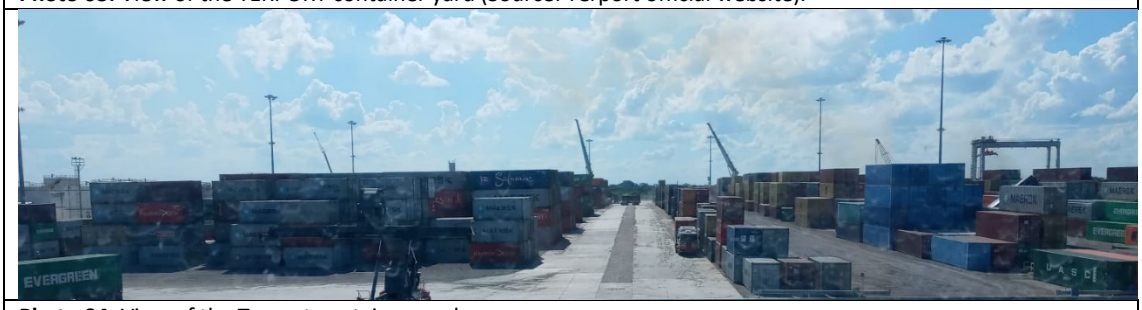


Photo 04: View of the Terport container yard.



Photo 05: View of the Terport quay (Source: Terport official website).



Photo 06: View of the lorry parking area.

5.4.1.7
Social Organisations

According to interviews conducted for the ESIA, in Villeta there are organised groups working with the Food and Agriculture Organisation of the United Nations (FAO), writers' association, professional and sports fishermen's association, factory unions, and sanitation boards.

The NGO Crecer advocates for the protection of children's rights in the municipality. It is a partner of the Alda Foundation and Global Infancia.

The factories have trade unions whose scope of action is limited to the respective companies. Neighbourhood committees are registered with the municipality.

No mention was made of any areas invaded by social movements. On the other hand, there is information that the inhabitants of old settlement localities are critical of the rice producers and factories that discharge their effluents into the river, and they propose an inspection of compliance with the applicable norms.

5.4.1.8
Indigenous Populations

To verify the existence of indigenous communities or villages in the vicinity of the ATOME plant project, the geographical bases of the Instituto Paraguayo del Indígena (INDI) and the Federación por la Autodeterminación de los Pueblos Indígenas (FAPI) were consulted.

Figure 5.4.1.8.a below shows that according to these sources there are no indigenous communities close to the Project. The closest indigenous people live in urban communities located in the urban area of Asunción and in the neighbouring city of Luque (see details 1 and 2 in **Figure 5.4.1.8.a**). The closest is the Cerro Poty community , in the Jukyty neighbourhood of Asunción, about 42 km from the ATOME plant site. The indigenous people are of the Ava Guarani ethnic group.

Figure 5.4.1.8.a
Indigenous communities in relation to the Project

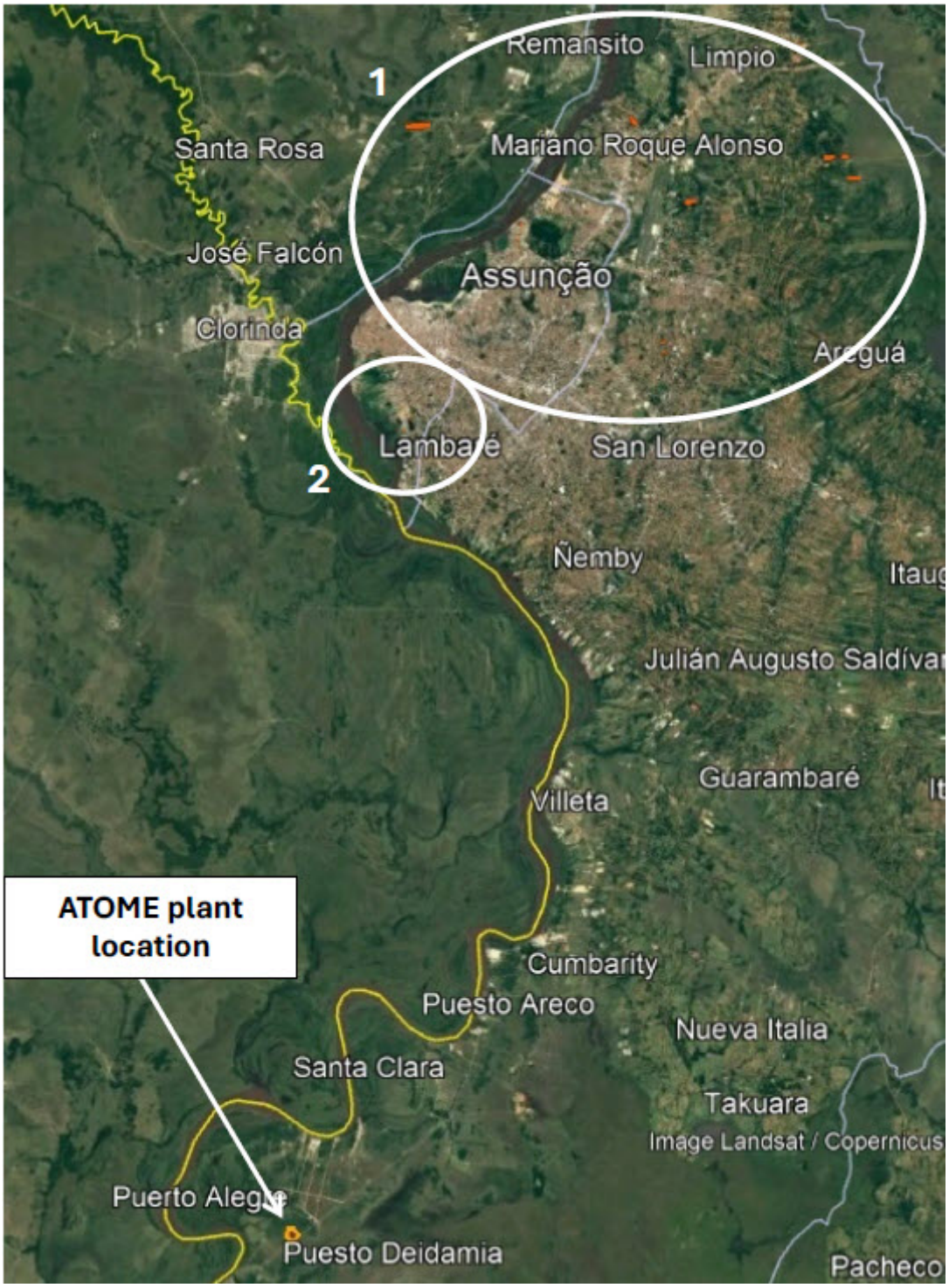


Figure 5.4.1.8.a
Indigenous communities in relation to the Project
Detail 1



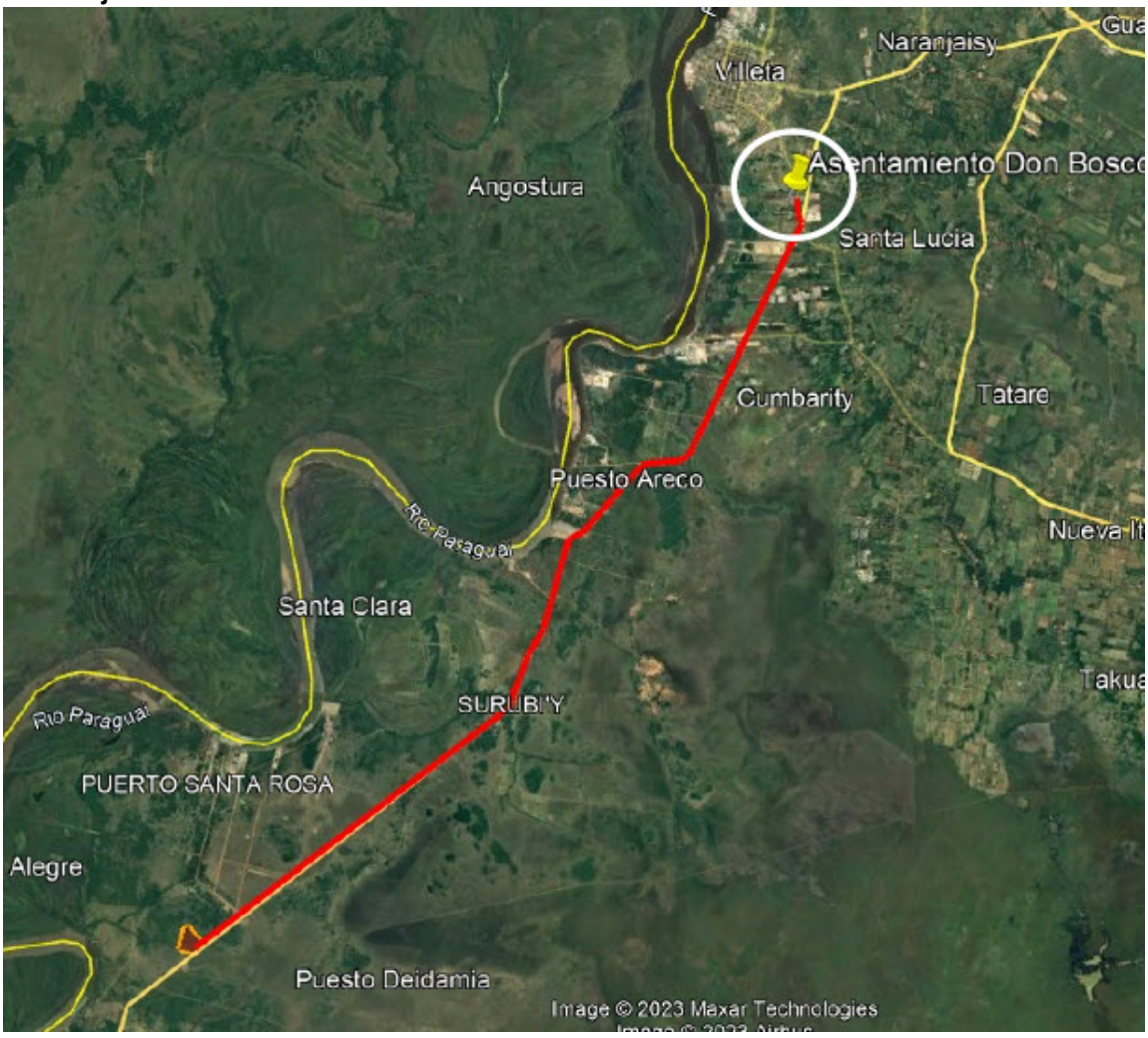
Detail 2



Source: Instituto Paraguayo del Indígena and Federación por la Autodeterminación de los Pueblos Indígenas (FAPI).

During a fieldwork interview, however, the presence of a small Ava Guaraní community in the Don Bosco settlement of Villeta was mentioned. The search for information on this community revealed that it is in fact the Takuapumirî community, of the Mbya Guaraní ethnic group, located in Guasu Corá, and distant about 26 km from the ATOME Project by road (see **Figure 5.4.1.8.b**). The coordinates of the Don Bosco Settlement or Don Bosco Social Territory, where the indigenous community is located (P1 - 445,048 m E and 7,175,415 m S; P2 - 445,027 m E and 7,175,613 m S - see Detail **Figure 5.4.1.8.b**), were obtained from the Ministry of Urbanism, Housing and Habitat (MUVH) of Paraguay[17] .

Figure 5.4.1.8.b
Location of the Ava Guaraní indigenous community of the Don Bosco Settlement in relation to the Project.



[17] https://www.muvh.gov.py/sitio/wp-content/uploads/2021/09/IM-P02-08-FONAVIS.pdf

Detail



According to the information found at[18] , the community is made up of a total of 33 families, including children, young people and adults. The Takuapumirî community subsists on handicrafts, some family farming and contributions from citizens, and does not receive support from INDI. Wood carving is one of the forms of subsistence of the community, making various shapes and figures of animals, with emphasis on species that are in danger of extinction.

As can be seen in **Figure 5.4.1.8.b**, the Don Bosco Settlement where the indigenous people live is located in the urban expansion area of Villeta, neighbouring the Sol Naciente settlement. It is far from the ATOME Project, but relatively close to the Villeta - Alberdi Road, which, along this stretch, will be used by the Project during the construction and operation phases by the buses that will transport the workers. Although its boundaries are about 220 metres from the Ruta Villeta - Alberdi, this community will not be directly impacted by the Project, as it is located on the margins of the Ruta Villeta - Nueva Italia, parallel to the Ruta Villeta - Alberdi (see Detail **Figure 5.4.1.8.b**).

In any case, this community will be part of the stakeholders to be informed of Project activities as part of the Project's Stakeholder Engagement Programme.

[18] https://tucronista.com/news.php?slug=comunidad-ind-gena-takuapumir-de-villeta-solicita-atenci-n-al-indi

5.4.1.9
Archaeological and Cultural Heritage[19]

5.4.1.9.1
Study Methodology

The working method for the study of the presence of archaeological and historical features in the study area (30 hectares of the Plant's land) was developed in two stages: the first was a review of secondary information and accounts of battlefield archaeology, trying to locate areas and/or sites with field information and identification of archaeological features.

The second stage consisted of fieldwork in March 2023, with a walk-over of the ATOME Plant site area and a review of areas of potential human presence and/or modification.

5.4.1.9.2
General Appreciations - Historical Context

The construction area of the Project is located in Villeta, site of an emerging economy and service and food supply enterprises. It is considered the industrial and port city of the country, located 28 km from Asunción and connected by National Route PY01. It was formerly known as the city of oranges.

Since past times, the site was a port for the supply of agricultural products, and known for the quantity of oranges produced and supplied to the ships, where the Naranjeras de Villeta were the workers from sunrise to sunset and model of the Paraguayan woman (**Figure 5.4.1.9.2.a**). In this context, on 24 February each year they are remembered on the Day of the Paraguayan Woman, who since the Great War has gained prominence for her selflessness and loyalty, a woman who spared no effort to defend Paraguay.

Founded on March 5th 1714 by the then Governor of the Province of Paraguay Juan Gregorio Bazán de Pedraza with the name "San Felipe Borbón en el Valle de Baztán" with the objective of the Spanish territorial expansion from Asunción and protection of the interests against the Indians coming from the Chaco. During the government of Dr. Francia, it became an important guard post and a communication channel with the outside world, thus enabling the development of the district.

During the War of the Triple Alliance, after vacating the defence on the Tebicuary River, Francisco Solano López, as the best defence zone in September 1868, settled in the Cumbarity Company in Villeta and set up his headquarters on the north side of the Pikysyry stream.

19 ARCHAEOLOGICAL HERITAGE: Part of the Cultural Heritage made up of movable and immovable assets that belong to cultures or ways of life prior to the present day, and whose study usually requires specific methodologies, mainly prospecting, excavation and stratigraphic analysis, as they are mostly hidden or even buried. CULTURAL OR HISTORICAL HERITAGE: The movable, immovable and intangible assets that we have inherited from the past and that society has decided are worth preserving as its signs of identity.

Figure 5.4.1.9.2.a
Villetan orange trees



A frontal attack by the Allies against the fortification at Pikysyry, a division would remain in the south holding the Paraguayan positions and a naval division would try to force the Angostura pass and land troops in the north, closing the encirclement. This plan came to fruition on 4 December 1868 with the crossing of the river by the three imperial corps towards the city of San Antonio, since with the exception of Villeta there were no other fortifications on the riverbanks.

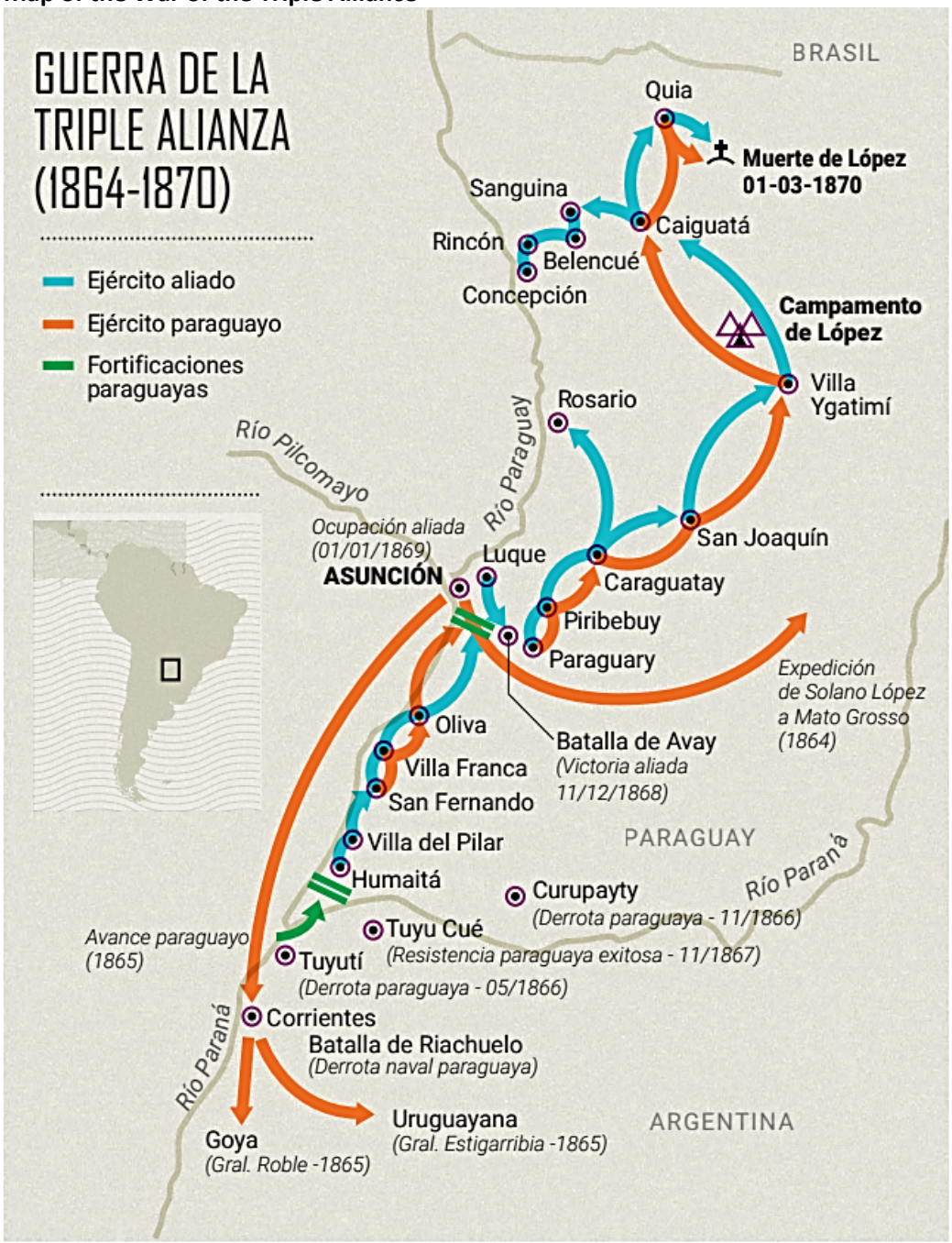
With the forced change of front, López sent a force commanded by Bernardino Caballero where on 6 December at the Ytororõ bridge they faced the Empire's troops, which, after heavy casualties on both sides, the Paraguayan men retreated towards Villeta without being pursued. López, thinking of the vanguard, ordered Caballero to make another manoeuvre before Lomas Valentinas, this time on the southern bank of the Avay stream, which was a bad decision due to the open terrain and the shallow waters compared to those of Ytororõ. The battle was fought on 11 December in the midst of a storm that rendered the Paraguayans' flintlock rifles unusable, leaving them to use bayonets and machetes as weapons. The casualties among the Paraguayan troops were 3500 dead and more than 1000 prisoners (many of them later presumed dead, including a large number of children). "That was not a battle but a horrible butchery". José Ignacio Garmendia (1841-1925).

These events and narratives consider the area of Villeta as an archaeological site[20] of battlefields, where these events are still present in the collective memory, it is also a site of study for historians, and has monuments to martyrs who fell. It was a war against Paraguay carried out by

20 ARCHAEOLOGICAL SITE: Concentration of archaeological remains (parts, ruins or sets of objects) on and/or under the surface of the earth or on the submarine platform of its jurisdictional waters or on the bottom of rivers and/or lakes, which shows the human activity developed in the past, in a determined space or place, considering that they are in a context of disuse and that they reflect a way of life that no longer exists today.

the Triple Alliance (see **Figure 5.4.1.9.2.b**), made up of the Brazilian Empire, the centralist government of Argentina and the faction of the Colorado faction of Uruguay.

Figure 5.4.1.9.2.b
Map of the War of the Triple Alliance



The Allies were supported diplomatically and financially by Britain. Paraguay, which had developed its own industry thanks to an agrarian reform policy that gave land to the peasantry, was supported by the caudillos of the Argentine interior and the Uruguayan whites. The Colombian government also gave diplomatic support to the Republic of Paraguay.

5.4.1.9.3
Field Surveys

The field surveys have been carried out with archaeological walks and surface archaeological prospection[21] through transects, supported by drone imagery at sites that are difficult to access (**Figure 5.4.1.9.3.a**).

Two distinct vegetation areas were identified: Flooded *Copernicia alba* hydromorphic savanna, located in the lower areas of the terrain (developed on mostly clay soils) and the Semi-deciduous Sub-humid Forest Island (developed on clay loam soils, in higher areas of the terrain and subjected to periodic flooding) (**Figures 5.4.1.1.9.3.b, 5.4.1.9.3.c and 5.4.1.9.3.d**).

21 ARCHAEOLOGICAL PROSPECTION: Excavation with archaeological methodology by means of boreholes and/or borings in order to discover one or more archaeological sites in terrestrial and subtidal environments. This activity requires the authorisation of the SNC for its execution.

Figure 5.4.1.9.3.a
Sampling and walkover zones in the study area (March, 2023)

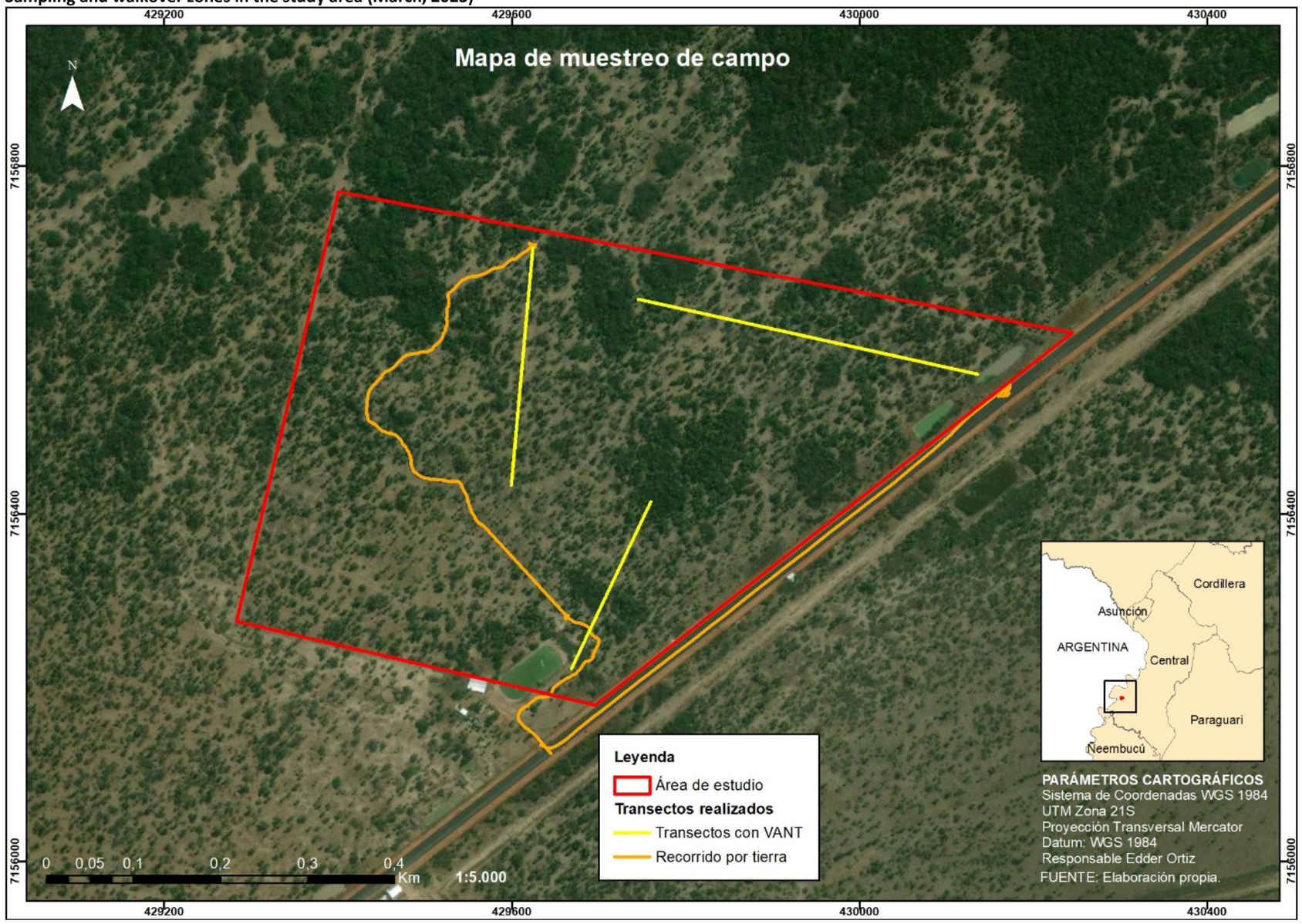


Figure 5.4.1.9.3.b
Archaeological surface walks and surveys in forest area or island Sub-humid Semi-deciduous forest



Figure 5.4.1.9.3.c
Archaeological surface surveys and prospection in savannah palm groves



Figure 5.4.1.9.3.d
Archaeological surface survey in palm savannah and semideciduous sub-humid forest islands



5.4.1.9.4
Process Results and Recommendations

As these are sites where literature and collective memory refer to battlefields of the Great War, the potential cultural elements to be found in the earthworks for the construction of infrastructure and services would be given by ballistic elements (rifles, bayonets, and bullets, among others), carriages supplying inputs, skeletal remains and others. On the other hand, being close to the Paraguay River (2 km from the study area), potential fishing sites of native peoples are considered, where it is possible to find burial mounds of camp sites.

No cultural elements or vestiges were found during the visits, due to the vegetation formations present, in addition to the changes in land use and removal. However, areas of potential human use were visualised. As this is a verification, excavations cannot be carried out without permission from the enforcement authority.

Understanding that these cultural elements could only be found in earthworks, they are considered "fortuitous findings"[1] , for which we present the steps to follow at the time of work, all framed in the Cultural Heritage Law (3.051/2006)[2] and its Resolution SNC N° 1104/2019 "which approves the National Protocol of Preventive Interventions for Archaeological and Palaeontological Heritage"[3] , where all infrastructure works in places and sites with historical background and scientific research reference must implement the aforementioned standard.

The ATOME plant construction project will include archaeological monitoring during the construction phase to assess the magnitude of potential fortuitous finds and, if necessary, to draw up a Preventive Archaeology Action Protocol[4] , in order to take the necessary steps to safeguard fortuitous finds.

One of the immediate actions to be taken at the start of the earthworks will be archaeological monitoring[5] as indicated by the cultural safeguard, who will evaluate the archaeological potential[6] and recommend the steps to be taken, and will induct the technicians and site operators, in order to safeguard the integrity of the archaeological entities found, in the process of the scheduled works. These measures are described in the ESMP, in **Chapter 7.0**.

1 ARCHAEOLOGICAL FIND: Archaeological remains or evidence found on or below the surface of the land or on the underwater shelf and rivers.
2 http://www.cultura.gov.py/wp-content/uploads/2017/12/LEY-3051-2006.pdf
3 http://www.cultura.gov.py/wp-content/uploads/2022/03/Regimen-Normativo-Cultural.pdf
4 PREVENTIVE ARCHAEOLOGY: Set of actions, mainly administrative, aimed at avoiding the negative impact of works or earthworks on archaeological and historical sites.
5 ARCHAEOLOGICAL MONITORING: Permanent supervision of any earthworks by an archaeologist in order to identify in a timely manner the existence of archaeological assets at risk and to avoid their destruction.
6 AREAS WITH ARCHAEOLOGICAL POTENTIAL: these are sectors that either by their geographical characteristics or by the presence of some known archaeological sites, allow inferring the possibility of archaeological findings in the specific area of the project, even if the visual inspection and background check do not indicate the presence of an archaeological site in that place, but in the surrounding area (e.g. proximity to historic centres, coastal areas, streams, among others).

5.4.2
Area of Direct Influence

5.4.2.1
Land Use and Land Occupancy

In **Section 5.3.1.2** of the Biotic Environment, **Map 5.3.1.2.a - Vegetation Cover and Land Use Map** was presented, with the results of the mapping of the vegetation cover and land uses in the Area of Direct Influence (AID) of the ATOME Plant, focusing mainly on the classification of the phytophysiognomies of the vegetation. This Section presents the characteristics of the anthropic uses of the Project's AID.
Map 5.3.1.2.a and the following **Figure 5.4.2.1.a** and respective Photos show the delimitation of the AID, where it can be verified that the region is very unoccupied, with the use of the Plant's surroundings basically composed of native Savannah and Forest vegetation and areas of cultivation and pasture.

The cultivation areas are located on the opposite bank of National Route PY19 to the bank where the Project site is located, and consist of large areas of rice plantations irrigated with water pumped from the Paraguay River and brought to the plantations through canals.

On the same side of the road is ANDE's Buey Rodeo substation (**Photo 01**), which will supply power to the plant. Around the ES there are two existing TLs, the 2x220 kV Guarambaré - Buey Rodeo TL, with metal structures, and the 66 kV Buey Rodeo - Villeta TL, on concrete poles (**Photos 02 and 03**), which will be crossed by the 220 kV TL to be deployed as part of the Project. The aforementioned rice plantations are crossed by the 220 kV TL (see **Photos 02 to 04**).

Next to the SE are areas of grassland, in mosaic with areas of savannah.

On the same side of the road as the Plant's land, the predominant use corresponds to savannah areas, with fragments of sub-humid forest. On the roadside and adjacent to the Plant's land, there is a property with silvopastoral uses (**Photo 05**), as will be seen in the profile described in **Section 5.4.2.**2 below.

As mentioned in **Table 3.1.1.2.b**, **Section 3.1.1.2**, the ATOME Plant site area is occupied by hydro morphic savannas wooded with black palm or Karanda''y (*Copernicia alba*) and forest islands, with recent livestock use (**Photos 06 to 08**). There is a cut (**Photo 09**) formed by the exploitation of borrow material for road works, almost entirely within the Plant site and with a small part located on neighbouring land (see detail in **Figure 5.4.2.2.a** in the following Section).

The IDA also includes National Route PY19, which is asphalted and in good traffic conditions, with traffic signs and the presence of a hard shoulder (**Photos 10 and 11**).

Figure 5.4.2.1.a
Land use and occupation in the AID

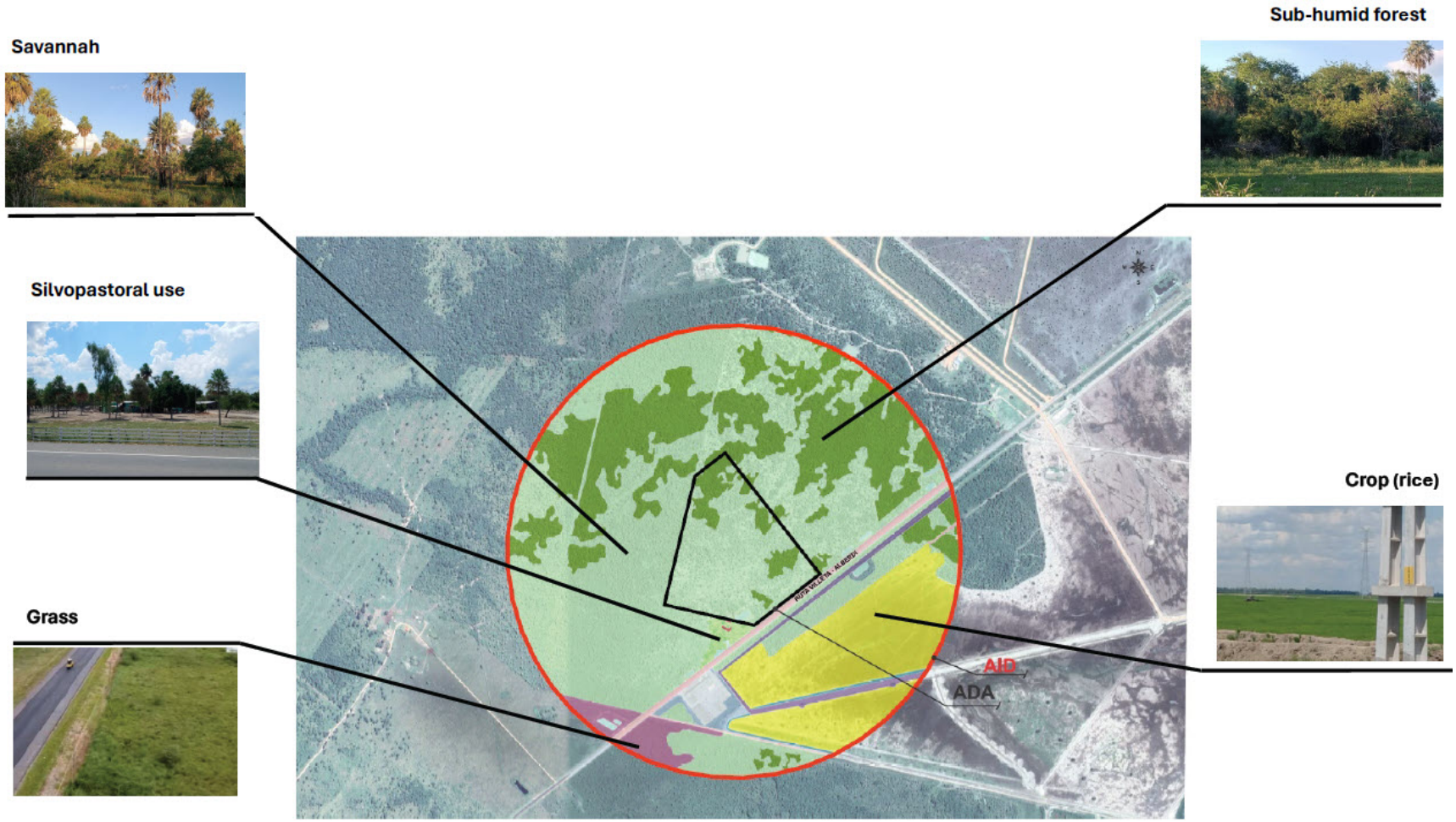
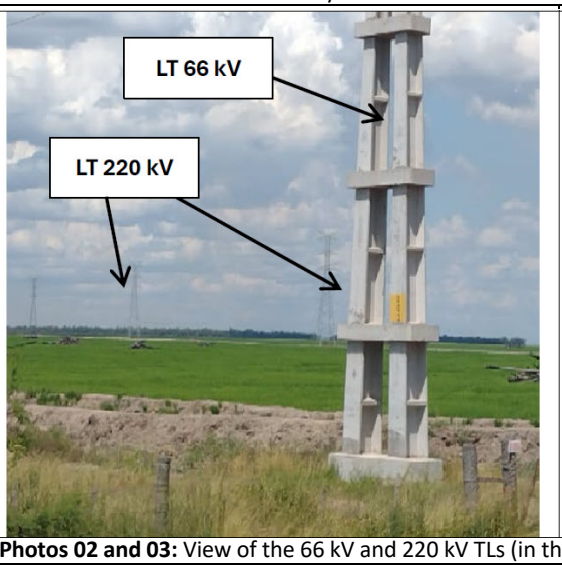
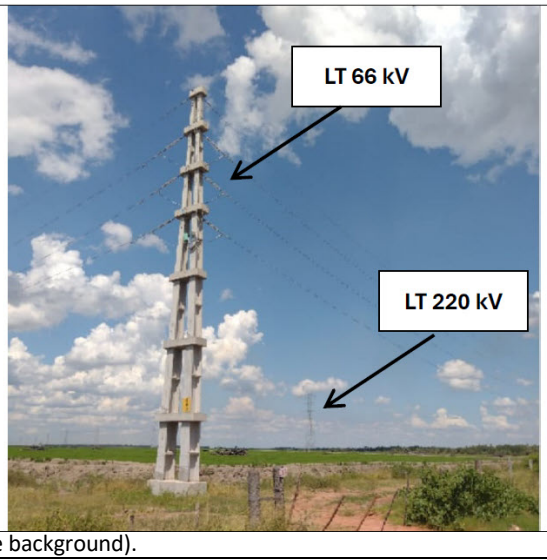




Photo 01: General view of SE Buey Rodeo.





Photos 02 and 03: View of the 66 kV and 220 kV TLs (in the background).



Photo 04: View of the rice plantations in the background, as well as the 220 kV TL running through them.



Photo 05: General view of the property next to the plant site.





Photos 06 and 07: Vegetation characteristics of the Plant's terrain.



Photo 08: Vegetation characteristics of the Plant's terrain.



Photo 09: Lagoon located partly on Plant land and partly on neighbouring property.





Photos 10 and 11: Route PY19 in the section where the Project is located.

5.4.2.2
Establishments and Residences Located in the AID and Socio-Economic Profile of Residents

As mentioned in the previous Section, the west side of the Plant site borders a rural property, as shown in **Figure 5.4.2.2.2.a** below and in **Photo 12**.

Figure 5.4.2.2.a
Property adjacent to the ATOME Plant site

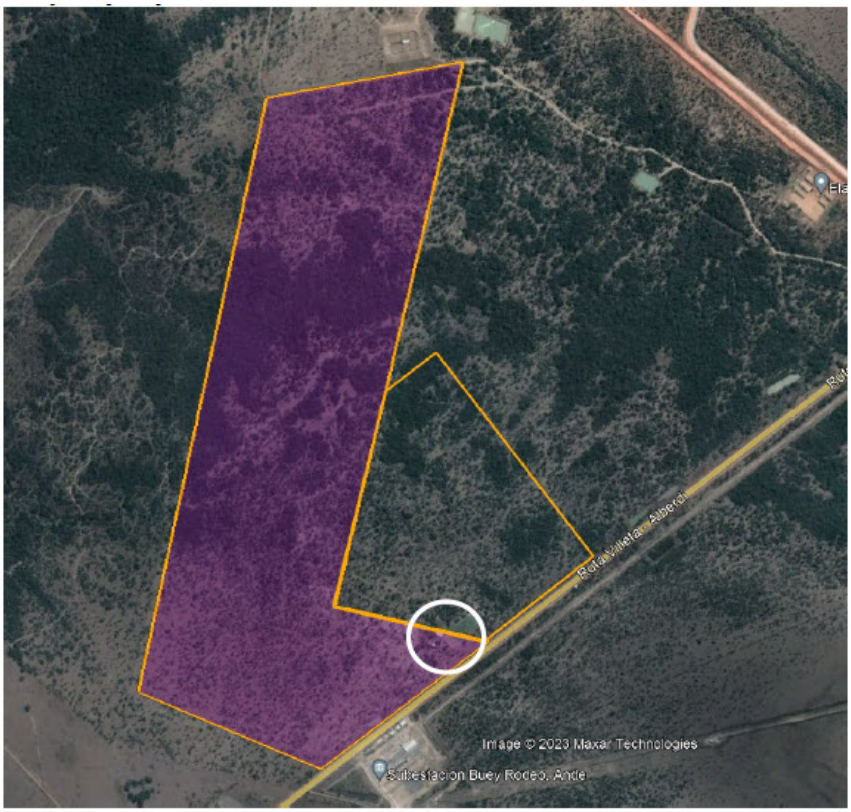




Photo 12: Property next to ATOME's land.

In order to gather information from the stakeholders identified as the main interested parties due to their proximity to the Project area, 12 interviews were carried out, with the aim of making a preliminary diagnosis of the occupants of the neighbouring property, so as to base the assessment of the potential impacts on them and determine the corresponding management measures.

Identified actors

The interviews conducted in March 2023 yielded a total of 5 actors (**Table 5.4.2.2.a**) related in various ways to the neighbouring property. These are the owner and people employed by the owner to carry out productive and administrative activities on the farm.

Table 5.4.2.2.a
Identified actors

ACTOR	Type of residence		Use of Property			
	Temporary	Permanent	Recreativo	Productive	Housing	Labour
Owner	X*		X	X		
Resident 1 (Foreman)		X			X	X
Resident 2 (Labourer)		X			X	X
Resident 3 (Cook)		X			X	X
Resident 4 (cook's daughter/worker's sister)		X			X	
Total	**1**	**4**	**1**	**1**	**4**	**3**

* Usufruct housing at weekends or occasionally during the week.

As can be seen in the table, two types of social units related to ownership were differentiated, these are:

- **Owner/User of the property:** person/family who regularly attends the property and does not reside permanently. In this case, the owner is considered to be the person who holds the title to the property and uses the property for recreational/productive purposes.

- **Residents/household:** person/family that uses the property and uses it as a family dwelling, being permanently present on the property. This unit includes the foreman, labourer, cook and the cook's daughter, who work under a dependency relationship with the employer, except for the cook.

The owner or user of the property acquired his farm 10 years ago, which is between 6 and 7 hectares in size. It is a livestock production unit called "Ganadera San Rafael" (**Photo 13**). In an interview, he also mentions that he rents some 100 hectares of adjacent land. The interviewee is a driver/trader.

The residents or components of the family dwelling presented different profiles, as described below:

- **Resident 1 (Foreman): He is** 40 years old and is in charge of the establishment. His family does not live on site. He uses a motorbike as a means of transport. In terms of education, he has completed his basic school education. He joined the establishment one year ago.

- **Resident 2 (labourer):** 28 years old and his role is to assist in the foreman's activities. He lives with his mother on the site. He travels by public transport and, in terms of education, has completed the sixth grade of primary school. He used to work for the same employer and has been working for the same employer for six months.

- **Resident 3 (Cook): she** is the mother of the farmhand and has the function of cooking in the establishment.

- **Resident 4 (daughter of the cook and sister of the labourer): resides** on site temporarily.

It should be noted that, as of November 2023, the number of people living in the neighbouring property has changed, with only three people living permanently, two of whom work and one is a minor. According to conversations with current employees, the situation varies constantly according to the needs of work on the farm . Therefore, the workers are not permanent as the owner of the property changes the workforce according to his needs.

Infrastructure and services

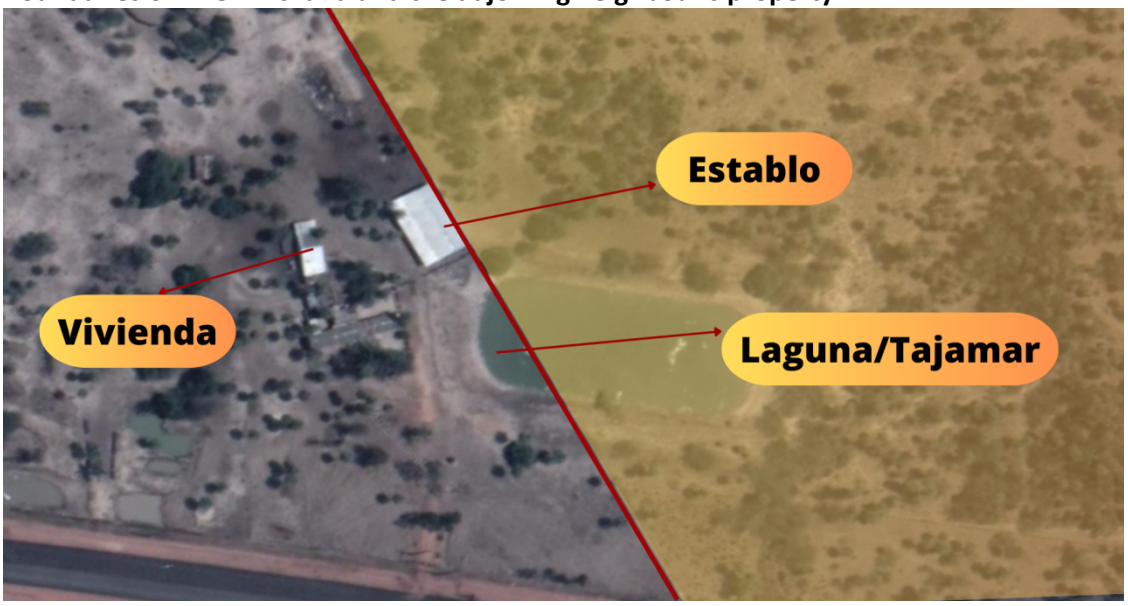
Few infrastructures are observed on the property in relation to the total area of the property, totalling six types of areas occupied by constructions, which are detailed in **Table 5.4.2.2.b** below.

Table 5.4.2.2.b
Infrastructure on the property

Infrastructure	Description
Housing	**Characteristics:** the four-room house covers an approximate area of 90 m^2 . In general, it is built with baked material (brick) and a zinc sheet roof with a ceiling. The windows are made of glass and the floor is tiled.
Corral with pens	**Characteristics:** built with wood
Stable	**Characteristics:** it has approximately 285 m^2 and is built with wood and a sheet metal roof.
Tajamar	**Size:** 2400 (95% of the area is on the ATOME property and only 5% is on the neighbouring property).
Artesian well	**Characteristics:** it is made of PVC material and is 20 m deep. **Uses:** drinking water for consumption and also used for domestic and cleaning purposes.
Cesspit	**Use:** sewage disposal.

As can be seen in **Figure 5.4.2.2.b,** the corral with pens and the stable are very close to the boundary of the ATOME farm, so this infrastructure would be the most affected in the construction and operation phase of the ATOME plant. It also shows the location of the dwelling.

Figure 5.4.2.2.b
Boundaries of ATOME's land and the adjoining neighbour's property



As for the method of waste disposal, waste is burned because there is no municipal waste collection service at this point. In the case of available energy sources, electricity is available, but gas and firewood are also used for cooking.

Productive activities on the farm

In the field surveys it was found that the farm is a livestock production unit. As already mentioned, the production unit is developed on approximately 7 hectares owned and 100 hectares leased and exploits the production of morocco ducks, sheep (22 heads), goats (28 heads), donkeys (6), horses (10) and 55 heads of cattle (**Photos 14 and 15**).



Photo 13: Entrance and name of neighbouring property.



Photo 14: View of the duck breeding pond.



Photo 15: View of sheep and goat breeding.

Perception of the inhabited area and of the project

As part of the survey, the owner of the farm was asked about his perception of security in the area, and he indicated that the risk in the area was cattle rustling, but that this disappeared as rice fields replaced livestock production. For his animals the biggest risk of damage is snakes causing mortality.

The owner of the neighbouring property stated that he was not aware of the Omega Green project planned for the neighbouring area but was aware of the ATOME plant.

6.0 Analysis of the Environmental and Social Impacts and Risks of the Project

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Free Trade Zone and Hydrogen, Ammonia and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

SUMMARY

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6.0
Analysis of the Environmental and Social Impacts and Risks of the Project

6.1
Identification and Characterisation of Impacts

6.1.1
General Methodological Reference

This ESIA used a well-established impact assessment methodology based on technical literature and the current state of the art internationally. Literature references such as the works of Sanchez (2006), Morgan (1998), Porter & Fittipaldi (1998), Canter (1996), Wood (1995), Morris & Therivel (1995), Turnbull (1992), World Bank (1991), EPA (1999) and Gertler *et al*. (2016) were the basis for the methodological structuring of this assessment.

Based on the technical characteristics of the project and the results obtained during the diagnostic stage (baseline), the environmental and social impacts and risks were identified and assessed.

As defined in the IFC Performance Standards on Environmental and Social Sustainability (IFC, 2012), environmental and social impacts refer to any potential or actual changes to the physical, natural or cultural environment and the surrounding community or workers resulting from the project.

Environmental and social risks, in turn, are a combination of the probability of a given hazard occurring and the severity of the impacts resulting from its occurrence.

The main methodological steps developed in this ESIA are described below.

First, all impacting actions of the planning, implementation and operation phases of the project, which may cause social, economic, cultural and environmental changes or which will require the appropriation/use of natural resources or available infrastructure and utilities, were identified. The description of each action (see **Section 6.1.2**) was based on the information on the project and its construction and operational procedures presented in **Chapter 2.0** (Project Description).

The environmental components considered likely to be affected are:

C.1 - Components of the Physical Environment

- C.1.01 - Soil / Relief
- C.1.02 - Surface and groundwater resources
- C.1.03 - Climate and air quality

C.2 - Components of the Biotic Environment

- C.2.01 - Flora and Vegetation
- C.2.02 - Fauna

C.3 - Components of the Socio-Economic Environment

- C.3.01 - Employment and local economy
- C.3.02 - Infrastructure, social equipment and public services
- C.3.03 - Community and worker health and safety
- C.3.04 - Quality of life of the population
- C.3.05 - Historical, Cultural and Archaeological Heritage

Protected Wildlife Areas and Indigenous Communities were not considered as potentially impactful components because the project does not interfere with any area or territory, in the latter case, that is so delimited.

Based on the analysis and interpretation of the relationships between the impacting actions and the identified environmental components, the potential risks and impacts associated with the project have been established (**Section 6.1.3**), i.e. those that can be reasonably foreseen and are likely to occur.

Based on the description and analysis of each potential impact, and in accordance with the legal specificities required under this ESIA, the environmental measures were classified as preventive, mitigation, control and monitoring and compensatory, as presented in the Environmental and Social Management Plan - ESMP in **Chapter 7.0.**

Preventive measures refer to all planned actions to ensure that previously identified risks and potential impacts can be avoided.

Mitigation measures are those measures aimed at ensuring the prevention or minimisation of the intensity of identified impacts. Preventive and mitigation measures therefore tend to be incorporated into current engineering practices, often becoming technical standards or legal requirements. The assurance that the works will be executed following these measures is given by the commitments made by the ESIA, the incorporation of environmental controls requirements in the manufacture of the equipment and by the subsequent inspection, hence the importance of control and monitoring measures.

Monitoring measures are designed to measure the effectiveness of mitigation measures and to demonstrate compliance with legal requirements and also with contractual agreements.

Compensatory measures, on the other hand, refer to ways of compensating for negative impacts that cannot be mitigated or cannot be controlled and reversed by other measures.

In the case of positive impacts, the proposed measures aim to enhance their beneficial effects.

The proposed measures are structured in Environmental and Social Programmes that make up the ESMP for the construction and operation stages of the project. The grouping of measures in the Programmes aims to make them operational and facilitate their management.

All potential impacts of the project were cross-checked against the preventive, mitigation, control and compensatory measures included in the project design and those proposed in the ESMP to ensure that all were covered by some measure or some form of prevention, mitigation,

control and compensation.

The objective of the detailed impact and risk assessment is to qualify and quantify (where possible) the resulting impact, i.e. the residual impact that may materialise even after the actual implementation of the ESMP measures.

Taking into account the implementation and effectiveness of the proposed environmental and social programmes and respective preventive measures included in the project design, the resulting impacts were assessed and rated according to a set of attributes selected on the basis of state-of-the-art environmental impact assessment methods, as presented below. The attributes considered were as follows:

- Nature of impacts (positive or negative)
- Location and spatialisation
- Stage of occurrence
- Impact (direct or indirect)
- Temporary - Induction
- Temporality - Duration
- Reversibility
- Probability
- Magnitude (before and after proposed mitigations)

A summary characterisation of each attribute used to characterise the resulting environmental impacts is presented below.

Nature

Indicates whether the resulting impact is negative or positive. The same impact can have two opposite vectors, one positive and one negative, on the same component.

Location and spatialisation

Defines the spatial spread of each impact. Impacts may occur in the Area of Direct Influence (AID) or in different geographical areas within the Area of Indirect Influence (AII), with direct and indirect action varying according to the component. However, it should be mentioned that there may be resulting impacts that, although identified, have a diffuse geographical scope, not restricted to a defined spatial unit, and may occur in a macro regional or national context.

Occurrence phase

Indicates whether the resulting impact will occur in the planning, construction or operation stages of the project.

Advocacy

Indicates whether the impact will be direct or indirect. Direct impacts have a clear and simple cause and effect relationship and arise directly from the impacting actions implemented in the construction and operation phases. Indirect impacts already considered have a secondary or indirect dependence on the impacting actions.

Temporary - Induction

This is an attribute associated with the induction time of a potential impact in relation to the initiation of the impacting actions. Induction can be immediate (impact starts immediately after the action), short term (up to 2 years), medium term (2 to 10 years) and long term (more than 10 years or over the lifetime of the project).

Temporality - Duration

This attribute is associated with the period of time that the impact will remain after the impacting action has ceased and all planned measures have been implemented. The impact may cease immediately after the completion of the action, or it may be short term (up to 5 years), medium term (5 to 10 years) or long term (more than 10 years). The resulting impact can still be considered permanent, i.e. it will not be interrupted even with the implementation of the relevant measures.

Reversibility

Defines the degree of reversibility of the impact and is directly related to the intensity. In case of negative impacts, these can be reversible or irreversible. Resulting impacts considered reversible cease to occur or have a negligible intensity after the impacting actions cease and/or the applicable measures are implemented. Irreversible impacts, even after the implementation of measures, make up the resulting impacts of medium to high intensity.

Probability

The likelihood of a certain impact occurring. The environmental impacts identified through the interaction between the impacting actions and the environmental and social components are defined as "potential environmental impacts", i.e. predicted impacts that may or may not occur. However, depending on the characteristics of the project and the areas of influence, as well as experience with other projects, it is possible to assess the impact according to the degree of probability of occurrence: low probability, medium probability, high probability and certain occurrence.

Magnitude

It is defined as the magnitude of the impact in absolute terms, indicating the degree of change in the quality of the environmental or social component that may be affected by the project in all its phases (planning, implementation and operation). In other words, it is the difference between the assumed environmental quality after the effects generated by the project's actions and that observed before such processes took place. It is important to note the magnitude

before and after the implementation of mitigations as many of the potential impacts are mitigable with good practices and control technologies. Therefore, magnitude is the attribute that defines, together with the degree of mitigability of the impact, its degree of residual significance, as will be discussed in the next item.

Attribution of the degree of significance and assessment of the final residual impact

As an attribute of the analysis, significance corresponds to the assessment of the value of each impact. This is an assessment that brings together results from several attributes and indicates the degree of sensitivity of a given environmental impact. It therefore determines the degree of severity, albeit indirectly, of each environmental impact, supporting decision-making with regard to the application of specific environmental measures for the optimisation of positive effects or the remediation of negative effects on the environment.

Within the scope of this study, the definition of the degree of significance for each impact has been made by cross-checking the attribute magnitude and reversibility, as shown in **Table 6.1.1.a** below.

Table 6.1.1.a
Combination of indicators to define the degree of significance of impacts

Magnitude	Reversibility		
	Reversible	Partially reversible	Irreversible
Baja	Baja	Moderate	Media
Media	Moderate	Media	High
High	Media	High	High

In relation to the combination of attributes presented above, two factors should be highlighted. On the one hand, magnitude, which represents the magnitude of the impact, i.e. the extent of the possible effects of the interventions when comparing the quality of the environment before and after the impacting actions. On the other hand, reversibility, which tends to represent the vulnerability and sensitivity of each assessed component, i.e. the capacity of environmental systems to assimilate energy inputs and maintain their characteristics as close as possible to those observed before the interventions.

Following the analysis, the assessment of the final residual impact, which represents the state of the environment after the implementation of all prevention, control, mitigation and compensation measures proposed in the ESMP (see **Chapter 7.0**), was carried out. The analysis of the residual impact, however, is linked to the application of another rating attribute: the degree of mitigability. This attribute refers to the levels of possibility that the negative effects of an impact can be controlled. It should be noted that mitigability depends both on the nature of the affected components and the possibility of technical and economic implementation, as well as the political and institutional effort to do so on the part of the Project developer. Impacts have been classified as Fully Mitigable, Highly Mitigable, Moderately Mitigable and Low Mitigable.

Within the scope of this study, the definition of the residual degree of significance has resulted from the crossing of the attributes degree of mitigability and significance, as shown in **Table 6.1.1.b**.

Table 6.1.1.b
Residual degree of significance of impacts from the combination of degree of mitigability and significance

Degree of mitigability	Importance			
	Baja	Moderate	Media	High
Fully Mitigable	Baja	Baja	Baja	Media
Highly Mitigable	Baja	Baja	Moderate	Media
Moderately Mitigable	Baja	Moderate	Media	Media
Low Mitigable	Baja	Moderate	Media	High

6.1.2
Impact Actions

This Section identifies all actions with the potential to generate environmental and social impacts in the planning, implementation and operation phases of the project. As mentioned above, the actions were identified and described in accordance with the technical specifications of the project and their respective construction procedures detailed in **Chapter 2.0.**

In total, 24 actions with potential impact were identified, 3 actions related to the planning phase, 16 actions related to the construction phase and 5 actions related to the operation phase, as specified in **Table 6.1.2.a**, below.

Table 6.1.2.a
Actions in the planning, implementation and operation phases of the project

Project Phase	Impactful Actions
A.1 - Planning Phase	A.1.01 Dissemination of the project
	A.1.02 Initial operational structuring
	A.1.03 Studies of locational and technological alternatives
A.2 - Implementation Phase (works)	A.2.01 Mobilisation of construction workers
	A.2.02 Mobilisation of construction support areas
	A.2.03 Vegetation clearance and site clearance
	A.2.04 Implementation / Adequacy of accesses
	A.2.05 Flows of vehicles, equipment and workers
	A.2.06 Earthworks
	A.2.07 Execution of foundations
	A.2.08 Civil works
	A.2.09 Assembly
	A.2.10 Assembly of towers
	A.2.11 Launching of cables
	A.2.12 Operation of construction support facilities
	A.2.13 Demobilisation of support areas
	A.2.14 Demobilisation of workers
	A.2.15 Recovery of direct intervention areas
	A.2.16 Negotiation and compensation of owners

Table 6.1.2.a
Actions in the planning, implementation and operation phases of the project

Project Phase	Impactful Actions
A.3 - Operation Phase	A.3.01 Mobilisation of operational workers
	A.3.02 Plant Water Catchment
	A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines
	A.3.04 Transport of inputs and outputs
	A.3.05 Environmental controls during operation to avoid or minimise potential impacts

Each action is described below in terms of the main executive procedures and functional aspects considered relevant to the assessment of the environmental and social impacts potentially arising from the various phases of the project.

A.1 - Planning Phase

A.1.01 Dissemination of the project

This action includes all activities related to the dissemination of information on the project implementation works, involving official statements by authorities, news published by the media or contacts established in the region by ATOME or representatives. The repercussion of the news related to the works generates positive expectations, such as possible job offers and movement of the local economy, and negative ones, such as noise, atmospheric emissions and traffic nuisance, risk of accidents, among others.

A.1.02 Initial Operational Structuring

This action incorporates all activities preliminary to the works, including:

- Field inspections and interviews with the population in the area of influence for the ESIA;
- Studies for the Executive Project, including soundings, topographical surveys, cadastres.

A.1.03 Location and Technological Alternatives Studies

This action includes the studies of siting alternatives carried out within the framework of this ESIA (see **Section 3.1**), which led to the choice of a site for the Plant and a layout for the TL and the water and effluent pipelines that were the best possible from the point of view of preventing and/or minimising environmental and social impacts. It also includes the technological studies carried out by the engineering team, so that the different technologies adopted for the different components of the Plant led to a Project that has environmental controls to provide the lowest possible levels of atmospheric emissions, noise, quality of treated effluents and for the containment of chemical substances to prevent environmental pollution, complying with the most restrictive national and international standards.

A.2 - Implementation Phase (Works)

A.2.01 Mobilisation of construction workers

It involves the selection and hiring of workers (direct labour) for the construction and assembly works of the plant, water catchment and effluent discharge infrastructure and the LT. This action is considered separately due to its relevance as an impact vector, resulting in the creation of jobs and corresponding income.

As reported in **Section 2.7.6** of **Chapter 2.0**, an estimated 1020 to 1073 direct workers will be employed, considering the peak months of the works. In addition to these, it is estimated that there will be about 40-50 workers for the LT works and the water catchment system and water and effluent pipelines.

Some of this workforce needs to be skilled and will not be recruited locally. However, a large part of the workers will be recruited in the region.

A.2.02 Mobilisation of construction support areas

This action includes the activities necessary to set up the area for temporary construction support facilities within the plant site itself (see **Section 2.7.1.5**). It also includes the contracting of quarries for the acquisition of borrow material and stockpiles of surplus material, if necessary.

This impactful action encompasses all the tasks necessary for the implementation of the support facilities, including clearing and preparing the land, civil works, construction of the septic tank and others.

Section 2.7.2.1 indicates that the volume of borrow material required for backfilling the site will be obtained from commercial riprap quarrying in Surubi'y or, as a last resort, by reworking. Where appropriate, supplementary environmental studies will be carried out and potential impacts and mitigation measures will be assessed.

A.2.03 Vegetation clearance and site clearance

Prior to the commencement of works, vegetation clearance and land clearing will be carried out in the area where the plant facilities will be constructed. Initially, a vegetation area of 24.75 ha is planned to be cleared, corresponding to the existing native vegetation in Zones A and B shown in **Figure 2.7.2.1.a** of **Section 2.7.2.1**, being 2.76 ha of sub-humid semi-deciduous forest and 21.99 ha of savannah. Thereafter, in a future expansion of the Plant for Zone C, the total suppression area for the facility will be expanded to 29.85 ha, of which 6.14 ha are sub-humid forests and 23.7 ha are savannahs. In addition, vegetation removal is foreseen for the opening of access roads, underground implementation of water supply and effluent discharge pipes (0.69 ha, being 0.55 ha of savannahs and 0.14 ha of sub-humid semi-deciduous forests) and in the service strip in the centre of the LT easement and tower areas (area of 0.07 ha of savannahs).

Vegetation removal and land clearing are activities consisting of cutting trees and shrubs of any size, removing stumps, branches, entangled roots, grass and organic matter soil layer up to a

thickness of 20.0 cm. Stump removal includes excavation and total removal of tree stumps larger than 30.0 cm in diameter and roots.

This vegetation removal and land clearing leads to soil exposure, which, according to its susceptibilities, can cause localised laminar and linear erosion processes, especially if these actions are carried out during the rainy season and if good management practices are not applied. It is also associated with noise and dust emissions. All these potential impacts will be managed with good construction sector practices.

A.2.04 Implementation / Adequacy of accesses

This action includes the activities for implementation of temporary accesses, including a site access road from National Route PY19 and other internal roads to the construction support facilities and to specific points on the site to access the locations of each plant structure to be built, such as the areas for the implementation of the intake infrastructure and piping for water supply from the Paraguay River to the ATOME Plant and piping for effluent discharge.

It also includes the implementation of the internal road system of the plant, including paving (transport and placement of base and sub-base material, construction of guides, gutters, pavements and asphalt pavement).

The potential impact of this action is associated with the possible occurrence of localised erosion processes and the risk of soil contamination, if good management practices are not applied, as well as noise and dust emissions and an increase in impervious surface, modifying current drainage conditions.

A.2.05 Flows of vehicles, equipment and workers

This action corresponds to the transport of materials, equipment and workers necessary for the construction of the project. Transport will be carried out on existing roads, mainly Ruta Nacional PY19, but also on other roads in the region, including the access roads between Villeta and Asunción.

This transport will be carried out with different types of vehicles, including trucks, tractors, excavators and other heavy vehicles, buses transporting workers, cars and motorbikes.

For workers' transport, 1 to 8 daily bus trips are estimated, considering round trips, with the peak between months 17 and 18. As for truck traffic, 10 trucks are estimated for backfilling, which will make 6 round trips per truck per day, for a total of 5,429 trips on National Route PY19 (Villeta - Alberdi) during the works. A further 450 truck trips are also planned between the Terport port and the site to transport containers with imported goods, intermittently for 5 months. The grouping of loads in shipments will be maximised to minimise the number of trips and the impact on traffic on Route PY19.

During the works, the transport of oversized cargo from Montevideo by river to the Port Terport, mostly by container ships, and from there to the plant site, is also mentioned. Initially, an approximate number of 40 - 50 river trips is considered for the arrival of the goods at the site.

During the construction phase, this action may mainly affect users of the PY19 on the access section to the plant. Some flows will be more diffuse, with no concentration of vehicles, but others, such as workers' buses, will have a more concentrated flow at certain times, corresponding to the entry and exit of workers.

A.2.06 Earthworks

This action corresponds to the earthworks necessary for the execution of the project.

This includes the activities necessary for the shaping and levelling of the land to the necessary levels to implement the plant buildings and the internal roads and laying of underground piping for the supply of water from the Paraguay river and piping for effluent discharge. They are associated with noise and dust emissions and the risk of erosion.

The planned backfill area for the plant is 255,000 m^2 , and the height of the backfill is 0.6 m. The existing cutwater will also be backfilled. The required volume of backfill material is 153,000 m^3 . General excavations of 102,000 m^3 are foreseen for levelling and compaction of plant or construction areas, for cutting embankments, for construction of patios, roads, pavements, canals, foundations, etc., producing a material that cannot be used for backfilling because the soil analyses carried out showed that the soil is not in suitable condition.

Backfill material will be obtained from a gravel quarry located in Surubi'y, or by reworking from a sand bank in the Paraguay River, as indicated in **Section 2.7.2.1.**

The earthworks also include the excavations necessary to open the trench through which the buried water and effluent pipes will be laid between the plant and the Paraguay River, with a planned volume of 2,300 m^3 , and the excavations in the river bed to install the water collection infrastructure.

A.2.07 Execution of foundations

This action includes the execution of the foundations of all the buildings and structures planned for the Plant, the pumping house for water collection, as well as excavations for laying the foundations of the LT towers.

These services correspond to the execution of deep and shallow foundations, including the driving of piles, the execution of local excavations, the assembly of reinforcement and concreting.
The potential impact is associated with noise and dust emissions and vibration during pile driving activities. There is also a risk of soil and groundwater contamination and accidents with workers if prevention, management and good practice measures are not implemented.

A.2.08 Civil works

This set of activities covers the construction services for administrative buildings, water and effluent treatment station structures and the buildings of the various units that make up the plant. It also includes the execution of the temporary and permanent drainage networks and the implementation of the infrastructure for the collection and supply of water to the plant and the discharge of effluents (pumping house and installation of pipes).

These services include reinforced concrete and masonry work, among other associated services.

The potential impact of this action is associated with noise and dust emissions. The risk of soil and water contamination and accidents with workers is also mentioned if prevention, management and good practice measures are not implemented.

A.2.09 Assembly

This action is associated with the assembly activities of the Plant's structures, including installation of metal structures, installation of tanks, piping, equipment and machinery.

The potential impact is associated with noise and vibration emissions during lifting and assembly activities. Gaseous emissions from the equipment used, such as trucks and cranes, must also be considered.

A.2.10 Assembly of towers

The metal structures of the towers will be assembled, piece by piece and/or by pre-assembled sections on the ground, in the assembly areas prepared along the easement strip. Impacting actions refer to noise and vibration emissions during lifting and assembly activities. Gas emissions from the equipment used, such as trucks and cranes, must also be considered.

A.2.11 Launching of cables

For the launching activity of the conductor cables, the towers must be grounded and the lightning conductors must be mounted.

The cables will be launched using trucks and cranes, only in the launch strip within the easement strip, to avoid interventions in additional areas. The impacts of this action are mainly related to noise and vibration emissions.

The potential impact of this action is also related to a one-time disruption that will affect traffic on National Route PY19 for a few hours, which will require prior communication and signalling actions, as well as coordination with ANDE and the transport departments and obtaining the necessary permits.

A.2.12 Operation of building support facilities

Activities involving potential impacts during the operation of the construction support facilities are related to the handling of chemicals (fuels, oils, lubricants, paints and varnishes), water supply and disposal of effluents and solid waste, especially hazardous waste, and circulation of vehicles on internal and external accesses.

The potential impact of this action is associated with the emission of noise, vibrations, dust and combustion gases from the operation of machinery, equipment and vehicles and construction site traffic. It is also related to the generation of solid waste and domestic and industrial effluents, and the handling of hazardous products such as diesel/fuel. The potential risk of soil

contamination from possible fuel/oil leaks and occupational accidents is also mentioned, if prevention, management and good practice measures are not implemented.

A.2.13 Demobilisation of support areas

As mentioned, the construction camp will be implemented within the plant site itself. At the end of the works, the temporary facilities will be dismantled and the areas with exposed soil must be reclaimed to avoid the installation of erosive processes. In addition, the necessary actions must be taken to deactivate and neutralise the installed septic tank.

A.2.14 Demobilisation of workers

This action includes all procedures for the demobilisation of the workforce hired by contractors and subcontractors, the termination of labour contracts and the termination of contracts for the provision of materials and services.

Demobilisation will be gradual, i.e. as the stages defined in the works schedule are completed, leaving only a few employees needed for the completion of the work and the start of the operational phase.

A.2.15 Recovery of direct intervention areas

This refers to the recovery and/or regularisation of the land and perimeter tree planting and grass cover of the areas directly affected by the project, including not only the area of the construction camp and the area where the underground pipeline for water supply from the Paraguay River and the effluent discharge pipeline will be laid, but also all other areas not occupied by the plant's fixed structures and internal accesses and which have been affected in any way by the construction activities.

It should be noted that these activities will be carried out at the end of each stage of construction, in parallel to the execution of the work.

A.2.16 Negotiation and compensation of owners

The release of the LT easement strip and water and effluent pipelines has included the following activities:

- Contact with the respective landowners along the LT and pipeline routes;
- Register of owners;
- Cadastre of all productive and non-productive improvements located in the area of the easement strips, with the accompaniment of each landowner;
- Cadastre of the areas affected by the institution of easement strips;
- Calculation of compensation for land use restrictions established in the area of the land affected by the easement strips and by the improvements affected. This activity has already been carried out for the TL and will be carried out for the affected pipelines, taking as a reference the price established for the TL and the negotiations with the affected landowners.

A.2 - Operation Phase

A.3.01 Mobilisation of operational workers

It involves the selection and hiring of workers (direct labour) for the operation and maintenance of the plant. In this case it is a more specialised workforce, trained and qualified to operate the different units that make up the plant. The estimated number of workers in the operation phase will be 225 direct jobs, of which 195 are permanent and 30 are temporary, in addition to the workers involved in the land and river transport of CAN fertiliser, and other service providers. It is estimated that about 874 indirect jobs will also be generated.

As in the construction phase, it is associated with the positive impact of job creation and related income.

A.3.02 Plant Water Catchment

As mentioned in **Section 2.6.2.1.1,**

A flow of 242.70 m^3 /h will be captured from the Paraguay River for the Project. This water will be pre-treated and used for different purposes, including: drinking water, demineralised water (to supply electrolysers, NH Synthesis $Unit_3$, AN Plant, SNA Plant, GRAN Plant, replenishment for other services such as chemical dilution, etc.), service water, fire-fighting water and cooling tower replenishment water.

The water will be pumped and transported from the river to the plant through an underground pipeline. It is worth mentioning that of the 242.7 m^3 /h, 77.30 m^3 /h to 84.20 m^3 /h will be returned to the river as treated wastewater at the WWTP, resulting in a total extraction balance of 165.4 m^3 /h or 158.5 m^3 /h. This treated effluent to be returned to the river will be of a quality that meets the most restrictive national and international standards.

The potential impact is associated with the small reduction in river flow and dilution capacity.

A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines

The operation of the plant is associated with several actions that have the potential to cause environmental and social impacts. These are:

- Operation and maintenance of the effluent treatment plant, which will treat effluent from water pre-treatment, oil separator effluent, non-oil network effluent, sanitary effluent and cooling tower blowdown. Chemicals will be used and a liquid effluent will be generated and treated before discharge to the Paraguay River. Sludge will be generated from the effluent treatment process. The process may also emit odours;
- Management and disposal of effluents and sludge that must be treated in a special way and will be carried out through outsourced and qualified companies;
- Operation and maintenance of the Ammonia Synthesis Unit (NH_3), the Nitric Acid Plant (HNO_3) and the Ammonium Nitrate Solution Plant ($NH_4 NO_3$), where unintentional release of chemicals may occur;
- Flaring, generating emissions from combustion processes and fugitive emissions;

- Solid waste generation in administrative and industrial areas;
- Operation and maintenance of noise-generating equipment and vehicles, including compressors, power substation, pumps, generators, intakes and valves, and CAN fertiliser transport trucks.

Routine maintenance actions of the TL and of the water and effluent collection and piping include a set of works and services to be carried out periodically, preventively, or emergency, correctively, always following specific procedures for each service.

Routine maintenance aims to ensure structural integrity and operational performance.

For the TL, routine preventive conservation activities include selective cutting and pruning of vegetation in the easement strip and inspection of towers and cables, as well as inspection and maintenance of transformers. It is important to note that a large part of the TL easement is located in an area of rice cultivation, therefore, the potential impact on vegetation will be very small.

Emergency remediation activities include dealing with casual accidents involving damage to LT's physical or operational structures, mainly caused by cable breaks or tower falls, caused by natural events such as storms or strong wind gusts.

The potential impact of maintenance activities on pipeline easement strips is related to the impediment of regeneration of native vegetation, especially taller vegetation, and restrictions on use by landowners, who should only carry out activities compatible with the safety of the pipelines. In addition, the activities presuppose that ATOME will enter the properties for inspection and maintenance. It is important to note that ATOME will have signed right-of-way and aqueduct easement contracts with the affected landowners, which will grant permission for access to the easement areas for periodic and emergency maintenance activities.

A.3.04 Transport of inputs and outputs

This action is associated with the flow of trucks on National Route PY19 (Villeta - Alberdi) bringing production inputs to the plant and the transport of fertilisers from the plant to the Port Terport for export by river.

As mentioned in **Section 2.8.1.10**, the trips to transport inputs to the Plant will include 1 truck trip every 4 days to bring dolomite and 1 truck trip and 1 van trip per day to bring spare parts, consumables and others.

For the transport of fertiliser from the plant to the Port Terport, 50 trips per day (or 6 trips per hour) are estimated, including empty and loaded trucks, an estimated total for export of 770 tons/day (total computation for production in big bags or bulk). These trucks will be Scania type tractor + semi-trailer.

From Terport Port, the fertiliser will be transported by inland waterway via 4x4 convoy tugboats with barges.

In the case of road transport, the potential impact of the action is related to the deterioration of the road due to the increased circulation of heavy vehicles and the small appropriation of road capacity compared to the total capacity of PY19. In terms of risks, the possibility of vehicular accidents is mentioned.

In the case of inland waterway transport, it is associated with the small reduction in the capacity of the waterway. But it is important to note that the CAN volume should not be sufficient to fill a barge and should be transported together with other products. In other words, it is estimated that the CAN will not have an exclusive barge and the number of barges related to the CAN is not significant.

A.3.05 Environmental controls during operation

As mentioned in Action 1.03, the Project has been designed to adopt the necessary technology to meet the most stringent national and international standards related to pollution control and safety. Environmental monitoring and control measures are also foreseen to be implemented during operation to prevent and/or mitigate impacts on air quality, water quality, noise emissions and soil contamination and to prevent and respond to emergency situations. These measures include the following:

- Plant abatement system to reduce NOx concentrations in the tail gas;
- Atmospheric emission control technology;
- Effluent treatment;
- Flow meters to guarantee the volume used by the plant;
- Control/abatement of noise emissions;
- Drainage network to prevent environmental pollution;
- Handling of hazardous substances;

In addition to the control measures, the following monitoring measures will be carried out:

- Air quality monitoring;
- Monitoring of atmospheric emissions;
- Monitoring of the quality of treated effluent before discharge into the river;
- River water quality monitoring;
- Environmental noise monitoring;
- Occupational noise monitoring, among others.

6.1.3
Identification of Potential Impacts and Analysis of Resulting Impacts

The actions foreseen in the planning, construction and operation phases of the plant were cross-checked with the components of the physical, biotic and socio-economic environments likely to be impacted, allowing the identification of possible environmental and social impacts.

For this purpose, a *checklist-like* verification was carried out to ensure that all impacts had measures aimed at their prevention, control, mitigation or compensation.

The analysis of the potential socio-environmental impacts of the Project, the proposal of the programmes and respective measures, and the qualification of the resulting impacts before and after the implementation of the mitigation/control measures proposed for the project are presented below. In total, 22 possible impacts of the project were identified, being 7 impacts on the physical environment, 2 on the biotic environment and 13 on the socio-economic environment.

With the result of the analysis described in **Sections 6.1.3.1** to **6.1.3.3**, **Matrix 6.1.3.a - Impact Consolidation Matrix** was prepared, with the qualification of the full set of impacts and the targeted environmental programmes.

Matrix 6.1.3.a - Impact Consolidation Matrix

Matriz 6.1.3.a

Calificación de los impactos identificados

		Impactos	Calificación de los impactos												Programas y Medidas Ambientales y Sociales Propuestas
			Naturaleza Positivo / Negativo	Localización y especialización AID / AII / Difuso	Etapa de ocurrencia Planificación / COnstrucción / Operación	Incidencia Directo / Indirecto	Temporalidad (Inducción) Imediato / Corto Plazo / Medio Plazo / Largo Plazo	Temporalidad (Duración) Corto Plazo / Medio Plazo / Largo Plazo	Reversibilidad Total / Parcial / Irreversible	Probabilidad de Ocurrencia Baja / Media / Alta / Cierta	Magnitud Baja / Moderada / Media / Alta	Importancia Baja / Moderada / Media / Alta	Mitigabilidad No mitigable / Poco mitigable / Medianamente mitigable / Altamente mitigable / Totalmente mitigable	Importancia residual Baja / Moderada / Media / Alta	
Medio Físico	1. Suelo/Relieve	1.01 - Ocurrencia y/o intensificación de procesos erosivos durante la fase de construcción	Negativo	AID	Construcción	Indirecto	Inmediato	Corto Plazo	Total	Cierta	Media	Media	Altamente Mitigable	Baja	P.01 (5.1, 5.6, 5.7, 5.12), P.02 (5.1 a 5.4)
		1.02 - Aumento de la impermeabilización del suelo y alteración del régimen de drenaje actual	Negativo	AID	Construcción	Directo	Inmediato	Largo Plazo	Total	Cierta	Baja	Baja	Altamente Mitigable	Baja	P.01 (5.1, 5.6, 5.7, 5.12), P.02 (5.1 a 5.4)
	2. Recursos Hídricos Superficiales y Subterráneos	2.01 - Impactos en la calidad del agua del río Paraguay debido a la reducción del caudal y al vertido de los efluentes tratados durante la operación	Negativo	AID	Operación	Indirecto	Inmediato	Largo Plazo	Total	Baja	Baja	Baja	Altamente Mitigable	Baja	uso eficiente del agua durante la operación de la Planta, cumplimiento del límite de caudal a captar, tratamiento de los efluentes, mantenimiento de la ETAR, P.09 (5.6, 5.7, 5.12), P.10 (5.1)
		2.02 - Impacto en la calidad del agua del río Paraguay debido a la implantación de infraestructura de captación de agua	Negativo	AID	Construcción	Directo	Inmediato	Corto Plazo	Total	Baja	Baja	Baja	Totalmente Mitigable	Baja	P.01 (5.1, 5.2, 5.3, 5.6, 5.8, 5.9, 5.10, 5.12), P.02 (5.1 a 5.4 y 5.7), P.05 (5.2)
	3. Calidad del Aire	3.01 - Impacto en la calidad del aire durante la construcción	Negativo	AID y AII	Construcción	Directo	Inmediato	Corto Plazo	Total	Cierta	Baja / Media a Alta	Media / Media a Alta	Totalmente Mitigável	Moderada	P.01 (5.4), P.02 (5.1 a 5.4 y 5.7), P.03 (5.1 a 5.4)
		3.02 - Impacto en la calidad del aire durante la operación	Negativo	AID	Operación	Directo	Corto Plazo	Largo Plazo	Total	Cierta	Media	Media	Medianamente Mitigable	Moderada	tecnologías de control incorporadas al diseño de ingeniería de la Planta, controles de emisiones del grupo generador, P.03 (5.1 a 5.4), P.09 (5.2, 5.9, 5.10)
		3.03 – Reducción de las emisiones de GEI y de la huella de carbono en la producción de H2, NH3 y fertilizantes verdes	Positivo	Difusa	Operación	Indirecto	Largo Plazo	Largo Plazo	Parcial	Cierta	Alta	Alta	Potencialización	Alta	P.02 (5.5), P.03 (5.1 a 5.3), P.09 (5.1, 5.9, 5.10)
Medio Biótico	4. Flora y Vegetación	4.01 - Pérdida de cobertura vegetal y afectación de individuos de flora	Negativo	ADA	Construcción	Directo	Inmediato	Permanente	Irreversible	Cierta	Media	Alta	Poco Mitigable	Alta	P.01 (5.6, 5.12), P.02 (5.1 a 5.4), P.05 (5.5, 5.6), P.07 (monitoreo de Fauna y Flora durante la etapa de construcción y medidas de compensación), P.08 (5.1)
	5. Fauna	5.01 - Pérdida de hábitats de la fauna terrestre	Negativo	AID	Construcción	Directo	Inmediato	Largo Plazo	Irreversible	Cierta	Media	Alta	Poco Mitigable	Alta	P.01 (5.6, 5.12), P.02 (5.1 a 5.4), P.05 (5.5, 5.6), P.07 (monitoreo de Fauna y Flora durante la etapa de construcción y medidas de compensación), P.08 (5.2)
Meio Socioeconómico	6. Empleo y Economía Local	6.01 - Generación de empleos directos e indirectos durante las fases de planificación y des obras	Positivo	Difusa (AII y región)	Planificación / Construcción	Directo	Corto Plazo	Corto Plazo	Total	Cierta	Baja	Media	Potencialización	Media	P.02 (5.1 a 5.4), P.03 (5.1 a 5.4), P.05 (5.1 a 5.3)
		6.02 - Generación de empleos directos e indirectos en la fase de operación	Positivo	Difusa (AII y región)	Operación	Directo	Inmediato	Largo Plazo	Total	Cierta	Alta	Media	Potencialización	Alta	P.03 (5.1 a 5.3), P.05 (5.1 a 5.4), P.09 (5.1, 5.2)
		6.03 – Dinamización de la economía local en la fase de obras	Positivo	All	Construcción	Indirecto	Inmediato	Corto Plazo	Total	Alta	Baja	Baja	Potencialización	Media	P.01 (5.11), P.02 (5.1 a 5.4), P.03 (5.2)
		6.04 – Desplazamiento físico y/o económico por la adquisición de tierras y establecimiento de servidumbres	Negativo	ADA	Construcción	Directo	Inmediato	Medio a Largo Plazo	Parcial	Cierta	Baja	Moderada	Altamente Mitigable	Baja	P.02 (5.1, 5.4, 5.6), P.03 (5.1 a 5.4)
	7. Infraestructura, Equipamiento Social y Servicios Públicos	7.01 - Apropiación de la capacidad de las carreteras de acceso al proyecto en la fase de obras	Negativo	All	Construcción	Directo	Inmediato	Corto Plazo	Total	Cierta	Media	Media	Altamente Mitigable	Moderada	P.01 (5.10), P.02 (5.1 a 5.4), P.03 (5.1 a 5.4), P.05 (5.2, 5.5, 5.6)
		7.02 - Apropiación de la capacidad de las carreteras de acceso al proyecto en la fase de operación	Negativo	All	Operación	Directo	Inmediato	Largo Plazo	Total	Alta	Alta	Alta	Poco Mitigable	Alta	P.03 (5.1 a 5.4), P.09 (5.1, 5.12), P.12 (5.1 a 5.3)
		7.03 - Apropiación de la capacidad de la Hidrovía Paraguay – Paraná	Negativo	Difusa	Operación	Directo	Corto Plazo	Largo Plazo	Total	Baja	Media	Moderada	Medianamente Mitigable	Baja	P.03 (5.1, 5.3, 5.4), P.09 (5.1, 5.12), P.12 (5.1 a 5.3)
		7.04 - Sobrecarga de los sitios de eliminación de residuos sólidos en la fase de obras	Negativo	All o Difusa	Operación	Indirecto	Corto Plazo	Corto Plazo	Parcial	Baja	Baja	Moderada	Altamente Mitigable	Baja	P.01 (5.8. 5.9), P.02 (5.1 a 5.4), P.05 (5.2, 5.5, 5.6)
		7.05 – Impacto en la circulación de la Ruta Nacional PY19 durante el tendido de los cables de la LT, generalmente de pocas horas	Negativo	All o Difusa	Construcción	Indirecto	Corto Plazo	Corto Plazo	Total	Alta	Baja	Baja	Altamente Mitigable	Baja	P.01 (5.10), P.02 (5.1 a 5.4), P.03 (5.3, 5.4)
	8 - Calidad de Vida de la Población	8.01 - Generación de expectativas	Positivo / Negativo	AID y All	Planificación / Construcción / Operación	Directo	Inmediato	Largo Plazo	Total	Cierta	Alta	Media	Altamente Mitigable	Moderada	P.02 (5.1 a 5.4), P.03 (5.1 a 5.4)
		8.02 - Molestias causadas por las actividades de construcción	Negativo	ADA y All	Construcción	Directo	Inmediato	Corto Plazo	Total	Alta	Media	Moderada	Altamente Mitigable	Baja	P.01 (5.4, 5.5, 5.7, 5.10), P.02 (5.1 a 5.4, 5.7), P.03 (5.1 a 54), P.05 (5.2, 5.5, 5.6)
		8.03 - Molestias por ruido en la fase de operación	Negativo	AID y All	Operación	Indirecto	Inmediato	Largo Plazo, intermitente	Parcial	Baja	Baja	Alta	Totalmente Mitigable	Moderada	medidas de abatimiento de ruido ya incorporadas al diseño de ingeniería de la Planta, mantenimiento de los equipos y maquinaria, P.03 (5.1 a 5.4), P.09 (5.8)
		8.03 - Molestias por olores en la fase de operación	Negativo	AID	Operación	Indirecto	Inmediato	Largo Plazo	Total	Baja	Media	Moderada	Medianamente Mitigable	Baja	P.03 (5.1 a 5.4), P.09 (5.11)
		Riesgos													**Programas y Medidas Ambientales y Sociales Propuestas**
Medio Físico	9. Recursos Hídricos Superficiales y Subterráneos	9.01 – Riesgo de impacto en la calidad de las aguas subterráneas durante la fase de construcción													P.01 (5.1, 5.2, 5.3, 5.6, 5.7, 5.8, 5.9, 5.10, 5.12), P.02 (5.1 a 5.4, 5.7), P.05 (5.2), P.06 (5.1)
	10. Suelo/Relieve	10.01 - Riesgo de contaminación del suelo durante la fase de construcción													P.01 (5.1, 5.2, 5.3, 5.6, 5.7, 5.8, 5.9, 5.10, 5.12), P.02 (5.1 a 5.4), P.05 (5.2), P.06 (5.1)
		10.02 - Riesgo de contaminación del suelo en la fase de operación													P.09 (5.3, 5.4, 5.5, 5.12), P.05 (5.2)
Meio Biótico	11 Flora y Vegetación	11.01 – Riesgo de propagación de especies invasoras													P.01 (5.6), P.02 (5.1 a 5.4), P.07 ((monitoreo de Fauna y Flora durante la etapa de construcción)
	12. Fauna	12.01 – Riesgo de impactos sobre la fauna asociados a la presencia de trabajadores durante la construcción													P.01 (5.6, 5.10), P.02 (5.1 a 5.4), P.05 (5.2, 5.5, 5.6), P.08 (5.2)
Meio Socioeconómico	13. Infraestructura, Equipamiento Social y Servicios Públicos	13.01 – Riesgo de aumento de la demanda de servicios de salud													P.03 (5.4), P.02 (5.1 a 5.4), P.04 (5.1 a 5.7)
	14 – Riesgos de impactos en la Salud y la Seguridad de la Comunidad y de los Trabajadores	14.01 - Riesgos para la salud y la seguridad de los trabajadores durante la construcción													P.01 (5.7, 5.10), P.02 (5.1 a 5.4), P.03 (5.2, 5.3), P.04 (5.1 a 5.7), P.05 (5.2, 5.4, 5.5), P.06 (5.2, 5.3)
		14.02 - Riesgos para la salud y la seguridad de los trabajadores durante la operación													diseño de la Planta realizado teniendo en cuenta mejores tecnologías disponibles (BAT); especificaciones para evitar que se produzcan accidentes en la operación; controles para detectar cualquier funcionamiento anormal de manera temprana; P.05 (5.4), P.09 (5.1, 5.2, 5.12), P.10 (5.1, 5.2, 5.3, 5.4)
		14.03 - Riesgo para la salud y la seguridad de los trabajadores de otras partes interesadas durante la operación (trabajadores del transporte fluvial y terrestre, trabajadores de Terport, otros)													P.03 (5.4), P.09 (5.1, 5.2, 5.12), P.12 (5.1 a 5.3)
		14.04 - Riesgo de para la salud y la seguridad de la comunidad durante la construcción y operación													P.03 (5.1, 5.3, 5.4), P.09 (5.2, 5.12, 5.13), P.12 (5.1 a 5.3)
	15 – Riesgos de impactos en el Patrimonio Arqueológico y Cultural	15.01 - Riesgo de daños al patrimonio arqueológico o cultural durante el movimiento de tierras													P.01 (5.1, 5.6), P.02 (5.1 a 5.4), P.11 (5.1)

Estructura del Plan de Gestión Ambiental y Social

P.01 – Programa de Control Ambiental de la Construcción
5.1. Gestión de las actividades de movimiento de tierras
5.2. Prevención y control de la contaminación del suelo
5.3. Gestión de agua y efluentes
5.4. Control y monitoreo de emisiones atmosféricas
5.5. Control y monitoreo de ruido y vibraciones
5.6. Control de las actividades de supresión de vegetación
5.7. Gestión de las instalaciones temporales/campamento de construcción
5.8. Gestión de residuos sólidos
5.9. Manejo de materiales peligrosos
5.10. Control de tráfico de construcción
5.11. Promoción y desarrollo de proveedores locales
5.12. Recuperación de áreas degradadas por las obras

P.02 - Programa de Gestión Ambiental y Social
5.1. Organización y equipo
5.2. Supervisión de la construcción
5.3. Procedimiento de garantía de conformidad
5.4. Coordinación de programas ambientales y sociales del PGAS
5.5. Gestión de las emisiones de gases de efecto invernadero
5.6. Procedimientos de negociación y adquisición de tierras y establecimiento de servidumbres
5.7. Medidas de monitoreo de calidad ambiental

P.03 - Programa de Participación de las Partes Interesadas
5.1. Identificación y análisis de las partes interesadas
5.2. Consulta pública
5.3. Subprograma de comunicación
5.4. Mecanismo de gestión de quejas, consultas y sugerencias

P.04 - Programa de Salud y Seguridad Laboral
5.1. Preparación del Plan Integral de Salud y Seguridad (PISS)
5.2. Personal para el manejo de salud y seguridad
5.3. Requisitos mínimos para Procedimientos de Trabajo Seguro (PTS)
5.4. Capacitación en seguridad ocupacional
5.5. Supervisión de salud y seguridad
5.6. Gestión de salud del trabajador
5.7. Comité para la prevención de accidentes

P.05 - Programa de Gestión del Trabajo y Condiciones Laborales
5.1. Preparación de una Política de Recursos Humanos
5.2. Contratación y capacitación laboral
5.3. Condiciones de trabajo y de empleo
5.4. Mecanismo de manejo de reclamos de trabajadores
5.5. Código de conducta para los trabajadores
5.6. Educación ambiental y social de trabajadores

P.06 - Programa de Respuesta a Emergencias para la Fase de Construcción
5.1. Plan de Acción de Emergencia en caso de derrame de productos peligrosos
5.2. Plan de Acción de Emergencia para incendios / explosiones
5.3. Plan de Acción de Emergencia para eventos extremos, como tormentas severas y sequías

P.07 – Plan de Acción de Biodiversidad (PAB)
Elaboración del PAB - Programa de Conservación de la Biodiversidad
Monitoreo de la fauna y flora
Compensación ambiental mediante conservación de bosques
Compensación ambiental mediante adquisición de Certificados de Servicios Ambientales
Compensación ambiental por árboles taladas

P.08 - Programa de Prevención de Impactos en la Flora y Fauna
5.1. Rescate de germoplasma
5.2. Ahuyentamiento previo y rescate de fauna durante la fase de construcción

P.09 - Programa de Gestión Ambiental y Social de la Fase Operación
5.1. Supervisión del cumplimiento de medidas ambientales y sociales de la fase de operación
5.2. Capacitación ambiental y social del equipo de operación y mantenimiento (O&M)
5.3. Gestión de residuos sólidos
5.4. Manejo de materiales peligrosos
5.5. Manejo de productos peligrosos
5.6. Monitoreo del efluente tratado
5.7. Monitoreo de la calidad del agua
5.8. Monitoreo de ruido
5.9. Monitoreo de emisiones atmosféricas
5.10. Monitoreo de calidad del aire
5.11. Control de olores
5.12. Supervisión de empresas contratadas
5.13. Mantenimiento de la franja de servidumbre

P.10 - Programa de Respuesta a Emergencias para la Fase de Operación
5.1. Plan de Acción de Emergencia en caso de explosión física en estructuras de la Unidad de síntesis de NH_3, Planta de Electrólisis, tanques de H_2 y NH_3 y compresores de gas de síntesis
5.2. Plan de Acción de Emergencia en caso de incendios en estructuras de la Unidad de síntesis de NH_3, del Edificio de electrólisis, en los tanques de H_2 y NH_3, en los compresores de gas de síntesis, en la Planta de ácido nítrico (AN) y en la Planta de solución de nitrato de amonio (SNA)
5.3. Plan de Acción de Emergencia en caso de fugas de NH_3, HNO_3 o NH_4NO_3
5.4. Plan de Acción de Emergencia para eventos extremos, como tormentas severas y sequías

P.11 - Programa de Conservación del Patrimonio Arqueológico y Cultural del ADA
5.1. Acompañamiento arqueológico y procedimiento en caso de hallazgos fortuitos

P.12 - Programa de Gestión del Transporte en la Fase de Operación
5.1. Capacitación de conductores
5.2. Mantenimiento rutinario
5.3. Inspección de las carreteras e implantación de mejoras

6.1.3.1
Physical Environment

1 - Soil/Relief Impacts

1.01 - Occurrence and/or intensification of erosion processes during construction phase

Impactful actions	A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.06 Earthworks A.2.07 Execution of foundations A.2.08 Civil works A.2.13 Demobilisation of support areas A.2.15 Recovery of direct intervention areas
Impact Component	C.1.01 - Soil / Relief

Analysis of potential impact

The generation or intensification of erosive processes during construction activities is associated with the set of interventions on the ATOME plant site, in addition to the areas of implementation of the TL, the water supply pipeline and water collection infrastructure, and the effluent discharge pipeline. Of particular importance are those actions that involve the exposure of soil surfaces and the execution of cuts and embankments, with the potential for greater impact in areas of steeper slope relief transposition and drainage. Also included in this context are activities that in some way concentrate rainwater, especially on unprotected and erosion-prone land. These interventions include actions of potential impact linked to the services of opening new roads, improvement of existing roads, vegetation removal, earthworks and excavations at construction sites and the formation of temporary spoil piles.

As mentioned in the Project description, the planned backfill area on the site of the Plant is 255,000 m^2 , and the height of the backfill is 0.6 m. Thus, the required volume of material is 153,000 m^3 , including the backfill for the existing pit. It is being considered to be sourced from a pre-selected riprap quarry located in Surubi'y, about 14 km from the ATOME Plant. According to data presented in **Section 5.2.7**, this is a conglomerate/riprap quarry approved by the VMME-MOPC (registration no. 354).

In addition, vegetation will be removed to open access roads, in the service strip of the TL and in the easement of the water supply and effluent discharge pipelines. Excavations are also planned for the foundations of the towers of the TL and for the underground installation of the water and effluent pipes.

For the levelling and compacting of plant or construction areas, cutting of embankments, construction of yards, roads, pavements, canals, foundations, etc., general excavations of 102,000 m^3 are foreseen, producing a material that cannot be used for backfilling because the soil analyses carried out showed that the soil does not present the appropriate conditions. This surplus material will be temporarily accumulated in the ADA, until it is sent to a duly authorised surplus material disposal area and some of it can be used for reclamation of natural areas.

In this sense, the volume to be borrowed is 153,000 m^3 and the surplus material is at least 102,000 m^3 .

As a second option for fill material, in addition to the gravel quarry, consideration will be given to obtaining sand by reworking sediment banks in the Paraguay River. If this option is chosen, the necessary complementary studies will be carried out and submitted to MADES in due course together with the assessment of possible impacts and mitigation measures.

In case of reworking, the sands can be used together with the gravel. In this case it would be necessary to increase the height of the backfill (by 0.85 m of sand and 0.15 m of slabs) and therefore its volume.

In any case, the change in the dynamics of the land surface, due to the necessary soil cleaning and excavation interventions, may induce new erosion processes or intensify existing ones.

The land area and along the LT and the water supply and effluent discharge pipes, as well as a large part of the IIA, is in Low Plain relief, where the possibility of concentrated stormwater runoff is lower, as indicated by the environmental diagnostic studies. The frequency of observation of erosion processes along the IIA and its surroundings is low, as are their intensities.

These areas are dominated by Alfisols with a slight susceptibility to erosion. Although there is some susceptibility to erosive processes, the low drainage incision and the low slopes observed in these terrains condition little kinetic energy to surface runoff, which implies laminar and furrow processes, which are occasional and of low intensity. These areas are therefore considered to be of low sensitivity to the induction of erosive processes.

However, on the banks of the Paraguay River, even where the water catchment infrastructure will be implemented, these Low Plain lands are intercepted by the lateral and marginal erosion process of the river. In this way, the construction works can also contribute to the intensification of the already existing erosion processes. However, due to the size of the pumping house, the erosion is localised and short-term.

Piles of excess material, especially when placed in the rain, can also cause impact. In any case, priority should be given to the protection of the ground surface and drainage devices should be installed to channel rainwater.

Thus, it is noted that the intensity of erosion processes also depends on atmospheric conditions and the seasonal distribution of rainfall. In this context, it is observed that the region has two annual peaks. The main peak occurs in late spring, coinciding with the increase in frontal rains and the onset of summer rains (between November and December), and the secondary peak occurs in late summer (in April). In turn, the dry period is limited to the months between June and September, when it generally rains less than 80-90 mm on average per month. Therefore, during periods of higher rainfall, more attention should be paid to the implementation of measures to prevent this type of impact.

Mitigation Measures

Given the potential conditions, the following measures are foreseen in the ESMP to prevent, control and mitigate this impact:

- **Construction Environmental Control Programme:** mainly measures for the Management of earthmoving activities, in addition to measures for the Management of temporary facilities/construction camp, Control of vegetation suppression activities and Recovery of areas degraded by the works.

- **Environmental and Social Management Programme:**
  - Construction Supervision, including Contractors and Subcontractors
  - Conformity Assurance Procedure
  - Coordination of Socio-Environmental Programmes of the GSAP

In addition to the measures foreseen in the above Programmes, it is important to note that the EPC contractor will adopt commonly used construction best management practices to prevent or minimise the temporary potential for erosion within the site.

Rating of the resulting impact

This is a negative impact of the construction phase, with a scope in the IDA (and IIA in case of the use of sand from refining). It is direct and has a certain probability of occurrence. It is immediate and has a short duration (construction period). It is reversible, of medium magnitude along the LT and in the case of exclusive use of riprap as fill in the plant area, but of high magnitude if it is decided to use sand from the reworking process, being of medium importance. Considering that this is a highly mitigable impact, the residual significance was low.

Impact rating (attributes) **Occurrence and/or intensification of erosion processes during construction phase**			
Nature	Negative	**Location and spatialisation**	IDA (IIA)
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Media		
Importance	Media		
Mitigability	Highly Mitigable		
Residual importance	Baja		

1.02 - Increased soil sealing and alteration of the current drainage regime

Impactful actions	A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.05 Earthworks A.2.07 Execution of foundations A.2.08 Civil works A.2.09 Assembly A.2.12 Operation of construction support facilities A.2.13 Demobilisation of support areas A.2.15 Recovery of direct intervention areas
Impact Component	C.1.01 - Soil / Relief

Analysis of potential impact

The installation of the Plant will represent an increase in impervious areas, as can be seen in the general *layout shown in* **Section 1.4**. The increase in impervious surface will be mainly in this area of the project, due to the paving of accesses, patios, implementation of buildings, car parks, treatment plants, among other covered and/or paved areas.

The land owned by ATOME Paraguay S.A. is approximately 30 ha, of which it is estimated that 9.48 ha (31.5%) correspond to land areas to be waterproofed (roads, buildings and slabs), 15.14 ha (50.3) correspond to areas without waterproofing (gravel and landscaped areas) and 5.47 ha (18.2%) correspond to areas with natural vegetation to maintain.

From these figures it can be seen that the areas occupied by the Plant's facilities that require land sealing correspond to 31.5% of the ADA, 3% of the AID (total of 314 ha) and 0.03% of the IIA (total of 36,000 ha).

One of the main problems associated with soil sealing relates to the reduction of infiltration areas, with the consequent alteration of the natural balance between surface runoff and water percolation processes in the soil.

However, as shown in the diagnosis (**Section 5.2.3.2**), the soil surveys indicated the presence of silty clays in the initial layer, according to the geological profile of the borehole installed in the ATOME plot. Throughout the Plant area, in addition to the IIA, there is also a predominance of Alfisols (**Section 5.2.6**.), especially in the Low Plains areas (between 60 and 70 m.a.s.l.). These soils are known to have restricted permeability, containing a clay layer below the soil surface, as well as very low hydraulic conductivity, which restricts the gravitational movement of water and consequently prolongs the saturation period.

Studies carried out at the ADA and in the vicinity of the Plant, in the Omega Green Project area, have also shown the presence of impermeable clays in the initial soil layers. The permeability tests in the field in the Omega Green area also showed the impermeability of the initial layer, especially in cases where it is very hard, in the first 2.00-3.00m. Thus, it was confirmed that surface water accumulations occur easily after precipitation in the soil due to the flat topography, but also due to the formation of a suspended water level formed on top of the impermeable clay extract.

From the above, it is considered that despite the waterproofing that the installation of the Plant and its future extensions will promote, it is estimated that this will not result in significant changes in the processes of water percolation in the soil, as these already present natural conditions of impermeability. In any case, priority should be given to maintaining permeable areas, as far as possible.

In addition, greater attention should be paid to concentrated discharges of rainwater collected from impervious surfaces in the Plant area. Considering that studies conducted in the Omega Green Project area also indicated the occurrence of dispersive soils on the surface, and subject to the formation of tubifications and rills, greater care should be taken to discipline water collected from impervious areas, with diffuse releases, to the detriment of concentrated releases, in order to promote the gentle percolation of water into the soil and avoid triggering erosion processes.

Mitigation Measures

During the construction phase, the EPC Contractor will be required to develop an Erosion and Sediment Control Plan, including the corresponding measures that form part of the **Environmental Construction Control Programme** of the ESMP, highlighting the following:

- On-site staking to minimise impact;
- Minimisation of cleared areas and stabilisation of slopes;
- Revegetation of cleared areas in the shortest possible time;
- Drainage control;
- Barrier and trapping methods, the following are mentioned for reference only: silt fences, check dams, sediment ponds, mechanical methods of sediment removal (siltbuster, culverts, etc.).

Other environmental programmes and respective measures to be implemented in order to prevent and mitigate this impact:

- **Construction Environmental Control Programme:** mainly management measures for earthmoving activities, in addition to management measures for temporary facilities/construction camps, control of vegetation removal activities and reclamation of areas degraded by construction works.

- **Environmental and Social Management Programme**
  - Construction Supervision, including Contractors and Subcontractors
  - Conformity Assurance Procedure
  - Coordination of Socio-Environmental Programmes of the GSAP

Rating of the resulting impact

Considering the application of the above Programmes and measures, this impact is considered to be negative, of scope in the AID, of the construction phase, with direct incidence, immediate temporality (induction) and of long duration (useful life of the Plant). For the operation stage, the Plant will have drainage systems with multiple functions: 1) to avoid contamination of

productive areas from non-productive areas, 2) to avoid erosion, 3) to allow infiltration of clean drainage. Therefore, it is reversible (in case of demobilisation of the Project, facilities and pavements are removed) and of certain occurrence. Its magnitude and importance are low due to the characteristic of the local soils which are naturally impermeable and all the good practices to be implemented by the contractors during the construction stage and the drainage network during the operation stage. This is a potentially cumulative impact, as will be discussed in **Section 6.1.5**. The residual significance is also low, as this is a highly mitigable impact.

Impact rating (attributes) **Increased soil sealing and alteration of the existing drainage regime**			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		
Mitigability	Highly Mitigable		
Residual importance	Baja		

2 - Impacts on Surface and Groundwater Resources

2.01 - Impacts on the water quality of the Paraguay River due to reduced flow and discharge of treated effluents during operation

Impactful actions	A.1.03 Studies of locational and technological alternatives A.3.02 Plant Water Catchment A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.05 Environmental controls during operation
Impact Component	C.1.02 - Surface and groundwater resources

Analysis of potential impact

As mentioned in **Section 2.6.2.1.1**, all water consumed by the plant will be obtained from the Paraguay River. For fire fighting and fire prevention purposes only, the water to be used will be supplied through a well to be used as a secondary water source for the system.

In Figure **2.6.2.1.1.a** in **Section 2.6.2.1.1**, 242.70 m^3 /h will undergo pre-treatment, of which 218.43 m^3 /h will be used for the intended uses (service water, fire fighting, drinking and cooling) and 24.27 m^3 /h will be rejected. Of the 218.43 m^3 /h, 33.5 m^3 /h will be sent to the demineralisation plant, whose resulting water will be used in the production process.

The water captured from the Paraguay river will be pumped and transported to the plant through an underground pipe. Thus, associated with this water demand, the potential impact refers to the reduction of the river flow and the discharge of treated effluent, with possible changes in water quality. The quantitative aspects of this impact are analysed throughout this text.

As mentioned in **Sections 2.6.2.2.9** and **2.8.1.6**, the effluents generated in the operation of the Plant include effluents from water treatment, sanitary water treatment, oil separators, non-oil network, and cooling tower blowdown. Taking into account these types of effluents, the total estimated flow is 77.3 m^3 /h, which is returned to the Paraguay River, after being treated at the Project's WWTP will meet not only the emission limits defined by Paraguayan legislation, but also the international standards of the IFC guidelines. This will ensure that this effluent is returned to the river with a better quality than the water captured.

Before being discharged into the Paraguay River, these effluents will be treated in a Wastewater Treatment Plant (WWTP), located at the Plant, whose treatment system will include two subsystems, one for wastewater collection and equalisation and the other for wastewater conditioning, control and discharge.

As mentioned in the project description (**Section 2.6.2.2.2.9**), the outflow effluents processed at the WWTP will comply with the discharge limits established in the Paraguayan legislation (Resolution 222/02) and in the General Environmental, Health and Safety Guidelines (MASS) and the IFC General and Nitrogenous Fertiliser Production MASS Guidelines . Effluents will be monitored at the outlet of the WWTP and discharge to the watercourse will only be possible if they comply with Paraguayan legislation (Resolution SEAM N° 222/02) and these international guidelines, taking into account the most restrictive values. As mentioned in **Table 2.6.2.8.b**, there will be instruments for continuous measurement of flow, temperature, pH and conductivity, in addition to the monitoring of a wider set of parameters to be carried out with the periodicity defined in the Environmental and Social Management Programme of the Operation Phase, as will be seen below.

The data presented in **Section 5.2.2.2.2.3**, which considers some industrial plants located in the District of Villeta, indicates that all of them indicate in their RIMA the management and/or treatment of their effluents, with a view to legal compliance, such as the Omega Green Project, located in part of the AID of the ATOME Project.

Regarding the water quality of the Paraguay River, the data shown in **Section 5.2.2.3** indicated high levels of total and faecal coliforms, total nitrogen and total phosphorus in all samples collected in the two sampling campaigns (C1 and C2). For the latter two parameters, the values were always above the limits established by the legislation for Class 2 waters. As for dissolved oxygen, the results did not meet the minimum limit of 5 mg/L in the March 2023 campaign, the flood period of the Paraguay River. Also in non-compliance with the quality standards, the presence of oils and fats, high water colour levels, as well as concentrations of aluminium, soluble iron and manganese were observed. For the other parameters, the limits established by the legislation for Class 2 waters were complied with.

As reported in **Section 5.2.2.3**, the appearance of dead fish in the river in March 2023 led MADES to carry out water quality collection and analysis during the same period as the collection carried out for the present study to investigate the causes of the fish mortality, and the results of the DO analysis also indicated very low values. It is not possible to pinpoint the exact causes of these low values, but according to MADES experts, they may be the result of the river flooding and the heat[1] , which increase the concentration of organic matter in the water and the oxygen demand.

[1] https://www.mades.gov.py/2023/03/12/muestras-de-agua-de-las-zonas-donde-se-denunciaron-mortandad-de-peces-seran-analizadas/

In sampling carried out for the studies of another project in the region (Omega Green Biofuel Production Industrial Complex), conducted at the same point corresponding to the site chosen for the water catchment of the ATOME project and during the months of November 2021 and May 2022, the same non-conformities were verified in all 10 collections. In addition, it was observed that the parameters of Aluminium and Total Phosphorus were also above the limits of the SEAM resolution Nº 222/02 in all 10 collections, Colour in eight, Dissolved Iron in one and BOD_5 on four occasions. It should be noted that the minimum monthly average flows of the Paraguay River occur between the months of October and March when they vary between 2,701 m^3 /s and 2,954 m^3 /s, while the maximum flows occur between May and June with an average monthly flow that reaches 3,851 m^3 /s and 4,191 m^3 /s, respectively.

From the above, it can be seen that the Omega Green Project sampling covered a low flow period between November and March, in addition to the high flow period sampling in May. In all periods, the water quality of the Paraguay River was degraded mainly due to organic pollution. Higher levels of electrical conductivity, total solids and chloride were found in the low flow months, so the possibility of improved water quality at high flow due to the dilution effect of pollution is considered.

In any case, it is considered that the effluent from the plant will not contribute to the degradation of the water quality of the Paraguay River, as it will comply with Paraguayan legislation (Resolution SEAM Nº 222/02) and international guidelines, in addition to the small volume foreseen (77.3 m^3 /h).

Taking into account the water quality data of the Paraguay River, obtained both for the present study and for the Omega Green study, organic pollution is one of the main concerns, in addition to oils and grease, which calls for greater control and monitoring of domestic effluent discharges along the river, as well as possible fuel or lubricating oil leaks from barges operating in the area.

With regard to the reduction in the flow of the Paraguay River, taking into account its average annual flow (3,200 m^3 /s), the flow to be captured for the Project, 242.70 m^3 /h (0.0674 m^3 /s), represents only 0.0021% of this total. Taking into account the minimum flow of the river, which is 2,701 m^3 /s, the percentage varies slightly to about 0.0025%.
However, it is important to remember that of the total flow to be extracted (242.70 m^3 /h), 77.30 to 84.20 m^3 /h will be returned to the river as treated effluent, resulting in a net extraction balance of 165.4 to 158.5 m^3 /h, respectively. These values correspond to 0.0016% or 0.0013% of the river's mean flow and 0.0019% or 0.0015% of its minimum flow.

In any case, it is interesting to consider the cumulative effects of the reduction in the flow of the Paraguay River, especially considering the most intensive uses. As presented in **Section 5.2.2.2.2.3**, it was found that for the District of Villeta (period from 2010 to 2014) the largest surface catchments were made by the industrial sector, with around 60.35%, followed by agricultural uses with around 29.25%.

Even considering the total abstraction of the Villeta District and the extreme scenario that everything would be abstracted from the Paraguay River, which is not real, a total abstraction of 3.70 m^3 /s or about 0.11% of the average annual flow of the Paraguay River (3,200 m^3 /s) was estimated.

In turn, based on data from some of the RIMAs consulted for industrial plants planned for the District of Villeta, it was verified that the catchment flows varied between 3.5 m^3 /h and 96.88 m^3 /h, the latter referring to the Omega Green Project, mentioned above. The RIMA for this plant reports that this water flow is needed as input for the electrolysis process and for the crusher. However, it does not report the rest of the flow needed for other uses. As for the origin of this water, the Environmental Audit Report of the Omega Green Project states that, in addition to the groundwater collection, water from the Paraguay River will also be used. However, neither this report, nor the RIMA, informs on the flow to be captured from each of the sources. The other RIMAs consulted indicate that the main source of water is from underground wells, in addition to the urban supply network.

The impact of the ATOME Project on this stretch of the Paraguay River due to flow reduction must be assessed in relation to the baseline, considering the current estimates of abstractions mentioned above, and the quality data resulting from the baseline sampling carried out for this study and those of the Omega Green project. The potential for cumulativity is assessed in **Section 6.1.5**.

Thus, considering that the ATOME and Omega Green Plants are potentially the largest consumers of water from the Paraguay River along the IIA, the sum of their withdrawals results in approximately 339.58 m^3 /h or 0.0029% of the average annual flow of the Paraguay River (3,200 m^3 /s) and 0.0035% of its minimum flow. However, as mentioned above, a part of this flow will return to the river at the same catchment point in the form of treated effluent, reducing the impact. Furthermore, there is no concrete information if or when the Omega Green Project will be built.

Therefore, the potential of the catchment for the ATOME Plant to concentrate pollution of the river and cause degradation of water quality is considered to be very low, even considering other industrial plants existing or planned for the IIA.

The ATOME Project will seek continuous improvement to maintain effluent discharge levels within required water quality standards, minimise water consumption, increase reuse, and consider alternative uses of groundwater.
Mitigation Measures

The measures to be applied to control and mitigate the impact are the efficient use of water during the operation of the plant, compliance with the flow limit to be taken from the Paraguay River, and the treatment of effluents according to national and international standards (adopting the most restrictive limits) to return treated effluent to the river with good quality. In addition to these measures, the following are mentioned:

- **Environmental and Social Management Programme for the Operational Phase**
  - Maintenance of the WWTP to ensure performance and effluent quality
  - Supervision of contracted companies

Monitoring Measures

- **Environmental and Social Management Programme for the Operational Phase**
  - Monitoring of treated effluent
  - Monitoring of water quality and volume of water abstraction

Rating of the resulting impact

With the implementation of all planned measures, the impact resulting from the operation phase is negative, of indirect impact and with scope in the IIA. It is of low probability, of immediate occurrence, fully reversible. It is considered an impact of low magnitude and low importance. It corresponds to a potentially cumulative impact, as will be seen in **Section 6.1.5**. Given that it is an impact that is easy to mitigate, the residual significance is also low.

Impact rating (attributes) **Impacts on the water quality of the Paraguay River due to reduced flow and discharge of treated effluents.**			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Operation	**Advocacy**	Indirect
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		
Mitigability	Highly Mitigable		
Residual importance	Baja		

2.02 - Impact on the water quality of the Paraguay River during the implementation of water harvesting infrastructure

Impactful actions	A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.06 Earthworks A.2.07 Execution of foundations A.2.08 Civil works A.2.09 Assembly A.2.13 Demobilisation of support areas A.2.15 Recovery of direct intervention areas
Impact Component	C.1.02 - Surface and groundwater resources

Analysis of potential impact

The implementation of the water catchment infrastructure on the banks of the Paraguay River will involve the removal of vegetation and land clearing, excavations, execution of foundations and slope protection structures, in addition to the civil works for the construction of the pumping house. In part, these actions will be carried out in areas that are already susceptible to the lateral and marginal erosion process of the river. In this way, construction actions may also contribute to the intensification of existing erosion processes.

It is considered that the structures will be implemented during periods of low water in the Paraguay River. Therefore, these actions have the potential to result in soil exposure and cause changes in water quality, mainly through the intensification of erosion processes and the entry of sediment into the water.

Potential changes in the physical properties of the water with a consequent change in quality include alterations in colour, increased turbidity and increased concentration of total solids. Potential chemical alterations arise mainly from the contribution of pollutants present in the sediment. As seen in **Section 5.2.2.5**, the analyses of the sediment sample collected at the site planned for the construction of the water intake structure showed that most of the parameters that have limits set by international standards are below them. However, the value for nickel exceeded the standard limit, and total phosphorus, although not limited by the guidelines, was elevated, indicating probable contamination by fertilisers used in surrounding agricultural areas. Analyses of water samples collected at the same site also indicate this probable contamination.

As shown in **Section 5.2.2.3**, the water samples analysed indicated high levels of total and faecal coliforms, total nitrogen and total phosphorus at the three points sampled in March (C1) and June (C2) 2023. For the latter two parameters, the values were always above the limits established by the legislation for Class 2 waters. As for dissolved oxygen, the results did not meet the minimum limit of 5 mg/L in the March 2023 campaign, the flood period of the Paraguay River. Also in non-compliance with the quality standards, the presence of oils and fats, high water colour levels, as well as concentrations of aluminium, soluble iron and manganese were observed. For the other parameters, the limits established by the legislation for Class 2 water were met. Thus, it can be observed that the waters of the Paraguay river already show the occurrence of quality parameters that are not in accordance with the established standards, even taking into account its high flow rates and the corresponding dilution capacity.

Alterations in water quality, both physical and chemical, may represent interference with the habitat of aquatic communities. It is important to note that the area of the pump house is very small and excavation/dredging activities will have a short-term duration. In addition, construction activities will apply state-of-the-art methodologies/technologies to minimise sediment mobilisation and erosion processes.

Mitigation Measures

Given these potential conditions, the following measures are foreseen in the ESMP to prevent, control and mitigate this impact:

- **Environmental Construction Control Programme**
  - Control of vegetation clearance activities
  - Management of earthmoving activities, including good practices for excavation, dredging and erosion control processes.
  - Construction traffic control
  - Water and effluent management
  - Prevention and control of soil contamination
  - Solid waste management
  - Hazardous materials handling
  - Recovery of areas degraded by the works
  - Environmental quality monitoring measures

- **Environmental and Social Management Programme**
  - Construction Supervision, including Contractors and Subcontractors
  - Conformity Assurance Procedure
  - Coordination of Socio-Environmental Programmes of the GSAP

- **Labour Management and Working Conditions Programme**
  - Job Training

Rating of the resulting impact

This impact of the construction phase has a negative nature, small area of influence (extent in the AID, direct incidence and low probability of occurrence. The induction is immediate and the duration is short term due to the small size of the structure to be built. After completion of the water intake infrastructure implementation activities, no sediment and associated pollutants are expected to reach the river. It is a reversible and localised impact due to the size of the pumping house and is considered to be of low magnitude and low significance. This is a fully mitigable impact and therefore of low residual significance.

Impact rating (attributes) **Impact on the water quality of the Paraguay River due to the implementation of water harvesting infrastructure**			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term

Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		
Mitigability	Fully Mitigable		
Residual importance	Baja		

3 - Air Quality Impacts

3.01 - Impact on air quality during construction

Impactful actions	A.2.02 Mobilisation of construction support areas A.2.05 Flows of vehicles, equipment and workers A.2.06 Earthworks A.2.12 Operation of construction support facilities A.2.15 Recovery of direct intervention areas
Impact Component	C.1.03 - Air Quality

Analysis of potential impact

This impact is mainly associated with the suspension of dust and emissions of atmospheric pollutants from mobile sources (equipment and vehicles). The first aspect is the result of land clearing activities, excavations and earthworks for the construction camp, opening of accesses, excavation for the placement of the underground piping for water collection and execution of the foundations of the Plant structures and the towers of the TL, in addition to the circulation of vehicles on the unpaved internal accesses.

Atmospheric emissions from mobile sources, in turn, derive from the use of vehicles and equipment (generators, tractors, backhoes, etc.) at the work fronts, in the construction camp and during the transport of materials on the roads to be used for the works. The combustion of hydrocarbon derivatives in equipment and vehicles generates emissions of sulphur and nitrogen oxides and carbon dioxide and monoxide, with potential negative effects on local air quality. In this case, the potential impact is related to the maintenance conditions of the equipment and machinery that use these fuels.

As indicated in Action A.2.05 in **Section 6.1.2**, heavy vehicle traffic related to the project is estimated at up to 1 to 8 daily bus trips for transport of workers during the construction period, a total of 5,430 truck trips in a 90-day period for transport of fill material, 450 trips spread over 5 months for transport of containers with imported goods, as well as transport of oversized loads.

Dust suspension and gas emissions may cause nuisance to the four to six residents of the house next to the Plant, as well as possible damage to vegetation and wildlife.

As the Villeta - Alberdi road is all paved along the stretch between Villeta and the plant site, in addition to the access roads between Asunción and Villeta that may be used during the works, the inconvenience to the inhabitants around the roads to be used will only be related to the emission of exhaust fumes from construction vehicles, but due to the existing number of vehicles on the road compared to the number of vehicles associated with the project, the impact of the

project is small. It is important to compare the Project traffic in relation to the average number of vehicles per day on the roads to be used during the works. **Table 6.1.3.1.1.a below** compares the trips that will be made during the Project works and the percentage they represent in relation to the equivalent vehicles per day on the two roads to be used, according to the calculations shown in **Tables 6.1.3.3.a** and **6.1.3.3.3.b** in **Section 6.1.3.3**.

Table 6.1.3.1.1.a
Project trips in relation to average traffic on roads

Project Journeys	Equivalent vehicles per day - Route Villeta - Alberdi	% of total	Equivalent vehicles per day - South Access	% of total
1 bus trip per day	48.4	2.1	255.2	0.4
8 daily bus journeys	48.4	16.5	255.2	3.1
6 truck trips per day with backfill material	178.5 / 376.2	3.4 / 1.6	1,558.9 / 2,149.4	0.4 / 0.2
3 truck trips per day for transport of containers with imported goods	178.5 / 376.2	1.7 / 0.8	1,558.9 / 2,149.4	0.2 / 0.1
1 oversized cargo trip every 4 days between January and December 2025	760	0.3	2,545	0.04

Taking into account the above figures, it is noted that the Project's heavy vehicle traffic does not represent a material impact on the traffic on the roads to be used and therefore should not be responsible for the deterioration of air quality due to exhaust emissions.

Also in view of the aforementioned figures, it is not considered that this incremental traffic of the Project could represent a nuisance for the residents of the Sol Naciente and Don Bosco settlements, which are on the margins of the Ruta Villeta - Nueva Italia, which is parallel and close (220 m) to the Ruta Villeta Alberdi.

Mitigation Measures

The measures aimed at preventing and mitigating this impact are included in the **Environmental Control Programme for Construction**, highlighting the procedures for controlling dust emissions, including soil wetting to minimise emissions during the dry season, and emissions of combustion gases from construction vehicles and equipment, which are required at each work or activity site, and the maintenance of vehicles and equipment. The environmental control measures for vegetation removal activities are also included in this Programme, with the prohibition of the use of fire, as well as procedures to optimise works and minimise the use of machinery and equipment and, consequently, atmospheric emissions and the management of temporary facilities/construction camp, which foresees the maintenance of emergency generators. In addition, it is mentioned that it will be a requirement of the contract with the EPCists that only heavy vehicles and equipment in good working order will be allowed to enter the Plant, which will also contribute to avoid small spills and ensure that combustion emissions from equipment and vehicles are within the limits set by standards.

It also mentions the Construction Supervision and Environmental Quality Monitoring Measures

to be implemented by ATOME as part of the **Environmental and Social Management Programme** and the measures of the **Stakeholder Engagement Programme**, mainly the communication with potentially affected people and the Complaints, Grievances and Concerns Mechanism.

Monitoring Measures

Environmental Construction Control Programme

- Visual emission monitoring (Ringelmann scale) of construction vehicles and machinery
- Monitoring of atmospheric emissions from stationary sources

Rating of the resulting impact

This negative impact of the construction phase reaches into the ADA/AID (and may disturb the four workers on the neighbouring property) and extends into the IIA to include the access roads. It is direct, immediately induced and of short duration. It is reversible and certain to occur. The magnitude is low and the significance is medium, but for the residents of the neighbouring property it is considered medium to high. It is a highly mitigable impact, which has resulted in a moderate residual significance.

Impact rating (attributes) **Impacts on air quality during construction**			
Nature	Negative	**Location and spatialisation**	DAI and IIA
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Low and Medium to High for the residents of the neighbouring house.		
Importance	Medium and Medium to High for neighbouring residents		
Mitigability	Fully Mitigable		
Residual importance	Moderate for neighbouring property workers		

3.02 - Impact on air quality during operation

Impactful actions	A.1.03 Studies of locational and technological alternatives A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.05 Environmental controls during operation
Impact Component	C.1.03 - Air Quality

Analysis of potential impact

During the operation of the plant, gases will be emitted into the atmosphere. To assess the impact of atmospheric emissions from the operation of the Plant on air quality and compliance with national and international standards, an atmospheric dispersion study was conducted considering the preliminary stationary gas emissions expected from the Plant, meteorological conditions and baseline air quality data. The AERMOD Gaussian plume dispersion model (AERMOD View software version 12.0.0 from Lakes Environmental) was used for the study. The full dispersion study report is presented in **Annex 4**. It is important to note that the atmospheric dispersion modelling has been carried out using preliminary data, as the design has not been finalised. It is expected that a new AERMOD will be conducted with final engineering data and atmospheric emission guarantees.

The points of the Plant where gases will be emitted are listed below and are indicated in **Figure 6.1.3.1.a**.

E1 - O-enriched air outlet$_2$ in USA
E2 - Venting of O_2 at the H Plant$_2$
E3 - Venting of H_2 at the H_2 Plant (intermittent)
E4 - NH main flare$_3$
E5 - Discharge from the Nitric Acid Plant (NA) following mitigation
E6 - Venting of process gas from the NH Synthesis Unit$_3$
E7 - NH secondary flare$_3$
E8 - Dust outlet of the grinding plant
E9 - Dust output from the pelletising plant
E10 - Fire System Diesel Generator Exhaust stack
E11 - Emergency Generator Exhaust Stack
E12 - AN Plant Auxiliary Boiler Exhaust Stack

According to engineering information, a part of the continuously emitted gases (i.e., H_2 , N_2 , H_2 O, O_2 and Argon) are not pollutants, considering that atmospheric air is composed of 78% N2, 20.9% O_2 , 0.96% Argon, 0.014% CO_2 and H_2 O (in the form of water vapour), additionally, it contains traces of gases such as neon, helium, methane and krypton. In addition, some emissions will be one-off and intermittent. However, there are some emissions from the Plant that, despite their small volume, are pollutant gases to be emitted continuously and therefore require greater control and demonstration of compliance with the standards. This is the case of the emissions foreseen in the main and secondary NH_3 flares (E4 and E7), in the nitric acid (AN) plant discharge after mitigation (E5), in the dust outlet of the grinding plant (E8) and in the dust outlet of the granulation plant (E9).

Figure 6.1.3.1.1.a

Location of equipment with atmospheric emissions in the operation. E1 to E3, E6: Non-polluting gases; E4, E5, E7, E8 and E9: Continuous emission sources; E10, E11, E12: Intermittent emission sources (scheduled events or contingencies).

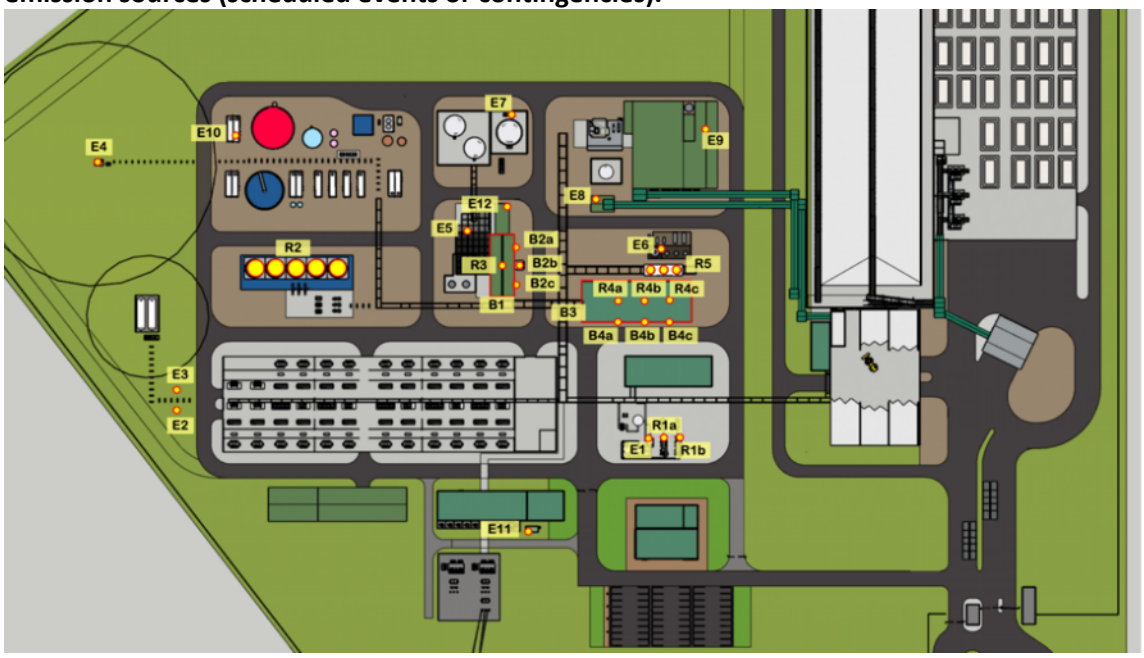


Table 6.1.3.1.1.b below, extracted from the **Annex 4** report, shows the characteristics of these 5 Project stationary sources and the emission rates for each air pollutant.

Emissions from these 5 sources were modelled using the AERMOD version 12.0 model mentioned at the beginning of this section, and the main findings are described below.

As results of the dispersion modelling, maximum values were obtained for each of the air pollutants in regime operating situation, which were added to the results of the measured concentrations in the field for the baseline. The results are shown in **Table 6.1.3.1.c** below, compared to the limits in Resolution No. 259/15 and to the IFC Guidelines standards (which are the same as those of the World Health Organisation - WHO).

In the sequence to the Tables, **Figures 6.1.3.1.b** to **6.1.3.1.f** are presented with the isoconcentration maps resulting from the operation of the Plant in regime conditions for the periods of 1, 8 and 24 hours, as well as for the annual period.

Table 6.1.3.1.b
Emissions and exhaust data from stationary sources provided by the Project

		Continuous operation (in steady state) - normal operation				
		E4 - NH main flare$_3$	E5 - Discharge from AN Plant after mitigation	E7 - NH secondary flare$_3$	E8 - Dust outlet of the grinding plant	E9 - Dust output from the pelletising plant
Transmitter characteristics	Chimney outlet height above ground level (m)	16	59,2	16	15	72
	Inner diameter (m)	0.61	0.95	0.61	0.8	3.3
Characteristics of the issue	Emission flux (Nm^3 /h)	98	58,212	98	17,000	220,000
	Output temperature (°K)	1,173	433	1,173	358	323
Emission rates (g/s)	Particulate matter (PM)$_{10}$	-	-	-	PM$_{10}$: 0.175	3.06
	Particulate matter (PM)$_{2.5}$	-	-	-	PM$_{2.5}$: 0.061	-
	Nitrogen oxides (NO)$_2$	0.0028	0.33	0.0028	-	-
	Carbon monoxide (CO)	0.0153	-	0.0153	-	-
	Ammonia (NH)$_3$	-	0.061	-	-	3.06

Table 6.1.3.1.c
Modelling results obtained during steady-state operation and comparison with the reference standard

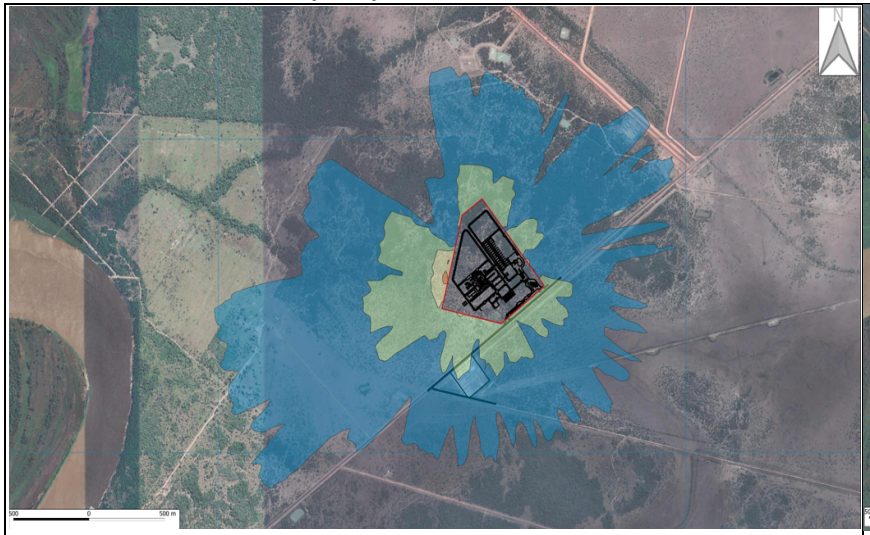
Parameter	Period	Modelling results (µg/m)^3	Baseline (µg/m)^3	Modelling results + baseline (µg/m)^3	Resolution Paraguay N° 259/15 (µg/m)^3	IFC Guidance (WHO 2021) (µg/m)^3
CO	1 h	21.2	768[1]	789.2	-	35,000
	8 h	7.7	400	407.7	10,000	10,000
	24 h	3.1	400	403.1	-	4,000[2]
NO_2	1 h	3.5	3.8	7.3	200	200
	24 h	0.6	2.7	3.3	-	25[2]
	Annual	0.05	Not available	Not calculated due to missing baseline value	40	10
PM_{10}	24 h	8.1	15	23.1	150	-
	24 h - 99th percentile. 4to day higher concentration[2]	5.5		20.5	-	45[2]
	Annual	1.1	Not available	Not calculated due to missing baseline value	-	15
$PM_{2,5}$	24 h	4.2	10	14.2	30	-
	24 h - 99th percentile. 4to day higher concentration[2]	3.5		13.5	-	15[2]
	Annual	0.7	Not available	Not calculated due to missing baseline value	15	5
NH_3	1 h	11	Not available	Not calculated due to missing baseline value	-	-

[1] Maximum concentration measured in 10 minutes

[2] 99th percentile (i.e. 3-4 days of exceedance per year).

Source: Air Quality Modelling Report. CSI Engineers (2023) (**Annex 4**).

Figure 6.1.3.1.b
CO isoconcentration map – operation in 1, 8 hours and 24 hours

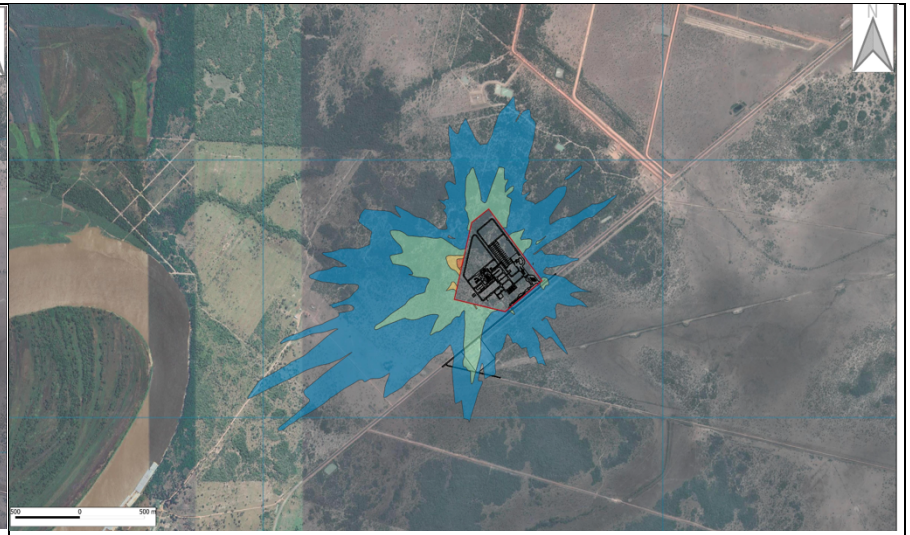


REFERENCIAS

Atome
Límites Atome

CO, concentración en 1 h (µg/m3)
3 a 7
7 a 15
15 a 20
20 a 22

Operation in regime – 1 hour

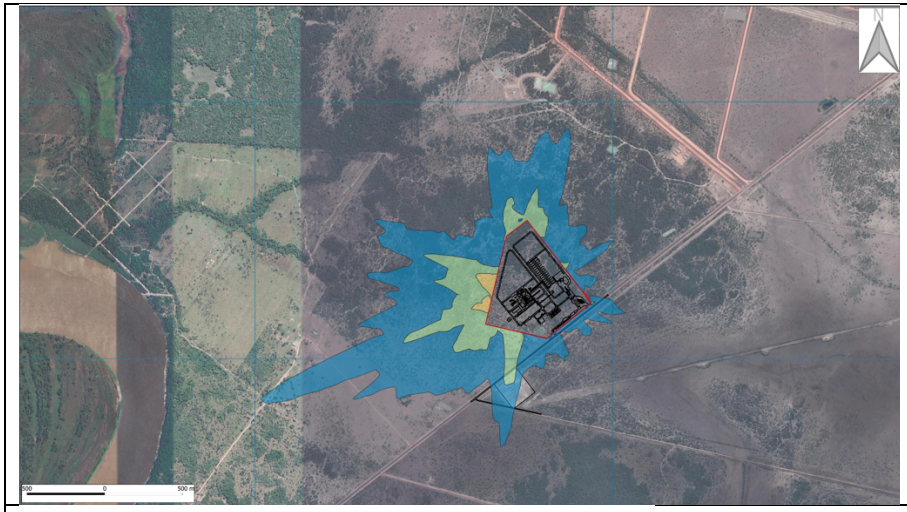


REFERENCIAS

Atome
Límites Atome

CO, concentración en 8 hr (µg/m3)
1 a 2
2 a 5
5 a 7
7 a 7,7

Operation in regime – 8 hours



REFERENCIAS

Atome

Límites Atome

CO, concentración en 24 hr (µg/m3)

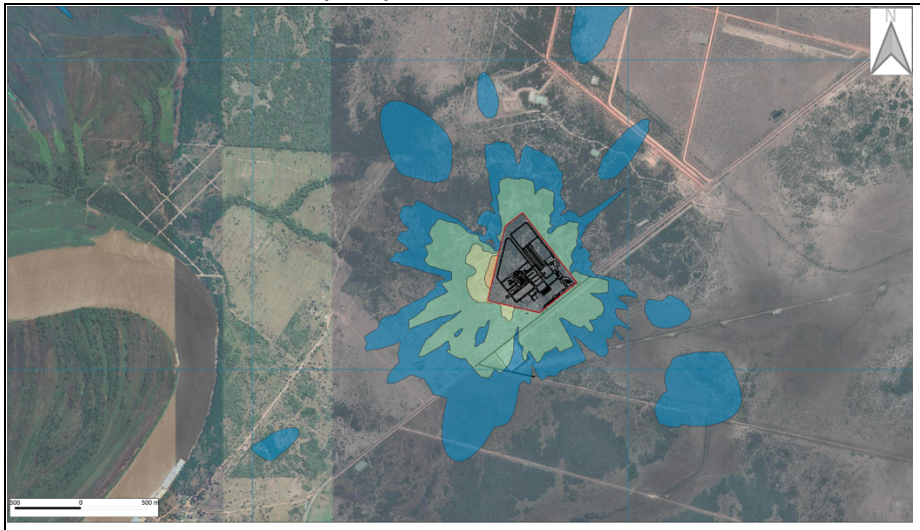
0,5 a 1

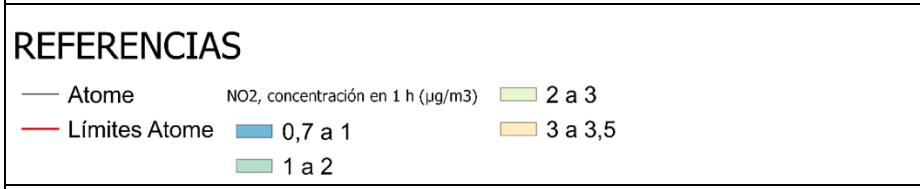
1 a 2

2 a 3,1

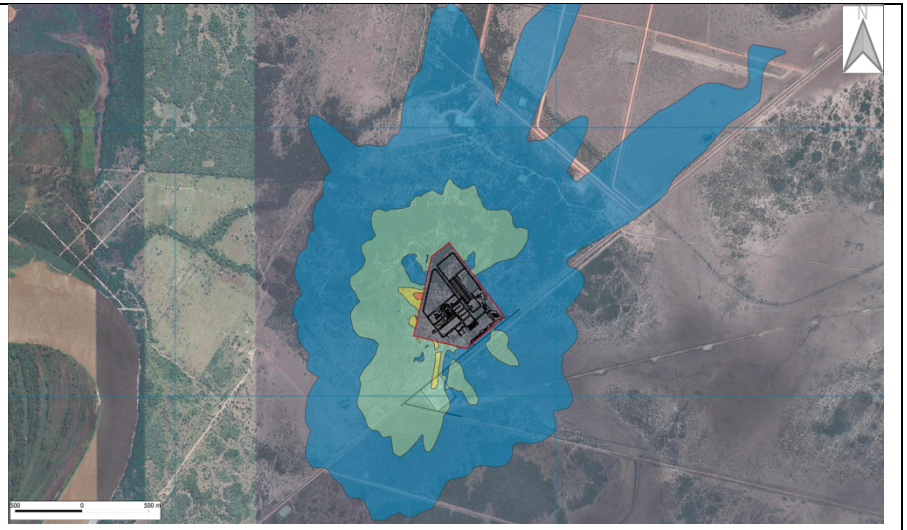
Operation in regime – 24 hours

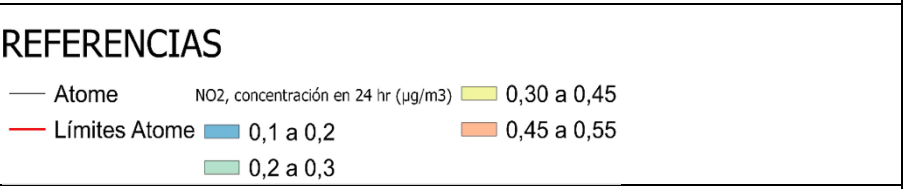
Figure 6.1.3.1.c
NO_2 isoconcentration map – operation in 1 and 24 hours and annual





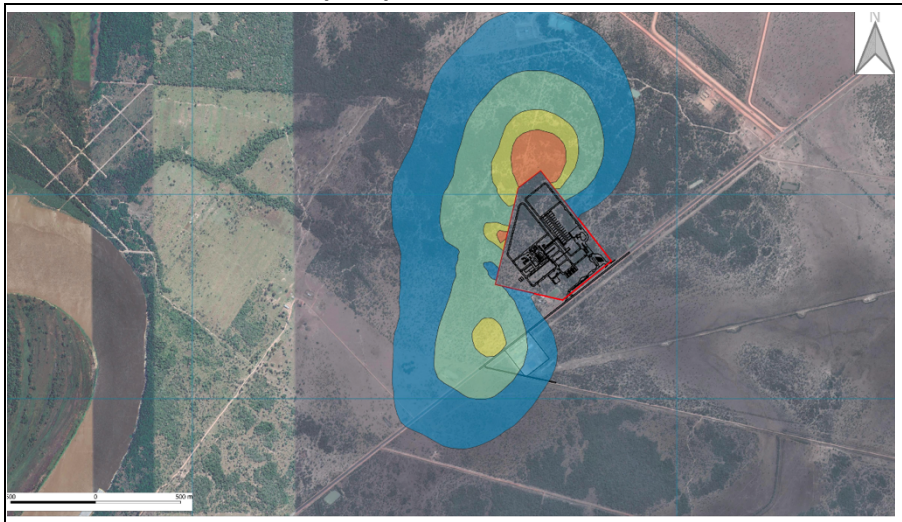
Operation in regime – 1 hour





Operation in regime – 24 hours

Figure 6.1.3.1.c
NO_2 isoconcentration map – operation in 1 and 24 hours and annual



REFERENCIAS

Atome

Límites Atome

NO2, concentración Anual (µg/m3)

0,02 a 0,03

0,03 a 0,04

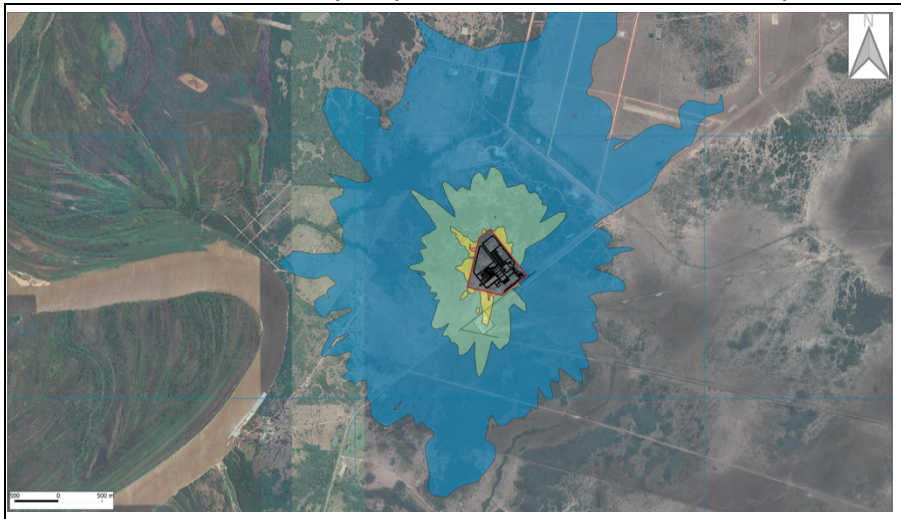
0,04 a 0,045

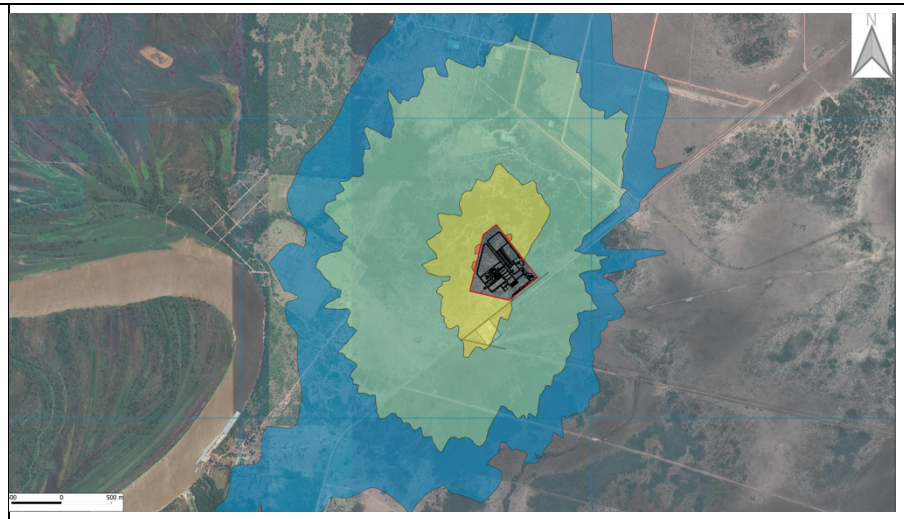
0,045 a 0,05

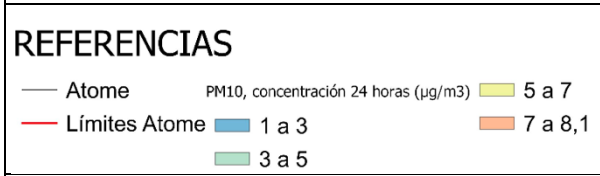
Operation in regime – Annual

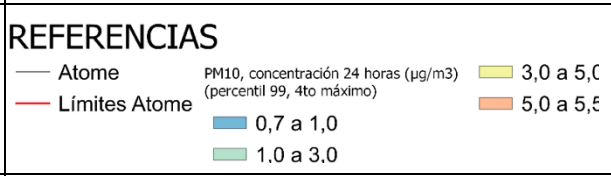
Figure 6.1.3.1.d

PM_{10} isoconcentration map – operation in 24 hours, 24 hourse percentile 99* and annual





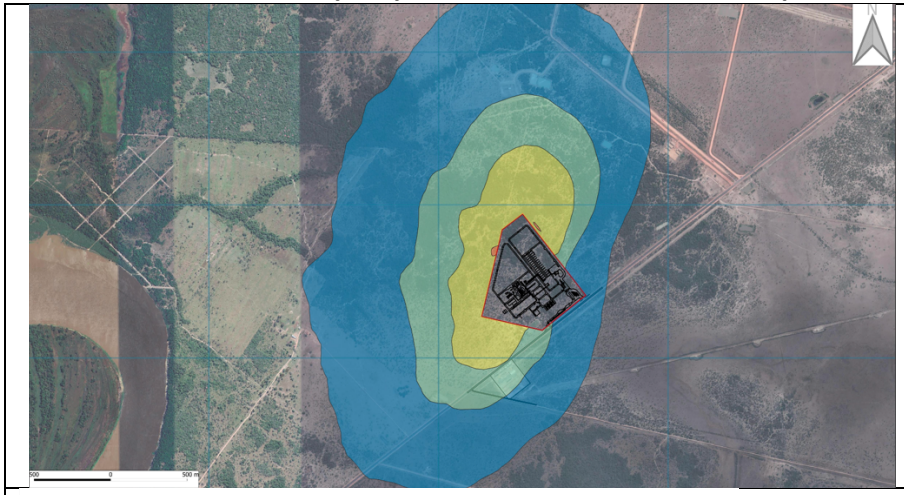


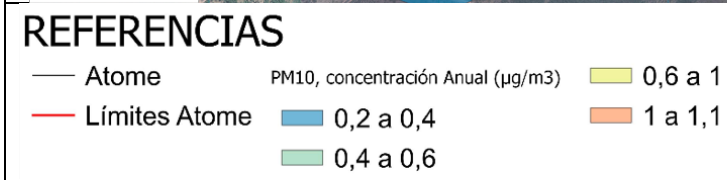


Operation in regime – 24 hours	Operación in regime – 24 hours percentile 99, 4th max

Figure 6.1.3.1.d

PM_{10} isoconcentration map – operation in 24 hours, 24 hourse percentile 99* and annual





Operation in regime – Annual

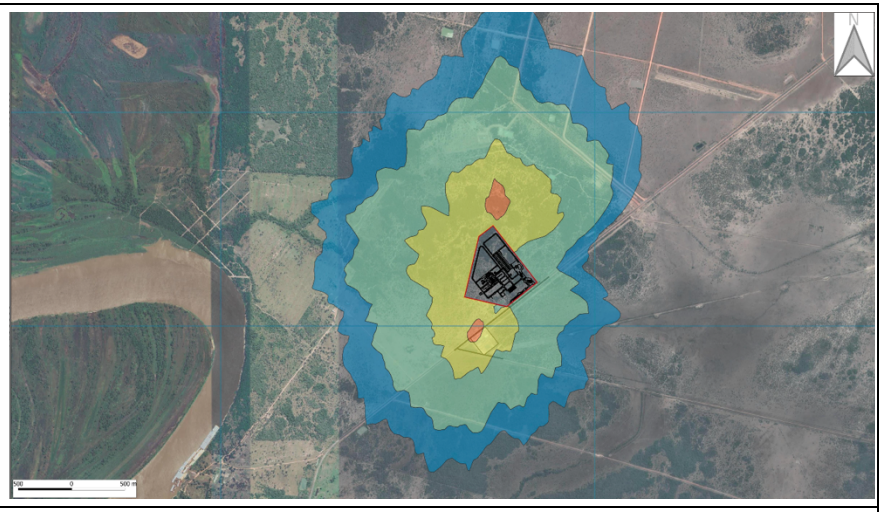
*99th percentile – corresponds to the 4th day of highest concentration (the IFC guideline states that the maximum expected target quality value corresponds to the 99th percentile, which implies that it can be exceeded in 3 to 4 days a year

Figure 6.1.3.1.e

$PM_{2.5}$ isoconcentration map – operation in 24 hours, 24 hours percentile 99 and annual



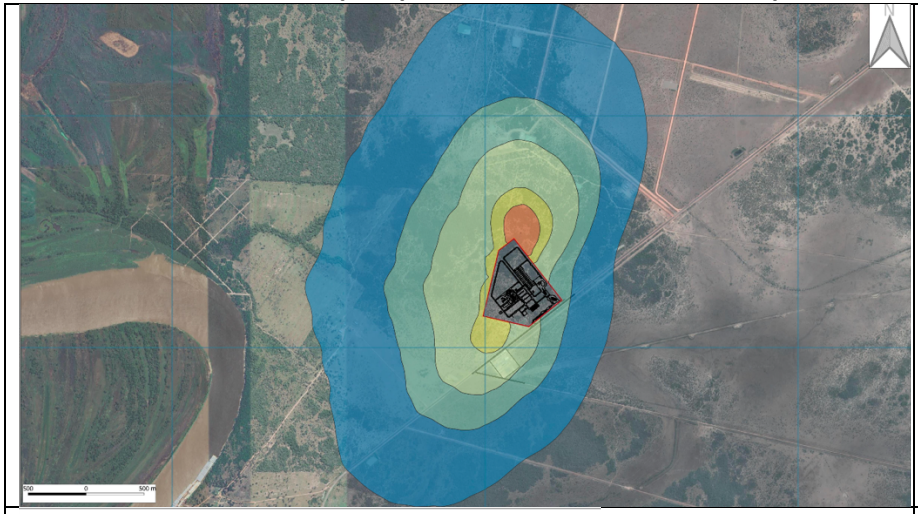
Operation in regime – 24 hours

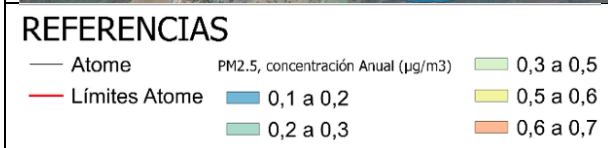


Operation in regime – 24 hours percentile 99, 4th max

Figure 6.1.3.1.e

$PM_{2.5}$ isoconcentration map – operation in 24 hours, 24 hours percentile 99 and annual

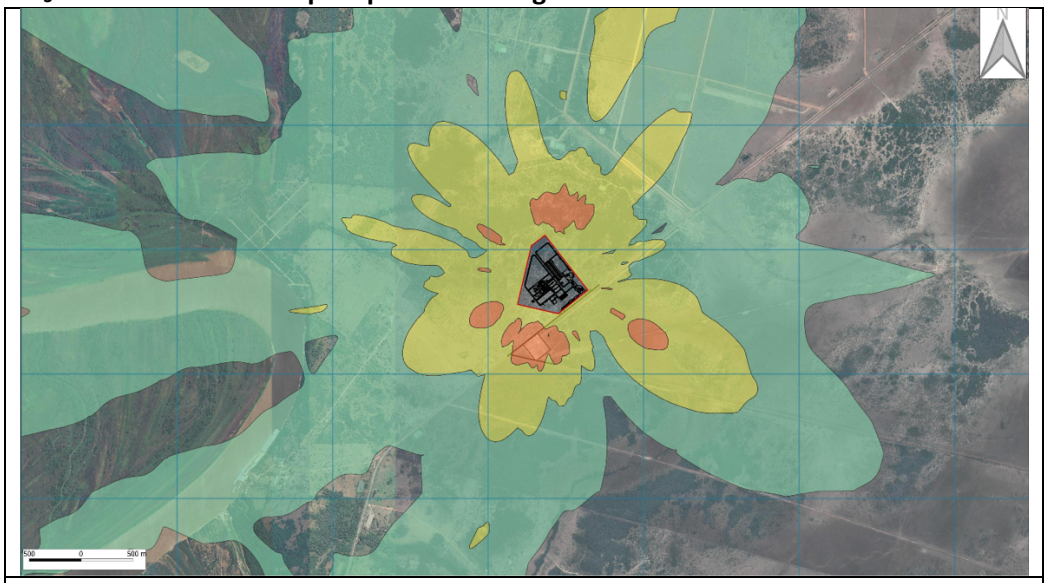




Operation in regime – Annual

Figure 6.1.3.1.f

NH_3 isoconcentration map – operation in regime 1 hour



Operation in regime – 1 hour

As the above Figures and the results in **Table 6.1.3.1.c** show, with respect to the CO parameter, the increase generated by the project will be very small compared to the baseline, and the expected concentrations in the future scenario (project + baseline) are significantly lower than the limits of Resolution No. 259/15 and the IFC Guidance.

With respect to NO_2 , both the Project's contribution and the current situation (baseline) show low values in periods of 1 and 24 hours, so that the target quality values are not expected to be exceeded in the future situation. The annual target quality value is not expected to be exceeded either, as the incremental contribution of the Project will be very low.

With regard to the emission of particulate matter (PM_{10} and $PM_{2.5}$), the incremental contribution of the Project is low, both for the daily and annual period. The future situation (baseline + project operating) complies with the target quality values of the Paraguayan regulations and the IFC Guide. With respect to the annual concentration values of PM_{10} and $PM_{2.5}$, in the absence of the characterisation of the current situation (baseline) it is not possible to predict the level of compliance of the future situation. Nevertheless, it would be reasonable to assume that the annual values foreseen in the Paraguayan regulations and reference guidelines will not be exceeded, due to the limited incremental contribution that the project is expected to generate.

With respect to ammonia emissions (NH_3), the Project foresees a low magnitude emission during operation. The maximum predicted hourly concentration is significantly lower than the guideline value of 1,400 µg/m^3 established by the Alberta Environment Authority, Canada, which is used as a reference in this case.

Therefore, no impact on future air quality is foreseen as a result of the Project's operation in regime (continuous operation under normal operating conditions).

For non-routine emissions, mitigation measures will be considered, including communicating with neighbours about these emissions and highlighting and encouraging the use of the complaints mechanism.

Based on the isoconcentration maps presented in **Figures 6.1.3.1.b** to **6.1.3.1.f** and the location of the house neighbouring the future Plant, the pollutant concentrations near the nearest house were estimated during operation at steady state. The estimated values are shown in **Table 6.1.3.1.1.d** and are summed with the baseline results. As can be seen, all values comply with the limits of Resolution N° 259/15. As for the IFC Guidance, almost all the established limits are complied with. Only for $PM_{2.5}$ the guideline value is exceeded by 2.3 µg/m^3 , but the fourth intermediate target is met. For this reason, it is again emphasised that the project will provide for additional mitigation measures to reduce $PM_{2.5}$ and PM_{10} emissions.

Table 6.1.3.1.1.d
Sum of calculated and measured concentrations at the neighbouring house site

Parameter	Period	Modelling results (µg/m)[3]	Baseline (µg/m)[3]	Sum (µg/m)[3]	Res. N° 259/15 (µg/m)[3]	IFC Guidance (WHO 2021) (µg/m)[3]	% of the sum (highest value) in relation to the most restrictive limit
CO	1 h	7 a 15	768[1]	775 - 783	-	35,000	2.2
	8 h	2 a 5	400	402 - 405	10,000	10,000	4.0
	24 h	0.5 a 1	400	400.5 - 401	-	4,000[2]	10.0
NO_2	1 h	1 a 2	3.8	4.8 a 5.8	200	200	2.9
	24 h	0.2 a 0.3	2.7	2.9 a 3	-	25[2]	12
	Annual	0.05	Not available	Not calculated due to lack of baseline value*.	40	10	-
PM_{10}	24 h	7 a 8.1	15	22 a 23.1	150	-	15.4
	24 h - 99th percentile. 4to day higher concentration[2]	3 a 5		18 a 20	-	45[2]	44.4
	Annual	0.6 a 1	Not available	SC	-	15	5.3
$PM_{2,5}$	24 h	2 a 3	10	12 a 13	30	-	43.3
	24 h - 99th percentile. 4to day higher concentration[2]	2 a 3		12 a 13	-	15[2] (guide)	86.6
	Annual	0.3 a 0.5	Not available	SC	15	5	-
NH_3	1 h	6 a 9	Not available	SC	-	-	-

*SC: not calculated due to lack of baseline value.
[1] Maximum concentration measured in 10 minutes
[2] 99th percentile (i.e. 3 to 4 days of exceedance per year)

Mitigation Measures

It is worth mentioning that the stacks will be designed to meet the environmental performance requirements related to fume burning capacity, opacity limits, and the concentration of pollutants at ground level allowed in relation to Paraguay's environmental legislation. In addition to the control technologies incorporated into the stack design, **Tables 2.3.2.2.1.2.a** and **2.3.2.2.2.2.a** also mention actions taken in the design of the NH Synthesis Unit$_3$ and the Nitric Acid Plant to mitigate the impact on air quality in the operation of the Plant, which are mentioned below:

- NH Synthesis Unit$_3$:
  - choice of AMOMAX-Casale catalyst;
  - production of ammonia from electrolytic hydrogen;
  - reuse of condensates from scrubbers, blowdowns and flash tanks in processes within the ammonia plant and/or AN plant, in a closed loop;
  - implementation of an advanced process control system;
  - use of indirect heat exchangers in the ammonia synthesis reactor.

- AN plant:
  - installation of air stream and liquid/steam ammonia filters to remove impurities from the raw material;
  - installation of static air-ammonia mixer to avoid excess ammonia in the burner and overheating of the catalyst;
  - control of the distribution of the air-ammonia mixture, speed, contact time and oxidation temperature in the catalyst;
  - monitoring of N_2 O levels in the tail gas;
  - optimisation of NH_3 /air and of pressure and temperature conditions in oxidation;
  - use of an abatement system consisting of Fe and zeolite catalysts at the tail gas outlet.

The maintenance of equipment and machinery to be carried out by the Plant's O&M workers is included as part of the **Operation Phase Environmental and Social Management Programme**.

It is also worth mentioning the Stakeholder **Involvement Programme**'s Complaints Handling Mechanism, through which complaints from the population regarding a worsening of air quality related to the Project will be received, which may require the intensification of monitoring and the proposal of complementary mitigation and attenuation measures.

Monitoring Measures

Environmental and Social Management Programme of the Operation Phase

- Air quality monitoring and monitoring of atmospheric emissions from chimney stacks

Rating of the resulting impact

Considering the correct implementation of control technologies to minimise/control emissions, the impact on air quality is rated as negative, of operation phase occurrence, and of extent in the AID. It is direct, short-term induction after the start of operation, and long-lasting. It is mitigable and certain. It is of medium magnitude and significance. This is an impact with a

potential cumulative effect, as will be discussed in **Section 6.1.5**. As mentioned above, these are preliminary results, as the design is not yet finalised. As engineering progresses, additional design changes and control technologies will be incorporated into the project to ensure compliance with national and international standards.

Impact rating (attributes) **Impact on air quality during operation**			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Operation	**Advocacy**	Direct
Temporary (Induction)	Short Term	**Temporality (Duration)**	Long-term
Reversibility	Partially reversible	**Probability of occurrence**	True
Magnitude and Importance			
Magnitude	Media		
Importance	Media		
Mitigability	Moderately Mitigable		
Residual importance	Moderate		

3.03 - Reduction of Greenhouse Gas (GHG) emissions and carbon footprint in the production of H_2 , NH_3 and green fertilisers

Impactful actions	A.1.03 Studies of locational and technological alternatives A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.05 Environmental controls during operation
Impact Component	C.1.03 - Climate and Air Quality

Analysis of the potential impact

The 70% of ammonia produced worldwide is mainly used in fertiliser production, as well as for the refinery and industrial sector. As ammonia is the second most produced chemical in the world[1] , about 200 Mt/year[2] , and as 95% of the hydrogen feedstock is derived from fossil fuels - representing about 2% of global fossil fuel use - ammonia production is responsible for the emission of 420 Mt/year of CO_2 -eq. This is 20% of the overall chemical sector's energy consumption and about 35% of the sector's emissions. Compared to the energy sector as a whole, ammonia production accounts for about 2% of final energy consumption and 1.3% of the energy sector's emissions (including emissions related to energy and industrial processes).

It is estimated that energy demand and direct CO emissions$_2$ in ammonia production have increased by 30% since 2000, while production volumes have increased by 40%[3] . The process of ammonia production through fossil fuels is energy intensive and emission ratios of approximately 2.84 tCO_2 -eq per t NH_3 produced can be found[4] .

To decarbonise the food industry, different alternatives to the ammonia production system are key. Haber Bosch's process electrification uses electricity generated from renewable energies

[1] Driven mainly by population growth, it is projected to increase to around 270 Mt/year of ammonia by 2050.
[2] Mt: Million tonnes; t: tonnes
[3] Mt: Million tonnes; t: tonnes
[4] Energy intensities are shown in gross terms to facilitate comparison between products and sectors, i.e. excluding the amounts of steam and other energy carriers that are produced as by-products. Industrial energy consumption includes energy used in blast furnaces and coke ovens and chemical feedstock. Industrial CO2 emissions include process emissions.

for the production of green hydrogen with the water electrolysis process, resulting in virtually zero CO_2 -eq emissions during the production of ammonia and thus of fertiliser.

It is estimated that most of the impacts of ammonia production depend mainly on the methods used to produce hydrogen, which can account for around 90% of its emissions[5][6] . Production based on water electrolysis and renewable energies is found to have a favourable environmental performance in terms of reducing GHG emissions as an action against climate change[7] . The values presented in **Table 6.1.3.1.1.e** are results of the life cycle analysis (LCA)[8] , considering the carbon footprint in the construction and operation stages, for different ammonia production scenarios.

Table 6.1.3.1.1.e
Summary of CO emissions$_2$ -eq for different LCA scenarios for ammonia production - these emissions consider both construction and operational stages.

Energy source	Hydrogen production process	Emissions (t CO_2 -eq/ t NH_3)
Fossil fuels	Steam + CAUC refurbishment	1.7[9]
Fossil fuels	Steam refurbishment	2.8[10]
Wind	Water electrolysis	0.24[11]
Hydroelectric	Water electrolysis	0.66[12]
Geothermal	Water electrolysis	0.27[13]
Solar	Water electrolysis	0.7[14]

Note: CAUC: Carbon Capture, Storage and Utilisation.

The results show that the production pathways using fossil fuels have the highest values, with values of 2.75 t CO_2 -eq/t NH_3 for medium-scale production and 2.6 t CO -eq/t NH_{23} for small-scale production[15] . As mentioned above, this is mainly due to the use of fossil fuels (natural gas) as feedstock and for electricity generation. The results for the other scenarios (based on

[5] V. Singh, I. Dincer and M. Rosen, "Life Cycle Assessment of Ammonia Production Methods" *Exergetic, Energetic and Environmental Dimensions,* p. 935-959, 2018.
[6] The Royal Society, Ammonia: Zero-carbon fertiliser, fuel and energy store, 2020.
[7] B. Andrea J., K. Kevin, K. Marina, S. Daniel A., M. Jacco, M. Syed, T. Michael, R. Kevin, V.-M. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021.
[8] Life -cycle assessment: is a design tool that investigates and assesses the environmental impacts of a product or service during all stages of its existence: extraction, production, distribution, use and end of life (reuse, recycling, recovery and disposal/disposal of waste).
[9] P. Arora, I. Sharma, A. Hoadley, S. Mahajani and A. Ganesh, "Remote, small-scale, 'greener' routes of ammonia production" *J. Clean. Prod,* vol. 199, p. 177-192, 2018.
[10] P. Arora, I. Sharma, A. Hoadley, S. Mahajani and A. Ganesh, "Remote, small-scale, 'greener' routes of ammonia production" *J. Clean. Prod.* vol. 199, p. 177-192, 2018.
[11] V. Singh, I. Dincer and M. Rosen, "Life Cycle Assessment of Ammonia Production Methods" *Exergetic, Energetic and Environmental Dimensions,* p. 935-959, 2018.
[12] B. Andrea J., K. Kevin, K. Marina, S. Daniel A., M. Jacco, M. Syed, T. Michael, R. Kevin, V.-M. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021.
[13] B. Andrea J., K. Kevin, K. Marina, S. Daniel A., M. Jacco, M. Syed, T. Michael, R. Kevin, V.-M. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021.
[14] B. Andrea J., K. Kevin, K. Marina, S. Daniel A., M. Jacco, M. Syed, T. Michael, R. Kevin, V.-M. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021. Agustin and R. Angel D., "Environmental life cycle assessment of ammonia-basedelectricity" 2021.
[15] P. Arora, I. Sharma, A. Hoadley, S. Mahajani and A. Ganesh, "Remote, small-scale, 'greener' routes of ammonia production" *J. Clean. Prod.* vol. 199, p. 177-192, 2018.

electrolysis and renewable energies) are below 0.7 t CO -eq/t NH_{23} , mainly related to the energy and materials needed for the construction phase and installation of power plants.

By producing a green fertiliser from a process that uses renewable energy, coupled with the incorporation of best available technologies on the market to reduce atmospheric emissions, the Project will have the potential to significantly reduce GHG emissions in the fertiliser and food industry sector.

According to Foley *et al*. (2011), food production is responsible for about one third of the world's total greenhouse gas (GHG) emissions, which is due to deforestation, methane emissions (CH_4) from cattle and rice cultivation, and nitrous oxide (N_2 O) emissions from soil fertiliser application.

The American Chemical Society[16] cites livestock as the main culprit in the problem of GHG emissions from food, but "hidden aspects" such as fertiliser production also contribute to the 13.7 million metric tonnes of CO_2 equivalent generated by the food system. Fertilisers, plant supplements (nitrogen, phosphorus, potassium, etc.) and soil management practices are hidden contributors. Although nitrogen, phosphorus and potassium are crucial for agriculture, their sources, production and supply chains contribute to GHG emissions.

In the case of fertilisers, traditional ammonia production methods (such as the Haber-Bosch process) increase the availability of ammonia fertilisers, but also generate significant CO production$_2$. Many of the methods to meet the growing demand for fertiliser nitrogen predicted in a 2019 FAO report currently focus on traditional ammonia production practices, which would continue to increase GHG production.
According to FAO data (2021), global emissions from agriculture, including land use, were 10.7 billion tonnes of CO_2 equivalent (CO_2 eq) in 2019.

By producing CAN with renewable energies it is possible to reduce up to 50% of the life cycle emissions of CAN, as is the case of the proposed Project, standing out for this and for the agronomic advantages mentioned, as a more sustainable alternative. With the production of green CAN, it is estimated that the Project will displace around 600,000 tCO_2 -eq/year of carbon emissions in the fertiliser sector. Considering the useful life of the Project (25 years), this impact would translate into 15,000,000 tCO_2 -eq avoided.

Empowerment Measures

The measures to be implemented to increase the positive effects of the impact are:

- **Stakeholder Engagement Programme**: public consultation and outreach measures on GHG emission reduction project benefits as climate change action
- **Environmental and Social Management Programme**, specifically the Greenhouse Gas Emissions Management measure.
- **Operation Phase Environmental and Social Management Programme**: supervision of compliance with environmental and social measures in the operation phase.

[16] https://www.cas.org/resources/cas-insights/sustainability/hidden-greenhouse-gas-emissions-plant-growth

Monitoring Measures

Environmental and Social Management Programme for the Operation Phase

- Monitoring of energy consumption and fuel use at the production stage
- Air quality monitoring and monitoring of atmospheric emissions from chimney stacks

Rating of the resulting impact

This is the main impact linked to the operation of the Plant, of a positive and permanent nature. It is diffuse in scope, has an indirect impact, induction and long-term duration. Its occurrence is certain and it is partially reversible. It has a cumulative effect (see **Section 6.1.5**). Its magnitude and significance are high, as is the residual significance after the application of potentiation measures.

Impact rating (attributes) **Reducing GHG emissions and carbon footprint in the production of H_2 , NH_3 and green fertilisers**			
Nature	Positive	**Location and spatialisation**	Fuzzy
Stage of occurrence	Operation	**Advocacy**	Indirect
Temporary (Induction)	Long-term	**Temporality (Duration)**	Long-term
Reversibility	Partially reversible	**Probability of occurrence**	True
Magnitude and Importance			

Magnitude	High
Importance	High
Mitigability	-
Residual importance	High

6.1.3.2
Biotic Environment

4 - Impacts on Flora and Vegetation

4.01 - Loss of vegetation cover and individual plant species affected

Impactful actions	A.1.03 Studies of locational and technological alternatives A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.15 Recovery of direct intervention areas
Impact component	C.2.01 - Flora and Vegetation

Analysis of potential impact

The main impact on flora and vegetation will be the removal of vegetation during land clearing (A.2.03), which is necessary for the implementation of all the plant's structures. In this regard, it is important to mention that native vegetation is present on 99.18% of the land where the construction of the Plant is planned.

For the construction of the Plant, it is initially foreseen to remove an area of vegetation of 24.75 ha, corresponding to Zones A and B in **Figure 6.1.3.2.a**, below, in which there are 2.76 ha of sub-humid semi-deciduous forest and 21.99 ha of savannah.

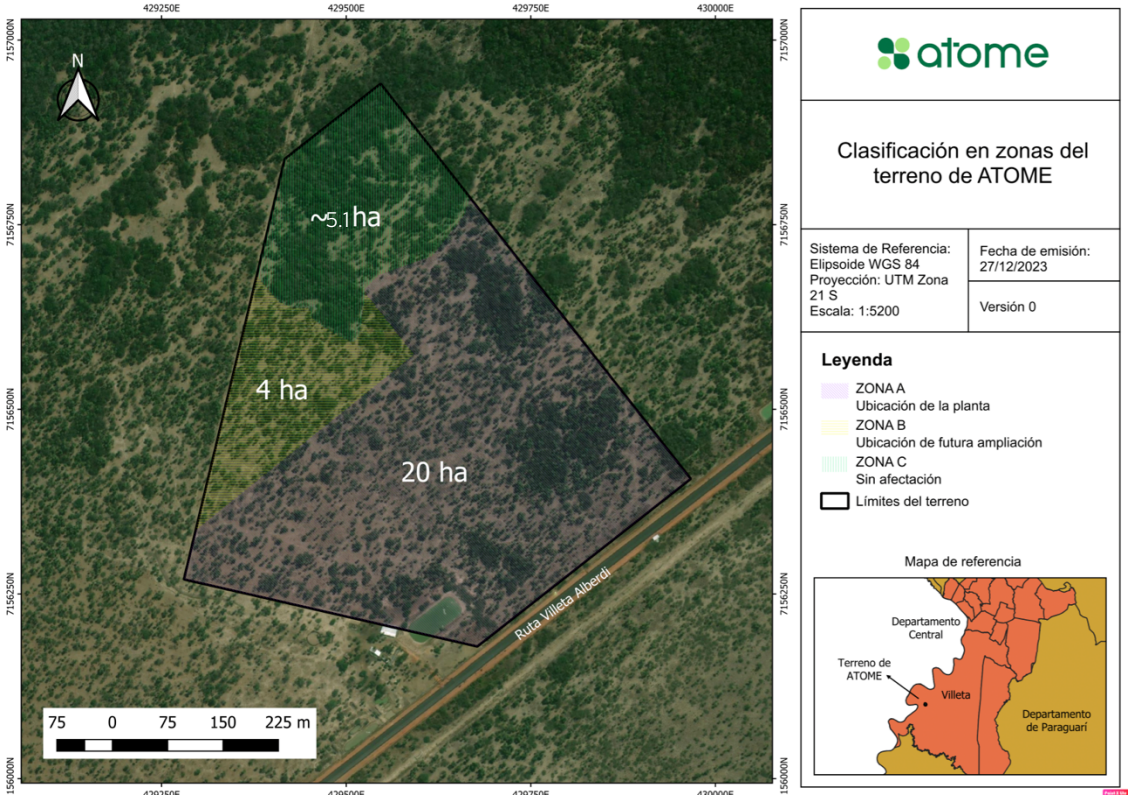
In principle, Zone C, where most of the existing sub-humid forest on the site is located (3.38 ha), will be preserved. If it is necessary to extend the plant facilities for Zone C in the future, the total area of suppression for the plant installation will be 29.85 ha, of which 6.14 ha are sub-humid forest and 23.7 ha are savannah.

For the implementation of the TL, the elimination of 0.07 ha of savannah is foreseen, and for the implementation of the underground water and effluent pipes, the vegetation to be eliminated is 0.69 ha, being 0.55 ha of savannah and 0.14 ha of sub-humid semi-deciduous forest. The rest will be intervention in already anthropised areas.

Habitat conversion will involve the cutting of individual flora and thus should reduce the number of individuals of flora species, including 4 threatened species, and the area of natural habitat. As detailed in **Section 5.3.1.3.2**, four threatened flora species were recorded in the Project's ADA: *Cohniella jonesiana* orchid, guaiac *Libidibia paraguariensis*, kangorosa *Monteverdia ilicifolia* and black locust *Prosopis nigra*, according to the MADES list.

None of these species is restricted to Paraguayan territory, according to the *Tropicos - Missouri Botanical Garden database*[17] *and the Global Biodiversity Information Facility (GBIF)*[18] . All of them also occur in Brazil and most of them are found in other South American countries, mainly Argentina and Bolivia.

Figure 6.1.3.2.a
Vegetation clearance areas



Thus, although habitat disturbance causes population reduction at the local level, the implementation of the Project will not result in significant reduction or extinction of threatened plant species. However, the reduction of a species' population may result in a decrease in its genetic variability, leading to losses in adaptive capacity and population decline (MURAWSKY & HAMRICK, 1992; MURAWSKY, 1995 *cf.* MANTOVANI *et al.*, 2012).

However, taking into account the distribution of the species and the size of the intervention, it is believed that there will be no significant decline in the populations of the species.

Prevention and Mitigation Measures

As preventive and mitigating measures for the impact of loss of vegetation cover, the previous studies of location alternatives carried out as part of this ESIA for the plant site and for the routes of the TL and water and effluent pipelines, which included as a criterion the preference for anthropised areas with less native vegetation, can be cited as preventive and mitigating measures.

[17] Tropicos - Home
[18] GBIF

In addition to these studies, mention is made of the rescue and relocation of plant germplasm, a mitigation measure prior to the suppression activities to be carried out under the **Flora and Fauna Impact Prevention Programme**. The rescue of germplasm will be carried out in the areas of clearing and the rescued materials may be allocated to the remnants of native vegetation that will be conserved and reconditioned within the Project site or destined for educational and/or research institutions.

It is also important to mention the vegetation clearing control measures foreseen in the **Construction Environmental Control Programme**, in order to ensure that only authorised areas are affected and with the adoption of procedures to protect the surrounding vegetation. The Programme also contains a comprehensive set of technical procedures for the execution of the works with the least possible environmental impact. This Programme also includes a measure for the recovery of areas degraded by the works.

It is also important to mention the environmental education measures and the Code of Conduct for workers of the **Labour and Working Conditions Management Programme** and the environmental supervision, monitoring and documentation of the works planned as part of the **Environmental and Social Management Programme**, to be carried out by means of a tool to control the activities developed by the Contractors, accompanying the implementation of the mitigating measures pre-established in the ESMP.

Finally, mitigation measures and conservation efforts are foreseen and will be detailed in the framework of a **Biodiversity Action Plan (BAP)**.

The BAP must define actions to mitigate the impacts of the Project, as well as actions to conserve and enhance the biodiversity values recorded in the region. Actions should be developed according to the stages of the impact mitigation hierarchy (as set out in the SA6) and should achieve zero loss of natural habitats. These measures should be detailed in the Biodiversity Conservation Programme, which should be an executive document, including description of actions, objectives, methodology, implementation schedule and evaluation indicators.

A **Fauna and Flora monitoring** measure is also foreseen **during the construction phase**, which will provide data for the preparation of the BAP.

Compensation measures to be proposed within the scope of the BAP for the unavoidable negative effects of the loss of vegetation cover include the following:

- Environmental compensation through forest conservation
- Environmental compensation through the purchase of Environmental Services Certificates, which provides for adherence to the Environmental Services Regime to comply with Law No. 3001/2006.
- Environmental compensation for trees felled to comply with Villeta District Ordinance No. 7/2022

Monitoring Measures

The Biodiversity Conservation Programme will include the biodiversity monitoring and assessment strategy of the BAP. It includes the monitoring of flora and fauna in the remnants of native vegetation that will be conserved and reconditioned within the Project site, with the objective of monitoring the health of relocated individuals, the maintenance of natural habitat characteristics and the identification of possible impacting agents.

Rating of the resulting impact

Considering the correct implementation of the ESMP programmes and measures listed above, this impact is considered to be of medium magnitude and high importance. It is characterised as a negative impact, with a geographical scope in the ADA and occurring mainly in the implementation phase of the Project. It has direct incidence, immediate induction and permanent duration. It is difficult to reverse and is certain to occur. It is cumulative, as can be seen in the analysis in **Section 6.1.5.** It is an impact that requires many mitigation measures and therefore the residual significance is high. It will therefore need to be compensated by measures to be detailed in the BAP.

Impact Rating (attributes) **Loss of vegetation cover and reduction of flora individuals.**			
Nature	Negative	**Location and spatialisation**	ADA
Stage of occurrence	Implantation	**Advocacy**	Direct
Temporariness (induction)	Immediate	**Temporality (duration)**	Permanent
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Media		
Importance	High		
Mitigability	Low mitigable		
Residual importance	High		

5 - Impacts on Wildlife

5.01 - Loss of terrestrial wildlife habitats

Impactful action	A.1.03 Studies of locational and technological alternatives A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.15 Recovery of direct intervention areas
Impact component	C.2.02 - Fauna

Analysis of potential impact

The loss of habitats used by fauna is essentially the result of the actions required by the Project, which involve the transformation of natural environments due to the removal of vegetation and land clearing. Even if the area is already anthropised and the species present are tolerant to environmental changes, the loss of part of the remaining habitats will reduce the area of distribution of the most mobile species and will entail the risk of reducing the population of the less mobile species, such as amphibians.

Examples of species with low mobility include amphibian species detected in the baseline surveys, such as *Dendropsophus minutos*, D*. nanus, Physalaemos cuvieri, Pseudopaludicola boliviana* and species of the genus *Leptodactylus.*

Considering the most mobile species, those that make up the group of birds and mammals can be mentioned. Among the mammals, the deer (*Subulo gouazoubira*), the felines (*Leaprdus geoffroy* and *Herpailurus yagouaroundi*), the large mullet (*Dasypus novemcinctus*), the tapeti (*Syklvilagus brasiliensis*), among others, are worth mentioning.

The search for less disturbed environments often results in changes in the dynamics of wild communities, i.e. new individuals move into previously undisturbed environments, densifying these new areas, resulting in possible increases in competition for food resources and refuges, thus generating friction between territorial species as in the case of several carnivore and bird species.

In the case of the Project, it is understood that the impact that will occur on the Plant site and the easement strips is small in comparison to the existing unoccupied areas in the surrounding area, which have land use and vegetation cover with characteristics that are mostly similar to those of the site. Therefore, it is understood that these surrounding areas have the carrying capacity to support these displaced species without causing a large accumulation and consequent competition for area and resources.

Mitigation measures

As mentioned above, the implementation of measures prior to vegetation removal activities to be carried out within the scope of the **Flora and Fauna Impact Prevention Programme** is foreseen, including the scaring and rescue of fauna.

Mention is also made of the vegetation clearing control measures foreseen in the **Environmental Control Programme for Construction**, as well as the measure for the Recovery of areas degraded by the works.

It is also important to mention the environmental education measures and the Code of Conduct for workers of the **Labour and Working Conditions Management Programme** and the environmental supervision, monitoring and documentation of the works planned as part of the **Environmental and Social Management Programme**, to be carried out by means of a tool to control the activities developed by the Contractors, accompanying the implementation of the mitigating measures pre-established in the ESMP.

Finally, mitigation measures and conservation efforts are foreseen and will be detailed in the framework of a **Biodiversity Action Plan (BAP)**.

As well as for flora, the BAP must define actions to mitigate the impacts of the project, as well as actions to conserve and enhance the biodiversity values recorded in the region. Actions should be developed according to the stages of the impact mitigation hierarchy (as set out in the IA6) and should achieve zero loss of natural habitats. These measures should be detailed in the Biodiversity Conservation Programme, which should be an executive document, including description of actions, objectives, methodology, implementation schedule and evaluation

indicators.

The measures foreseen in the Biodiversity Conservation Programme include:

- Compensation for native vegetation damage
- Wildlife monitoring in remnant natural areas
- Compensation through purchase of environmental services

Rating of the resulting impact

Taking into account the implementation of all the proposed measures, this negative impact is considered to be of direct incidence and occurs mainly in the implementation phase of the Project. It has an immediate and long term impact on the AID. It is irreversible and certain to occur. It is also cumulative (**Section 6.1.5**), of medium magnitude and high significance. Like the previous impact, it is poorly mitigatable, resulting in high residual significance. It will therefore need to be compensated for by measures to be detailed in the BAP.

Impact rating (attributes) **Loss of terrestrial wildlife habitats**			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Implantation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long term
Reversibility	Irreversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Media		
Importance	High		
Mitigability	Low mitigable		
Residual importance	High		

6.1.3.3
Socio-Economic Environment

6 - Impacts on Employment and the Local Economy

6.01 - Generation of direct and indirect jobs during planning and construction phases

Impactful actions	A.1.02 Initial Operational Structuring A.2.01 Mobilisation of construction workers
Impact Component	C.3.01 - Employment and local economy

Analysis of potential impact

This impact has already begun in the planning phase of the Project, with the contracting of companies to carry out drilling, to drill wells, to prepare the engineering design of the Project, to investigate the land available for the construction of the Plant, to collect data for the ESIA, such as the laboratory for the collection and analysis of water quality, the company to carry out air quality measurements, specialists to carry out modelling, specialists to measure noise, specialists in fauna, flora, physical environment, socio-economics, among others.

During the construction phase, the impact refers to the effects generated by the mobilisation of the labour contingent for the works and assembly of the ATOME green H_2 , NH_3 and fertiliser (calcium ammonium nitrate - CAN) production plant project. As reported in **Section 2.7.6**, the estimated labour force for construction of the Plant will be up to 1,020 to 1,073 direct workers, considering the peak months (months 21 to 24). Another about 40-50 workers will be hired for the works and assembly of the LT and water catchment system and pipelines. There will also be indirect workers involved, such as drivers of material supply companies, transport of workers, food supply company, etc., who are usually people who already live and work in the area.

Some of the direct jobs related to activities requiring technical qualifications will be necessary to bring in workers from outside the region or to train local workers. The majority, however, will be local workers, from the municipality of Villeta and other nearby municipalities in the same region. As local contractors will be hired, these workers will be transported to the site by bus by the companies themselves. Priority will be given to local workers (Villeta and region).

Empowerment Measures

The measures to be implemented to increase the positive effects of the impact are:

- **Labour Management and Working Conditions Programme:** Human Resources Policy, recruitment and job training measures for local workers, working and employment conditions.
- **Stakeholder Engagement Programme**: outreach measures on the number and type of jobs available, and requirements for labour recruitment.
- **Environmental and Social Management Programme**

Rating of the resulting impact

With the application of all the planned measures, the impact resulting from the construction phase is positive and direct, with a diffuse scope (IIA and neighbouring cities). It is certain, immediate and short-term (22-month construction and assembly period of the Project), fully reversible. It is considered an impact of low magnitude (because it is of short duration) and low importance. Taking into account the expected percentage of local workers to be hired, the significance was raised to medium.

Impact rating (attributes) Job creation in the construction phase			
Nature	Positive	**Location and spatialisation**	Diffuse (IIA and region)
Stage of occurrence	Planning and Construction	**Advocacy**	Direct
Temporary (Induction)	Short term	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Baja		
Importance	Media		
Mitigability	-		
Residual importance	Media		

6.02 - Generation of direct and indirect jobs in the operation phase

Impactful actions	A.3.01 Mobilisation of operational workers
Impact Component	C.3.01 - Employment and local economy

Analysis of potential impact

Although the operation phase is of a long-term nature, unlike the temporary nature of the implementation phase, the generation of direct employment should be smaller, mainly for local workers. As mentioned in **Section 2.8.4**, the workforce for the operation phase is estimated at 225 direct jobs, of which 195 are permanent and 30 are temporary. In addition, some 874 indirect jobs will be generated related to operations supervision services, such as environmental engineers, chemical and laboratory technicians, logistics and supply chain staff, HR specialists, legal, commercial and administrative staff, and people from the CAN fertiliser truck and barge logistics companies.

Of the total number of workers to be hired in the operation phase, priority will be given to those who are local (Villeta and region).

The lower number of workers to be hired for operation compared to the construction phase derives from the automation of various parts of the process, in addition to the very nature of the activities, i.e. the need to operate and carry out maintenance of complex installations such as the electrolyser unit, the ammonia synthesis unit, the air separator unit, the water and effluent treatment stations, the cooling tower, among others.

Due to the degree of specialisation required for some of the operation and maintenance activities, a smaller and more specialised workforce is needed.

In principle, this number of employees represents a less representative impact in relation to the regional labour market. However, they are quality jobs, associated with technical qualification, formality and permanence.

Empowerment Measures

To increase the positive effects of the impact, it will be implemented:

- **Labour Management and Working Conditions Programme:** recruitment and job training measures
- **Stakeholder Engagement Programme**: outreach measures on the number and type of jobs available, and requirements for labour recruitment.
- **Operation Phase Environmental and Social Management Programme:** Supervision of compliance with measures and environmental and social training of the O&M team.
- **Contractor and supplier supply programme**

Rating of the resulting impact

With the implementation of all planned measures, the impact resulting from the operation phase is positive and direct. It is certain, of immediate occurrence after the start of operation

and of long duration. It is diffuse in scope and fully reversible. It is considered an impact of high magnitude and high importance (because despite the smaller number of jobs, it is of long duration, and involves permanent jobs). It has cumulative potential, as shown in **Section 6.1.5**.

Impact rating (attributes) Job creation in the operation phase			
Nature	Positive	**Location and spatialisation**	Diffuse (IIA and region)
Stage of occurrence	Operation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	High		
Importance	High		
Mitigability	-		
Residual importance	High		

6.03 - Revitalisation of the local economy during the construction phase

Impactful actions	A.2.01 Mobilisation of construction workers A.2.02 Mobilisation of construction support areas A.2.12 Operation of construction support facilities
Impact Component	C.3.01 - Employment and local economy

Analysis of the potential impact

The construction and assembly period of the project, estimated at 31 months, will lead to an increase in the direct demand for goods and services by contractors in the region of influence of the project, especially for construction inputs (construction materials, ready-mix concrete, fuels, paints, varnishes), non-durable consumer goods (food, medicines, among others) and services (transport, accommodation, electricity, waste collection, telephony, banks).

Due to the location of the Project and the construction camp to be implemented, this demand will have to be supplied by the municipality of Villeta, which will receive the positive effects on its economy, insofar as a large part of the products and services will have to be purchased there. Thus, it is expected that most of the wage bill of the population employed on the construction site will remain in the municipality, which will be converted into consumption.

As some of the workers will be from outside the region, the increase in consumption related to these workers, in addition to the demand for products and services for the works directly, should stimulate the municipal economy.

With this increase in the consumption of goods and services and the dynamisation of the local economy, it is expected that the municipality will increase its tax collection, which, when applied in the municipality itself, will be of benefit to the population.

Empowerment Measures

The measures to be implemented to increase the positive effects of the impact are:

- **Environmental Construction Control Programme**, mainly the promotion and development of local suppliers;
- **Stakeholder Engagement Programme**: outreach measures for products and services required for the work.
- **Environmental and Social Management Programme**
- **Contractor and supplier supply programme**

Rating of the resulting impact

This is a positive impact of the construction phase, of scope in the IIA. It is indirect and has a high probability of occurrence. It is immediate and lasts for the construction period (short term). It is reversible, of medium magnitude and importance.

Impact rating (attributes) Boosting the local economy during the construction phase			
Nature	Positive	**Location and spatialisation**	IIA
Stage of occurrence	Construction	**Advocacy**	Indirect
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	High
Magnitude and Importance			
Magnitude	Baja		
Importance	Media		
Mitigability	-		
Residual importance	Media		

6.04 - Physical and/or economic displacement due to land acquisition and establishment of easements

Impactful actions	A.1.03 Studies of locational and technological alternatives A.2.03 Vegetation clearance and site clearance A.2.16 Negotiation and compensation of the owner A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines
Impact Component	C.3.01 - Employment and local economy

Analysis of potential impact

As mentioned in **Section 2.2.1**, in order to implement the Project, Atome has acquired the land on which the Plant will be built. The chosen area, with 30 ha, is constituted by Fractions 1 and 2 of a land owned by the company Monteclaro S.A. The acquisition of this land was a negotiation and acquisition in terms of "willing seller-willing buyer", applying market values.

Already in the case of the easement strips for the LT and the water and effluent pipelines, with 2.7 ha and 1.15 ha respectively (see **Section 2.2.1**), Atome already has agreements for long-term use of the easements.

The implementation of an LT imposes restrictions on the use and occupation of the easement strip, for its good future functioning. However, this restriction is partial and allows agricultural

and pasture uses in the easement. Only the cultivation of large trees (eucalyptus, pine, among others) is prohibited in the strip, as well as species whose management puts the LT at risk, such as sugar cane, for example, a crop that is generally cleared by burning.

In the easement strip, native grassland is permitted, with clearing of vegetation permitted where necessary. The cultivation of cereals, horticulture, floriculture and fruit crops of species not exceeding 3 m in height is permitted. Soybeans, beans, rice, maize, cassava and vegetables, and small fruit trees such as pineapple, melon and watermelon may be grown.

The removal of the existing land use for the implementation of the TL will take place in an area smaller than the easement strip. Called the intervention boundary, this area to be effectively removed consists of a 6.0 m wide service strip along the entire length of the route, plus the implementation area of each tower, estimated at 36 m^2 (6 x 6 m).

Taking into account the width of the service strip and tower implementation areas, as well as the quantification of land use in the ADA presented in **Section 5.3.1.3.3.3**, it appears that 2.64 ha of the service strip overlaps with areas of rice cultivation. As this is a crop compatible with the operation of an LT, it could subsequently be redeveloped in the easement strip. Therefore, of the 2.64 ha, most of it corresponds to the area where the impact of the loss of agricultural land is temporary, as rice or other small crops can be replanted in the operation phase. Only in the area of 36 m^2 corresponding to one of the towers that is in rice cultivation, the impact of loss of crop area will be permanent.

For the aqueduct easement strip to be established for water and effluent pipelines, most of the area is currently occupied by savannah (0.55 ha or 47.8% of the strip) and anthropogenic areas (0.46 ha or 40%), with small patches of sub-humid forest totalling 0.14 ha (12.2% of the strip). In this case, no areas of cultivation will be lost (see **Table 5.3.1.1.3.3.c** in **Section 5.3.1.3.3.3**).

For this aqueduct easement, in which the water and effluent pipes will be underground, the owner of the affected fraction and Atome will contractually regulate which buildings may or may not be built in the easement area.

For reference, an easement is like a mortgage on a portion of the land and the exercise of dominion in the area of the easement is limited by contract. The framework within which this can be regulated is the reasonableness of allowing use and maintenance. For example, in the case of underground pipelines, such as those in the Project, it is possible to build over them, but a mechanism must be foreseen to allow for maintenance and repair of the aqueduct. In practice, it is preferable to leave the easement area free.

In addition to temporary economic displacement in the area of the LT easement strip and permanent economic displacement in the area of the towers, it may occasionally be necessary to physically displace residents of the neighbouring estate to another area further away within the same property. This displacement would be due to the inconvenience caused by increased noise, dust, vibration and traffic emissions during construction and operation of the Plant. It should be noted that, as described in **Section 5.4.2.2**, the residents are not the owners of the land, but employees (foreman, labourer, cook and her daughter), and the owner stays in the house on weekends. If it is decided that this dwelling should be relocated within the estate itself, the measures set out in ND 5, which require the construction of a new dwelling equal to or better

than the current one, should be applied. ATOME will consult with the owner and workers before finalising the location, design and all matters relating to the relocation of the house within the same property.

Mitigation measures

ATOME's use of the areas that construct the LT easements and pipelines is guaranteed by a TRANSIT SERVITAGE CONSTITUTION document established with the landowners. This contract sets out the amount that Atome will pay as compensation as a lump sum, but makes clear the commitment to pay for any damage caused to the property during maintenance activities. It also sets out the exclusive obligations of the owner and Atome and the obligations to be fulfilled by both parties. The Disclosure measures and the **Stakeholder Engagement Programme**'s Mechanism for handling complaints, queries and suggestions also apply.

Rating of the resulting impact

Considering the implementation of the proposed measures, this impact, of the implementation phase, restricted to the ADA, is considered to be negative, certain to occur, of direct effect, immediate, of long-term duration and partially reversible. The magnitude is considered to be low and the significance moderate. The impact is highly mitigable and therefore its residual significance is low.

Impact rating (attributes) Acquisition of land and establishment of easements			
Nature	Negative	**Location and spatialisation**	ADA
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Medium to Long Term
Reversibility	Partially reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Baja		
Importance	Moderate		
Mitigability	Highly Mitigable		
Residual importance	Baja		

7 - Impacts on Infrastructure, Social Equipment and Public Services

7.01 - Appropriation of the capacity of access roads to the project in the construction phase

Impactful actions	A.2.05 Flows of vehicles, equipment and workers
Impact Component	C.3.02 - Infrastructure, Social Equipment and Public Services

Analysis of the potential impact

The ATOME plant is located on the margins of the National Route PY19 (Ruta Villeta - Alberdi). As the construction support facilities will be within the plant site itself, the National Route PY19 (Villeta - Alberdi) will be the most used access during the construction and assembly phase of the Project, either for the transport of workers in buses between Asunción and Villeta to the site, with an estimated 1 to 8 trips per day during the construction period (a peak of 8 trips

between months 17 and 18), and also for the transport of fill material between the gravel quarry located in Suruby'i and the construction site (a total of 5,430 truck trips in a period of 90 days or 60 trips per day), for the transport of containers with imported goods between the Port of Terport and the site (450 trips distributed over 5 months) and for the transport of oversized loads on the same route between Terport and the construction site.

The National Route PY19 is in good traffic conditions in its section between Villeta and the Project, fully paved and with road signs and hard shoulder.

The uses around the road on the route to the plant site are mainly industrial and service-providing businesses, such as the following:

- Organitec Fertilizantes S.A.
- Terport
- EFISA - Empresa Forestal e Industrial S.A.
- Jauser - Logistics Centre Villeta 2
- Alukler - Alumínio supplier
- Buenas Nuevas S.A. (wholesale trade)
- Puerto Seguro Fluvial SA - Import and Export Company
- Las Tacuaras - Nutrihuevos - Biotechnology Company
- Cremer Oleo Paraguay S.A.
- Hotel and Restaurant Puerto Guyrati
- Service Stations

There are also some informal, daily-occupancy market stalls and short stretches of the route where there are residential uses around the road, such as passing through the Guasu Korá settlement and the Surubi'y community.

The section with the highest density of occupation in the area will be the route taken by buses transporting workers from Asunción, which will have to leave the Asunción Bus Station, located on Avenida Fernando de la Mora, and travel along this avenue and then along the Acceso Sur to the beginning of the Villeta - Alberdi road.

Regarding the capacity of the accesses to be most used during the works, **Table 5.4.1.1.6.3.1.a** of **Section 5.4.1.6.3.1** shows that traffic surveys on the Villeta - Alberdi Road section between Villeta and Villa Olivia, carried out for the Paraguay Infrastructure and Transport Services Master Plan 2018 - 2028 in two periods of 2012 and 2018, yielded a total of 1,662 vehicles per day, the majority of which, 53.5%, are cars. Another 18% are T3 trucks with more than 5 axles, 10% are motorbikes, 10% are T2 trucks with 4 to 5 axles and the rest are trucks with 2 to 3 axles and buses.

On the Southern Access, the traffic count conducted in 2018 resulted in a total of 11,010 vehicles per day, of which 62% are cars. Motorbikes ranked second with 10.5% of the total, followed by T3 trucks with more than 5 axles with 9.2%, T2 trucks with 8.9%, T1 trucks with 8.3% and finally buses with 1.1%.

The capacity of a single-lane road, such as the Ruta Villeta - Alberdi, is 1,700 vehicles per hour, according to the *Highway Capacity Manual* (HCM) of the Transportation Research Board. For the Acceso Sur, a dual-lane road, the capacity is 1,800 vehicles per hour.

The HCM also indicates factors for calculating the equivalent vehicle capacity for the case of heavy vehicles. Taking into account the data in **Table 5.4.1.6.3.1.a**, factors of 2.2 for buses and trucks with more than 4 and 5 axles, 1.7 for trucks with 2 and 3 axles, and 2.5 for trucks with more than 5 axles have been applied. **Tables 6.1.3.3.3.a** and **6.1.3.3.b** below show the equivalent vehicles for the Villeta - Alberdi Route and for the Southern Access calculated from these figures. In the case of cars, no correction factor has been applied and motorbikes have not been taken into account. It is observed that the traffic on these roads results in totals of 2,252.1 and 13,334.5 vehicle equivalents per day, the Acceso Sur with almost six times more traffic than the Ruta Villeta - Alberdi, as it is an urban road and the other is a rural road.

Table 6.1.3.3.a
Calculation of daily equivalent vehicles on the Villeta - Alberdi road, section Villeta - Villa Olivia.

Vehicle types	TPDA	Factor	Equivalent vehicles per day
Cars	889	1	889
Bus	22	2.2	48.4
T1 (2 and 3 axles)	105	1.7	178.5
T2 (4 and 5 axles)	171	2.2	376.2
T1 (more than 5 axes)	304	2.5	760
Total	1,662		2,252.1

* vehicles per day. Source: Plan Maestro de Infraestructura y Servicios de Transporte del Paraguay 2018 - 2028, December 2020.

Table 6.1.3.3.b
Calculation of vehicle equivalents per day on the Southern Gateway

Vehicle types	TPDA	Factor	Equivalent vehicles per day
Cars	6,826	1	6,826
Bus	116	2.2	255.2
T1 (2 and 3 axles)	917	1.7	1,558.9
T2 (4 and 5 axles)	977	2.2	2,149.4
T3 (more than 5 axles)	1,018	2.5	2,545
Total	11,010		13,334.5

Assuming a peak-hour factor of 6% for Ruta Villeta - Alberdi, a single-lane rural road, a value of 67 equivalent vehicles per peak hour is obtained. Assuming that the flows in each direction are equivalent (which can vary throughout the day), and considering the value of 1,700 equivalent vehicles per hour per lane, or 3,400 equivalent vehicles per hour in total, the 67 equivalent vehicles per peak hour represent only 1.99% of the capacity of this road.

For the Southern Access, a dual-lane urban road, a peak-hour factor of 8% is assumed, resulting in a value of 553 peak-hour equivalent vehicles. Considering the 1,800 equivalent vehicles per hour per lane, or 3,600 equivalent vehicles per hour in total, the 553 equivalent vehicles per peak hour represent 14.8% of the capacity of this road.

Considering the worst case traffic situation generated by the Project during the works, the 8 peak worker bus trips, the 60 daily truck trips for transporting fill material and the 3 container truck trips for transporting imported goods result in a total of 71 trips per day, which, taking into account the factor of 2.2 for heavy vehicles, results in 156.2 vehicle equivalents per day and 9.4

vehicle equivalents per peak hour for the Villeta - Alberdi Route. For the Southern Access, the 8 daily bus trips expected on this road result in 1.4 equivalent vehicles per peak-hour (for a factor of 8%).

Taking into account the capacity of both roads (1,700 and 1,800 vehicle equivalents per day per lane), this would represent only 0.28% and 0.04% of their respective capacities. Added to the existing traffic, the increase brought about by the project would result in 76.4 vehicles per peak hour on the Villeta - Alberdi route, which would represent 2.25% of the road's capacity, and 554.4 vehicles per peak hour on the Acceso Sur, or 15.4% of its capacity.

Given that today the percentages of traffic in relation to road capacity are already 1.99% and 14.8%, it is considered that this increase in traffic during the works, mainly on the Villeta - Alberdi route, which will be the most used, should not represent a material impact on road capacity, with no reduction in fluidity and speed expected.

However, the risk of deterioration of the pavement conditions of the Villeta - Alberdi road in the section between Puerto Terport and the construction site, caused by the traffic of oversized loads, should be taken into account, damaging its conservation conditions and consequently the traffic flow.

The risks and nuisance caused by increased traffic to residents of dwellings on the edges of the access roads are assessed in Impact 8.02 and Risk 14.04.

Mitigation Measures

The following environmental programmes and respective measures should be implemented in order to prevent and mitigate this impact:

- **Construction Environmental Control Programme**: Construction Traffic Control measures, including the need for the EPCist to work in coordination with municipalities and Road Directorates, the application of good practices for traffic during construction and the development of a specific procedure for the transport of oversized loads, providing for a prior study of road conditions, coordination with the Road Directorate and other relevant authorities, and the transport of oversized loads at off-peak hours to minimise impact, as well as assessing the need for a number of measures, including: temporary reinforcement of channel and drainage crossings and temporary elevation of cables at power line crossings.
- **Environmental and Social Management Programme**
- **Stakeholder Engagement Programme**: communication measures for traffic diversions and disruptions, transport of oversized loads, improvement works; Mechanism for handling complaints, grievances and concerns
- **Labour Management and Working Conditions Programme**: Code of Conduct for Workers and Environmental and Social Education of Workers, including defensive driving training.

Rating of the resulting impact

Considering the application of the above Programmes and measures, this impact is considered to be negative, of scope in the IIA, of the construction phase, with direct incidence, immediate temporality (induction), and short duration (until the end of the work). It is totally reversible, of

certain occurrence, and of medium magnitude and importance, given the number of trips which are expected at certain times (such as during the execution of the backfilling) and that, in this phase, as different contractors are involved, it is necessary to establish security and control measures during the entry and exit of lorries on the site, with the risks which this entails for road users. Therefore, this impact is mitigable, resulting in moderate to low residual significance.

Impact rating (attributes) **Appropriation of the capacity of access roads to the project in the works phase**			
Nature	Negative	**Location and spatialisation**	IIA
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Media		
Importance	Media		
Mitigability	Highly Mitigable		
Residual importance	Moderate to low		

7.02 - Appropriation of project access road capacity in the operation phase

Impactful actions	A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.04 Transport of inputs and outputs
Impact Component	C.3.02 - Infrastructure, Social Equipment and Public Services

Analysis of potential impact

As mentioned in action A.3.04 in **Section 6.1.2**, in the operation phase a truck flow is estimated on the Villeta - Alberdi Route bringing production inputs. It is estimated 1 truck trip every 4 days between the Terport Port to the Plant to bring dolomite and 1 truck trip and 1 van trip per day to bring spare parts, consumables and others.

The distance between the Port Terport and the plant is about 15 km along the Villeta - Alberdi road (**Figure 6.1.3.3.a**).

Figure 6.1.3.3.a
Journey between the Plant and the Villeta Port Terport



An estimated 50 trips per day, including empty and loaded trucks, total estimated for the export of the 770 ton/day (total computation for the production in big bags or bulk). Taking into account an 8-hour working day, this results in an average of 6 trucks per hour.

In addition to the trips made by the CAN fertiliser transport trucks, another important flow that the Project will generate in the operation phase is that of the buses that will transport the workers. As mentioned in **Section 2.8.4**, in this phase there will be a total of 225 direct workers, 195 of them permanent, with an estimated 8 trips per day round-trip.

At the beginning of this impact assessment, some truck and van trips were also mentioned to transport dolomite, spare parts, consumables and others. However, these trips are insignificant compared to the traffic that will be generated to transport CAN fertiliser and workers.
As analysed in the previous impact, the flow of 67 peak hourly equivalent vehicles on the Ruta Villeta - Alberdi represents only about 1.99% of its road capacity. On the Acceso Sur, the flow of 553 equivalent vehicles per peak-hour represents 14.8% of its capacity.

Considering the 50 truck trips and 8 bus trips per day that the project will generate, this would represent 132 vehicle equivalents per day (considering a factor of 2.2), and 8 vehicle equivalents

per peak hour for the Villeta - Alberdi Route (for a factor of 6%).

The 10 bus trips, or 22 vehicle equivalents per day, would represent 1.76 vehicle equivalents per peak hour for the Southern Access (for a factor of 8%), as this road is intended for worker transport only.

Taking into account the capacity of both roads (1,700 and 1,800 vehicle equivalents per day per lane), the Project traffic would represent 0.24% and 0.05% of their respective capacities.

Added to existing traffic, the increase brought about by the Project would result in 75 vehicles per peak hour on the Villeta - Alberdi Route, which would represent 2.2% of the road's capacity, and 554.8 vehicles per peak hour on the Acceso Sur, or 15.4% of its capacity.

Knowing that today the percentages of traffic in relation to road capacity are already 1.99% and 14.8%, the impact of the project on these two roads can be considered negligible. Thus, the operation of the Project is not expected to cause inconvenience to users, associated with a reduction in fluidity and speed, overtaking difficulties, possible occasional traffic jams and pavement damage with deterioration of road conditions.

It is important to make it clear that the final method of transporting the fertiliser has not yet been defined, as it depends on the Business Plan that is being studied for the Project. Thus, it may happen that not all the 50 lorry journeys are made to the port of Terport, and that part of the production is transported by road from the Plant to the cities of Cascavel and Dourados, in Brazil. In any case, the route to both destinations assumes that the trucks will pass through the same section of the Villeta - Alberdi route that would be used to access Terport, applying the capacity calculations made for the river transport scenario.
After the Ruta Villeta - Alberdi, the route to these cities must be done through the following roads:

Cascavel - Ruta Guarambaré - Villeta (from Villeta to Guarambaré), Acceso Sur (from Guarambaré to Itá), Ruta Ypacaraí - Itá (from Itá to Ypacaraí), Ruta 2 (from Ypacaraí to Foz do Iguaçu, in Brazil), and BR-277 (from Foz do Iguaçu to Cascavel).

Dourados - Ruta Guarambaré - Villeta (from Villeta to Guarambaré), Acceso Sur (from Guarambaré to Itá), Ruta Ypacaraí - Itá (from Itá to Ypacaraí), Ruta 2 (from Ypacaraí to Caacupé), Ruta Caacupé - Tobatí (from Caacupé to Tobatí), Ruta Arroyos y Esteros - Tobatí (from Tobatí to Arroyos y Esteros), Route 3 (from Arroyos y Esteros to San Estanislao), Route 10 to bypass the urban area of San Estanislao, Route 3 (from San Estanislao to Yby Yaú), Route 5 (from Yby Yaú to Ponta Porã, in Brazil), and BR-463 (from Ponta Porã to Dourados).

The risks and nuisance caused by increased traffic to residents of dwellings on the edges of the access roads are assessed in Impact 8.03 and Risk 14.04.

Mitigation Measures

Taking into account that part of this impact is associated with an activity that will be carried out by a subcontracted company, the main measure to be mentioned to prevent it is the contracting of highly qualified companies, the **Environmental and Social Management Programme of the**

Operation Phase, through which ATOME will ensure that only companies that comply with Paraguayan legislation related to health and safety and working conditions and also the procedures of ATOME's environmental, social and OSH management system are contracted.

The transport management measures for the operation phase, including the transport of workers with their own vehicles/motorcycles or transported by vans/buses, are laid down in the **Transport Management Programme for the Operation Phase**, through which the most risky sections of the route, an appropriate signalling plan, speed control, transport rules, driver training, etc. will be defined.

It is also important to mention the measures of the **Stakeholder Engagement Programme**, which include communicating to the population about peak truck traffic hours, possible traffic disruptions, the channels available for complaints and queries, among other information, and the establishment of the complaints, claims and concerns management mechanism for any problems to be reported to ATOME, including road damage, noise and emissions nuisance, among others.

Rating of the resulting impact

Considering the application of the above programmes and measures, this negative impact of the operation phase of the project, which affects the IIA, is assessed as direct, of immediate induction and long duration, with a high probability of occurrence and reversible (in case of demobilisation of the plant, the transport of products by road will cease to exist). It has the potential for accumulation and is synergistic. It has a long duration and cumulative potential (**Section 6.1.5**). Considering that the daily truck and bus trips generated by the Project represent a very small percentage of the road capacity, and that during the operation phase it will be easier to establish control of security measures at the entrance and exit of vehicles at the Plant, this impact is classified as low in magnitude and importance. It is a highly mitigable impact, resulting in low residual significance.

Impact rating (attributes) **Appropriation of the capacity of access roads to the project in the operation phase**			
Nature	Negative	**Location and spatialisation**	IIA
Stage of occurrence	Operation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	High
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		
Mitigability	Highly Mitigable		
Residual importance	Baja		

7.03 - Appropriation of the capacity of the Paraguay - Paraná Waterway

Impactful actions	A.3.04 Transport of inputs and outputs
Impact Component	C.3.02 - Infrastructure, Social Equipment and Public Services

Analysis of potential impact

As mentioned in the previous impact, the option to be chosen for the transport of CAN fertiliser production has not yet been defined. The Business Plan being studied for the Project evaluates both the options of road transport only, to Cascavel and Dourados in Brazil, and road transport to the port of Terport, and from there by the Paraguay-Paraná waterway to the port of destination (Nueva Palmira, in Uruguay).

If the second form of transport is chosen, it is necessary to assess the impact that this increase in barge traffic will have on the waterway.

In order to calculate the number of barge trips to transport fertiliser on the waterway, the following assumptions were considered, as described in **Chapter 2.0:**

It is estimated that one barge trip every two days, and 100-150 trips per year. It is understood that some of these trips may be more concentrated at certain times of the year, as at other times, for example in the dry season, navigation may be restricted, as seen in the Inland Waterway Transport conditions included in **Section 5.4.1.3.6.2.**

In any case, the flow of barges resulting from the Project will lead to an increase in the use of the waterway, impacting its cargo transport capacity. However, according to data from 2019, it is estimated that the Waterway still operates with a tonnage well below its capacity, and actions are currently being coordinated for a greater use of shared resources, in order to achieve an increase that could double the current level of cargo transported by 2020/2025[19] .
The cargo system of the Paraguay-Parana Waterway has a capacity of approximately 100 million tons[20] , but according to data from different international organisations, more than 36 million tons of commercial cargo circulate annually through the waterway, most of which is grain[21] .

Despite this under-utilisation, countries such as Argentina, for example, have planned to double exports from the current 87 billion to 174 billion. As the Hidrovia is the main export-oriented infrastructure, this goal would require deepening the river to expand the carrying capacity of inter-oceanic vessels and facilitate their navigability[22] .

In addition to this forecast of increased use of the Waterway, and restrictions on navigation in certain seasons and stretches, as reported in **Section 5.4.1.3.6.2, there are** also climate change scenarios to consider, with extreme rainfall events and the consequent flushing of sediment from upstream into streams and creeks, and drought events, which may affect navigation.

In any case, as already mentioned in impact 7.02, the final form of transporting the fertiliser has not yet been defined, which depends on the Business Plan being studied for the Project. One of the possibilities evaluated is to transport the fertiliser 100% by road from the Plant to the cities of Cascavel and Dourados, in Brazil, which would eliminate this impact on the waterway.

[19] https://www.puertojennefer.com.bo/hidrovia.php.
[20] https://www.economy.com.bo/articulo/logistica/consultor-onu-destaca-potencial-salidas-maritimas-bolivia-como-canal-tamengo-hidrovia-paraguay/20220704172014006605.html.
[21] https://www.puertojennefer.com.bo/hidrovia.php.
[22] https://agenciatierraviva.com.ar/hidrovia-paraguay-parana-tres-decadas-de-impactos-socioambientales-y-de-democracia-ausente/.

Mitigation Measures

This impact is also associated with an activity that will be carried out by a subcontracted company. Therefore, mention is made of the implementation of the contracting of qualified companies from the **Environmental and Social Management Programme of the Operation Phase**, through which ATOME will ensure that a shipping company is contracted that:

- Comply with Paraguayan legislation and international requirements related to health and safety and working conditions; with the Paraguayan Waterway River Transport Agreement; and with the protocols of the agencies that regulate the use of the Paraguay-Paraná Waterway in each country.
- Has its own environmental, social and health and safety management system or is contractually obliged to adopt the procedures of the ATOME management system and the measures established in this ESMP, which will be based on coordination with the port authorities and contractors, in particular the safety and environmental control measures foreseen in the river transport of the NH_3 and the emergency response protocols of P.10.

Also mentioned are the measures of the **Transport Management Programme in the Operation Phase**, through which good environmental, social and health and safety practices associated with the Project's transport operation will be defined.
It is also important to mention the measures of the **Stakeholder Engagement Programme**.

Rating of the resulting impact

By implementing the proposed Programmes and measures, this negative impact of the operation phase of the Project is qualified as direct, diffuse, of short term induction and long term duration, with low probability of occurrence (it may not even occur if the business plan chooses the option of land transport at 100%) and reversible (in case of demobilisation of the Plant, the river transport of products will cease to exist). It is cumulative and synergistic. This is a long term impact, with cumulative potential (**Section 6.1.5**), of medium magnitude and medium significance. It is considered a medium mitigatable impact and therefore the residual significance is low.

Impact rating (attributes) **Capacity appropriation of National Route PY19 in the operation phase**			
Nature	Negative	**Location and spatialisation**	Fuzzy
Stage of occurrence	Operation	**Advocacy**	Direct
Temporary (Induction)	Short Term	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Media		
Importance	Moderate		
Mitigability	Moderately Mitigable		
Residual importance	Baja		

7.04 - Overloading of solid waste disposal sites in the construction phase

Impactful actions	A.2.03 Vegetation clearance and site clearance A.2.06 Earthworks

	A.2.07 Execution of foundations A.2.08 Civil works A.2.09 Assembly A.2.10 Assembly of towers A.2.11 Launching of cables A.2.12 Operation of construction support facilities A.2.13 Demobilisation of support areas
Impact Component	C.3.02 - Infrastructure, Social Equipment and Public Services

Analysis of potential impact

As noted in **Section 2.7.4**, it is estimated that various types of waste, including construction and demolition waste and miscellaneous packaging waste, will be generated during the construction and assembly of the Project. The total estimated volume of waste is 297 m^3 , of which the largest amount, 141 m^3 , corresponds to miscellaneous packaging, in addition to 29 m^3 of waste concrete, bricks, tiles and ceramic materials; 32 m^3 of wood, glass and plastic; 10 m^3 of bituminous mixtures, tar and other tarred products; 34 m^3 of metals; 25 m^3 of insulation materials; 15 m^3 of construction materials from gypsum; and 11 m^3 of other construction or demolition waste.

Among the waste generated, there are those that can be reused and those that can be recycled. There are also wastes considered hazardous, which cannot be disposed of in landfills, e.g. concrete mixtures, bricks, tiles and ceramic materials contaminated with hazardous substances; glass, plastic and wood contaminated with hazardous substances; coal tar and tarred products; metal wastes contaminated with hazardous substances; cables containing hydrocarbons; contaminated insulation materials; oil filters, batteries, batteries, oil filters, batteries, batteries and ceramic materials contaminated with hazardous substances; metal wastes contaminated with hydrocarbons; contaminated insulation materials; oil filters, batteries, batteries and ceramic materials; metal waste contaminated with hazardous substances; cables containing hydrocarbons; contaminated insulation materials; oil filters, batteries, paints, gypsum contaminated with hazardous substances; other construction and demolition waste contaminated with hazardous substances; and all types of packaging contaminated with hazardous substances.

In addition to construction and demolition waste, construction and demolition waste may also be generated:

- common waste (office waste, food waste, food packaging, toilet paper, PPE waste);
- outpatient waste;
- contaminated soil as a result of possible leaks or spills of fuels, oils and greases and other chemicals;
- surplus soil from excavation;
- vegetation suppression residues.

It is estimated that the generation of this solid waste at the camp and construction and assembly sites will have an impact on the waste disposal infrastructure available in the region, even if the amount of waste that will be generated is not significant.

Mitigation Measures

As part of the measures for the management of solid waste generated in the camp and the construction and assembly sites of the project, firstly, it is planned to implement a waste centre in the camp, where the separation and temporary storage of waste will be carried out until its final destination.

Waste that can be reused on site and recycled will be separated and the latter will be sold to licensed companies or donated.

As verified in the baseline, waste from the District of Villeta is removed by the company EMAASA, which takes the waste to a sanitary landfill in Villa Hayes.

Contractors shall engage the services of this company or another company available in the region that is duly licensed, and shall not dispose of the waste in uncontrolled landfill or burn and bury it.

The company collects and disposes of non-hazardous industrial waste and construction and demolition waste. For hazardous waste, disposal is available at the company TAYI AMBIENTAL S.A., located in Asunción, which operates a treatment plant for hospital, pharmaceutical, pathogenic, industrial, commercial hazardous and non-hazardous waste.

Waste management measures (Solid Waste Management and Hazardous Materials Management) are part of the **Environmental Construction Control Programme** of the ESMP (**Chapter 7.0**). Verification of the correct implementation of these measures by Contractors and subcontractors will be carried out through the Construction Supervision measure included in the **Environmental and Social Management Programme**.

It is also important to mention the measures foreseen in the **Labour Management and Working Conditions Programme**, such as Labour Training, the Code of Conduct for Workers and the Environmental and Social Education of Workers, through which workers will be informed of the appropriate waste management practices to be followed at the camp and construction sites.

Rating of the resulting impact

Considering the correct implementation of the measures foreseen in the ESMP for this construction phase impact, it is classified as negative, with an impact on the IIA or diffuse, indirect, short-term induction and short duration. It is fully reversible and its probability of occurrence can be considered low, due to the amount of waste that will be generated. The magnitude is low and the significance is moderate. Considering that this is a highly mitigatable impact, the residual significance is low.

Impact rating (attributes) **Overloading of solid waste disposal sites in the construction phase**			
Nature	Negative	**Location and spatialisation**	All or Diffuse
Stage of occurrence	Operation	**Advocacy**	Indirect
Temporary (Induction)	Short Term	**Temporality (Duration)**	Short Term
Reversibility	Partially reversible	**Probability of occurrence**	Baja
Magnitude and Importance			

Magnitude	Baja
Importance	Moderate
Mitigability	Highly Mitigable
Residual importance	Baja

7.05 - Impact on traffic on National Route PY19 during the laying of the TL cables, usually within a few hours

Impactful actions	A.2.11 Launching of cables
Impact Component	C.3.02 - Infrastructure, Social Equipment and Public Services

Analysis of potential impact

Since the Buey Rodeo Substation is located on the opposite side of National Route PY19, the TL will have to cross this road to reach its end point at the Plant substation. This crossing will require the temporary and timely interruption of traffic on this road during the cable laying activity.

The laying of the cables at the point of intersection of the LT with the road is expected to affect vehicle flows on the section of the junction for about 2 hours. It should be noted that the road to be intercepted does not have heavy traffic, as shown in **Table 6.1.3.3.3.a** in Impact 7.01.

This is a one-time, scheduled activity, which will require reinforcement of signage, coordination with municipalities and road directorates and adequate social communication.

Mitigation Measures

This impact can be mitigated through the adoption of appropriate measures, systematised in the ESMP, mainly in the **Environmental Control Plan for Construction**, such as the implementation of adequate signage days before the launching of the cables at the crossing point of the road, in coordination with the municipality and the Road Directorate; the request of permission for the laying of the cables; and the closure of the road once, for a couple of hours approximately.

Communication measures are also foreseen as part of the **Community Relations and Participation Plan**. The management of the measures will be done within the scope of the **Environmental Management Programme**.

Rating of the resulting impact

Considering the correct implementation of the measures foreseen in the ESMP for this construction phase impact, it is classified as negative, with an impact on the AID, direct, of immediate induction and very short duration, about 2 hours and only once. It is reversible and of high probability of occurrence, of low magnitude and importance. The impact is easily mitigated and therefore of low residual significance.

Impact rating (attributes) **Impact on traffic on National Route PY19 during construction**			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Operation	**Advocacy**	Indirect

Temporary (Induction)	Short Term	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	High
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		
Mitigability	Highly Mitigable		
Residual importance	Baja		

8 – Impact on the Quality of Life of the Population

8.01 - Generation of expectations

Impactful actions	A.1.01 Dissemination of the project A.1.02 Initial Operational Structuring A.2.01 Mobilisation of construction workers A.2.02 Mobilisation of construction support areas A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.04 Transport of inputs and outputs
Impact Component	C.3.03 - Quality of Life of the Population

Analysis of potential impact

Social impacts begin at the moment that parties potentially affected or interested by a particular project become aware of its existence, either through public news reports, through consultations and meetings with local entities and authorities, from field inspections for surveying, engineering and environmental studies, including interviews with the population and other situations.

The news and the presence of technicians related to the project in the region create fears about possible negative impacts, such as discomfort caused by construction activities, including noise emissions, dust, vibration, increased heavy vehicle traffic, the presence of workers from outside the region, among others; and/or positive expectations, such as those related to jobs, revitalisation of the local economy, increased business opportunities, other benefits for the community in general, among others.

Expectations also extend to the possible impacts and risks of the operation phase of the Plant, which refer to possible accidents with the equipment and installations, involving explosion and leakage of hazardous products; the worsening of traffic conditions and conservation of National Route PY19; the increased risk of accidents due to the transit of trucks that will transport CAN fertiliser and buses that will transport workers; the prohibition of some uses in the easement strips of the LT and the water and effluent pipelines; among others.

In case of uncertainties resulting from lack of information about the project and the interaction between potentially affected and interested persons, both fears and expectations may be exaggerated or may not correspond at all to the reality resulting from the project. Situations of uncertainty may create concern and distress and may even lead to contentious and conflicting attitudes and actions.

Mitigation and Potentiation Measures

It is important and necessary, as soon as possible, to develop information, communication and participation processes with the interested parties and possible affected parties on the characteristics of the project and the potential impacts, in order to reduce uncertainty and, on the other hand, to inform about the commitments to be assumed by ATOME to prevent, mitigate, control and compensate the impacts and to collect contributions to the design of the best mitigation solutions.
In the context of this ESIA, contacts and interviews were made with authorities and other stakeholders in Villeta, including residents of the only house in the vicinity of the plant, in semi-structured interviews.

A public consultation was also held in Villeta, as established in the **Stakeholder Engagement Programme**, to present the ESIA and to gather the population's contributions to improve the Project and the study.

All these measures are systematised in the **Stakeholder Engagement Programme** of the ESMP. The effective implementation of the measures will be verified through the Construction Supervision measure of the **Environmental and Social Management Programme**.

Rating of the resulting impact

It is an impact with negative and positive vectors, of certain but reversible occurrence, of geographic scope in the IDA and the IIA, starting at the planning stage, but mainly related to the construction phase and extending to the operation of the project. It is direct, immediate and long term in duration. The magnitude is high and the significance is medium. It is easily mitigated by the planned communication measures, resulting in moderate residual significance.

Impact rating (attributes) Generating expectations			
Nature	Negative and Positive	**Location and spatialisation**	DAI and IIA
Stage of occurrence	Planning/Implementation/Operation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	High		
Importance	Media		
Mitigability	Highly Mitigable		
Residual importance	Moderate		

8.02 - Nuisance caused by construction activities

Impactful actions	A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.05 Flows of vehicles, equipment and workers A.2.06 Earthworks A.2.07 Execution of foundations

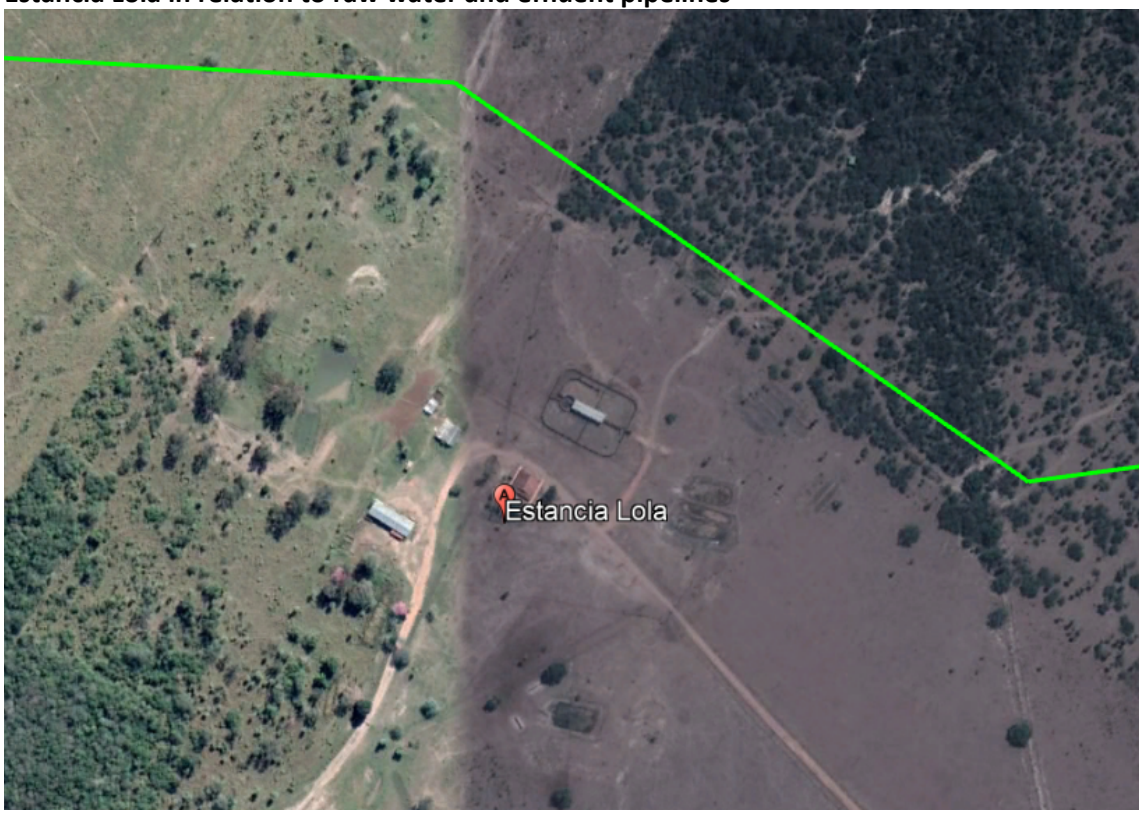
	A.2.08 Civil works A.2.09 Assembly A.2.10 Assembly of towers A.2.11 Launching of cables A.2.12 Operation of construction support facilities A.2.13 Demobilisation of support areas
Impact Component	C.3.03 - Quality of Life of the Population

Analysis of potential impact

Some construction activities have the potential to affect the well-being of people living near construction sites, access roads and construction camps due to increased noise, dust, vibrations and traffic.

In the case of the ATOME project, as verified in the diagnosis and in previous impacts, there is only one neighbouring house close to the boundaries of the plant site, where four or more people who work on the farm live, who will be the most impacted by the construction activities. In the case of the water and effluent pipelines, the works could cause inconvenience to the neighbours of Estancia Lola, who are some 200 metres from the route (**Figure 6.1.3.3.b**).

Figure 6.1.3.3.b
Estancia Lola in relation to raw water and effluent pipelines



In the area surrounding the Buey Rodeo substation and the easement strip of the future TL and the construction site of the pumping station on the banks of the Paraguay River, there are no human settlements.

Mention should also be made of the people who live around the access roads that will be used during the works, and who will be impacted by the increase in heavy vehicle traffic, with an increased risk of accidents and noise emissions. As mentioned in impact 7.01, the area around the Villeta - Alberdi road to be used more during the works, has dispersed uses, mainly corresponding to industries, service companies, in addition to some informal sales stalls, of daily occupation.

However, the surroundings of the sections of the Guarambaré - Villeta Route and mainly of the Southern Access to be used by buses transporting workers present a densely occupied environment. The population living in the houses on the sides of these roads will be more susceptible to the inconveniences and risks of Project-related traffic, and could be directly impacted.

The main nuisances caused by construction activities are related to increased emissions of noise, vibrations and dust, the latter mainly during construction. During the dry period dust generation and dispersion can be more intense, requiring daily mitigations. The activities with the greatest potential for generating this impact are earthworks, pile driving, assembly of metal structures, operation of concrete plants, aggregate storage, operation of generators, as well as heavy vehicle traffic on the internal access roads.

Mitigation Measures

The measures to prevent and mitigate this impact, systematised in the ESMP, are mainly those included in the **Construction Environmental Control Programme** (Air Emission Control; Noise and Vibration Emission Control; Construction Traffic Control; Temporary Facilities/Construction Camp Management). The effective implementation of the measures by Contractors and subcontractors will be verified through the Construction Supervision measure included in the **Environmental and Social Management Programme** , which also includes Environmental Quality Monitoring Measures.

It also mentions some of the measures of the **Labour Management and Working Conditions Programme** such as Labour Training, the Code of Conduct for Workers and the Environmental and Social Education of Workers. The contents to be addressed with workers will include:

- Take the necessary precautions in work carried out in the vicinity of the neighbouring residence to avoid as far as possible the inconvenience caused by construction activities;
- Avoid noisy and bright activities at night as much as possible;
- In dry periods, dampen the exposed floor at unpaved internal entrances to minimise dust emission;
- Cover trucks transporting dry soil and other aggregates with tarpaulins to prevent dust dispersal;
- Respect speed limits and adopt the routes defined in the Traffic Management Programme, which will try to give priority to passing outside urban sections.

As part of the **Stakeholder Engagement Programme**, outreach and communication measures and the Community Complaints, Grievances and Concerns Mechanism are mentioned.

Monitoring Measures

Environmental Construction Control Programme

- Noise monitoring
- Visual emission monitoring (Ringelmann scale) of construction vehicles and machinery

Rating of the resulting impact

This is a direct negative impact of the construction phase, mainly on the ADA and surroundings, but extending to the IIA due to access. It has an immediate induction and a short-term duration (construction period). It is reversible and has a high probability of occurrence. The magnitude is medium and the significance is moderate, but is considered medium to high for housing on the neighbouring farm. Being a highly mitigable impact, its residual significance is moderate for neighbours on the estate.

Impact rating (attributes) **Nuisance caused by construction activities**			
Nature	Negative	**Location and spatialisation**	ADA/AII
Stage of occurrence	Implantation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	High
Magnitude and Importance			
Magnitude	Medium and Medium to High for neighbouring residents		
Importance	Moderate and Medium to High for neighbouring residents		
Mitigability	Highly Mitigable		
Residual importance	Moderate		

8.03 - Noise nuisance in the operation phase

Impactful actions	A.1.03 Studies of locational and technological alternatives A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.04 Transport of inputs and outputs A.3.05 Environmental controls during operation
Impact Component	C.3.03 - Quality of Life of the Population

Analysis of potential impact

In the operation phase of the Project, some noise-emitting Plant equipment may affect the quality of life of the residents of the neighbouring property. As mentioned above, there is only one residence adjacent to the Plant site, where four or more people live and work on the farm where ducks, morocco, sheep, goats, donkeys, horses and cattle are raised, according to information from the interview.

Taking into account the operation of the plant, the emissions from the equipment that emit the most noise are as follows:

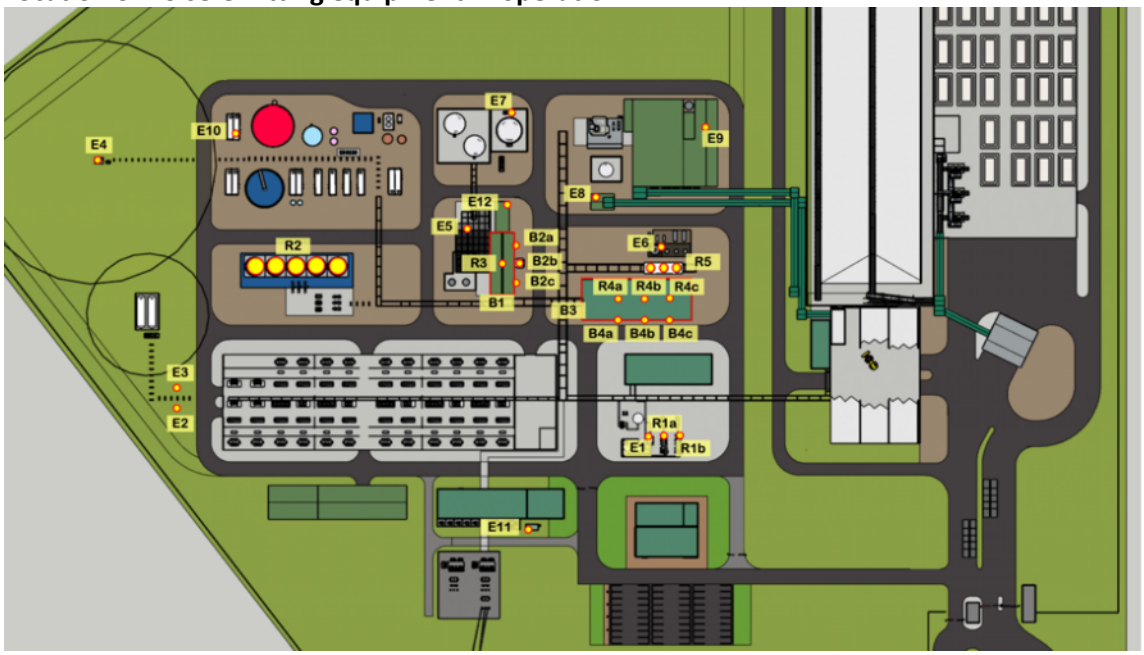
Table 6.1.3.3.c
Noise-emitting plant equipment

Point	Description	Emitted noise (dBA) *
R1a	USA main compressor	85
R1b	USA standby compressor	85
R2	Cooling tower (5 cells)	85
R3	Turboset	95
R4a	*Syngas* compressor	95
R4b	Standby compressor	95
R4c	NH Synthesis Unit Compressor$_3$	95
R5	NH refrigerator$_3$	85
B2a	Ventilation Turboset A	84
B2c	Ventilation Turboset B	84
B4a	Compressor building ventilation A	84
B4b	Compressor building ventilation B	84
B4c	Compressor building ventilation C	84

*1 m from the equipment.

This equipment is shown in **Figure 6.1.3.3.c in** relation to the Plant layout, using the codes R1 to R5, B2 and B4 shown in the Table and highlighted in red circles.

Figure 6.1.3.3.c
Location of noise-emitting equipment in operation



In addition to the noise caused by the Plant's equipment, noise caused by truck traffic within the plant must also be taken into account. However, taking into account that the flow will not be constant, it is understood that this contribution will be very small.

As the Acceso Sur is a road with a much higher current traffic volume than the Villeta - Alberdi Route, it is not considered that the 8 daily trips of the workers' buses could generate an increase in noise that would cause further nuisance to the residents of the houses located on its margins.

As for the LT, it is worth mentioning that due to the Corona effect, its operation produces a wide-range noise, with sounds generally described as buzzing, clicking or hissing. Although it is rarely of sufficient intensity or volume to cause annoyance and complaints from the surrounding population, it is an impact to be taken into account. Atmospheric conditions can cause significant variations in the intensity of the Corona Effect, especially in LTs with voltages above 220 kV, which is the main source of noise emissions resulting from the operation of LTs. In rainy and humid weather, the noise generated by the operation of TLs can reach relatively high sound levels and can be a source of discomfort for surrounding populations.

The ATOME LT project considers the maximum audible noise at the boundary of the easement strip as 45 (night) and 60 (day) dBA. These values are those defined by Law N° 1100/1997 for residential areas. On the other hand, the IFC limits daytime noise to 55 dB, slightly below the limit of Law No. 1100/1997.

To establish the current noise levels at the Project site, a Sound Pressure Level (SPL) measurement campaign was carried out between 30 September and 10 October 2023, during daytime and nighttime hours, at four selected receptors located in the vicinity of the Project, by means of a single continuous measurement of 20 hours duration per point.

To assess the impact on the noise environment caused by the project, noise modelling was carried out using the CadnaA model, which allows noise dissipation to be estimated from emitting sources, taking into account topography and other obstacles. The CadnaA software, from the German company Datakustik, initially considers the modelling of the current situation, with the topography, surrounding buildings and walls and current noise sources being inserted into the programme. The model is calibrated until the respective values measured in the campaign are obtained at the points.

The modelling was carried out by CSI Engineers in October 2023 and the full report "Noise Impact Assessment - Sound Pressure Level Modelling" can be found in **Annex 6.**

The results of the measurements were considered in the modelling, carried out at four points, one inside the plant considering the future location of the main noise sources such as the compressors, one at the main access to the site and in front of the road, one at the boundary of the property of Atome and the neighbour and the last one at the main access to the neighbour's property.

Eleven point receptors were defined along the perimeter of the site and four additional receptors were incorporated corresponding to the monitoring sites where the baseline measurements were taken. **Figure 6.1.3.3.d** shows the location of all point receptors considered.
The assessment of the impact on noise quality was carried out considering two different scenarios. The first corresponds to the scenario with all the main noise emission sources operating continuously and simultaneously (conservative assumption), without including noise abatement measures. **Figure 6.1.3.3.e** shows scenario 1 of plant operation. The second scenario analysed arises from considering the noise abatement measures defined during the engineering design of the industrial plant as additional instruments to mitigate the acoustic impact that the

project could generate on the environment. **Figure 6.1.3.3.f** shows the noise curves taking into account the noise attenuation measures.

Table 6.1.3.3.d below shows the analysis of the future situation (project + baseline) for each modelled scenario and its comparison with the adopted reference standards and guidelines.

Figure 6.1.3.3.d
Point receivers considered

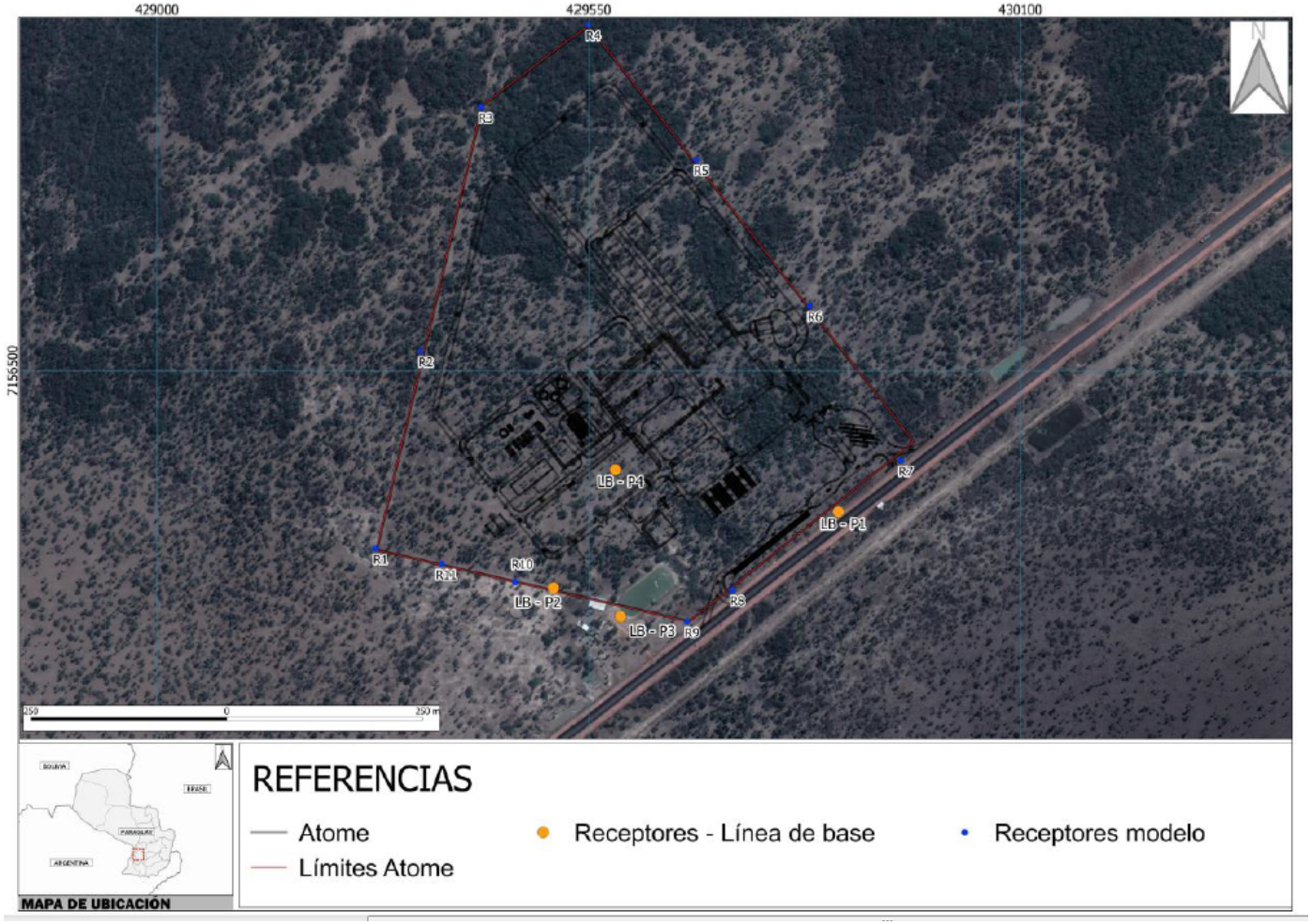


Figure 6.1.3.3.e
Scenario 1

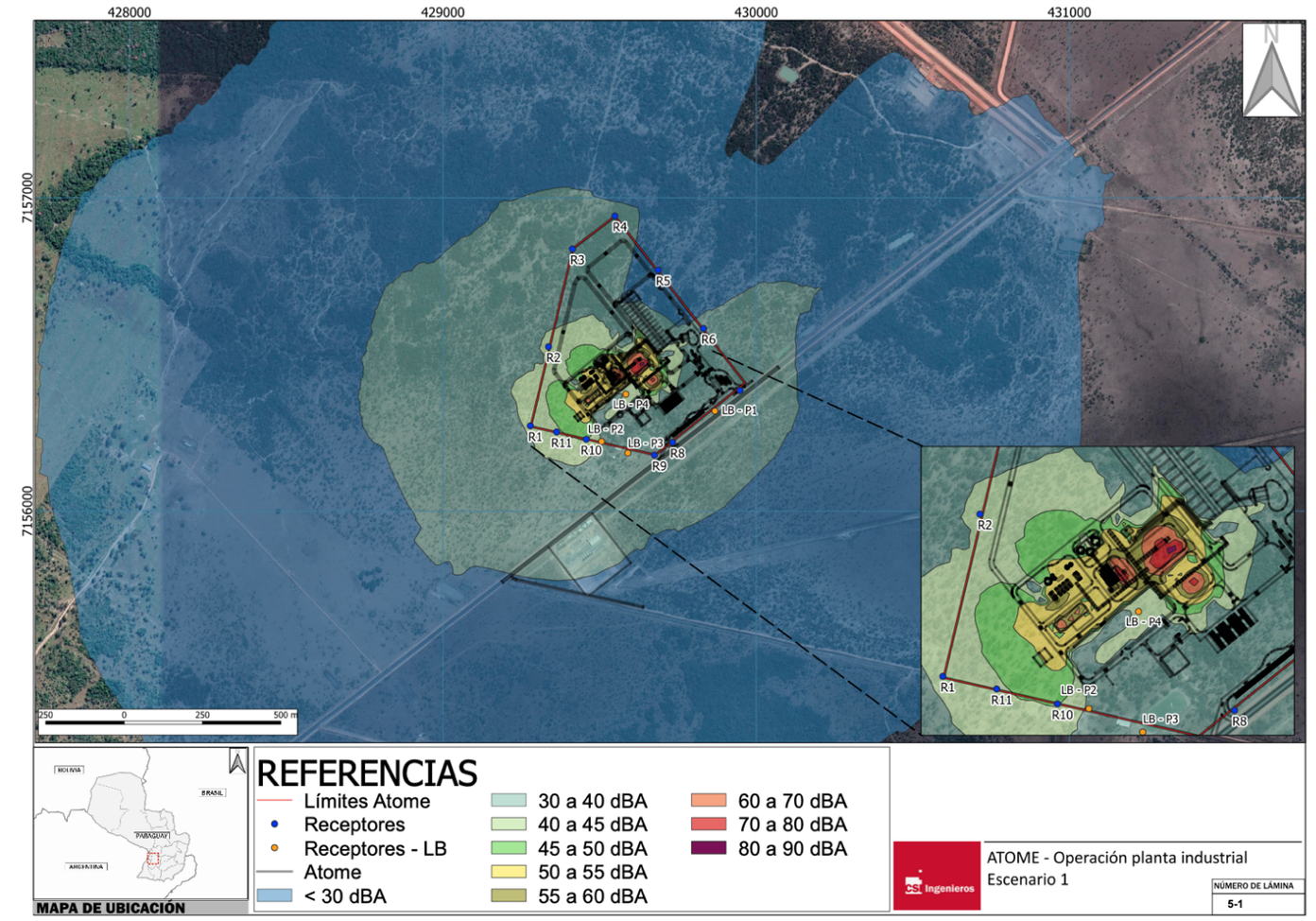


Figure 6.1.3.3.f
Scenario 2

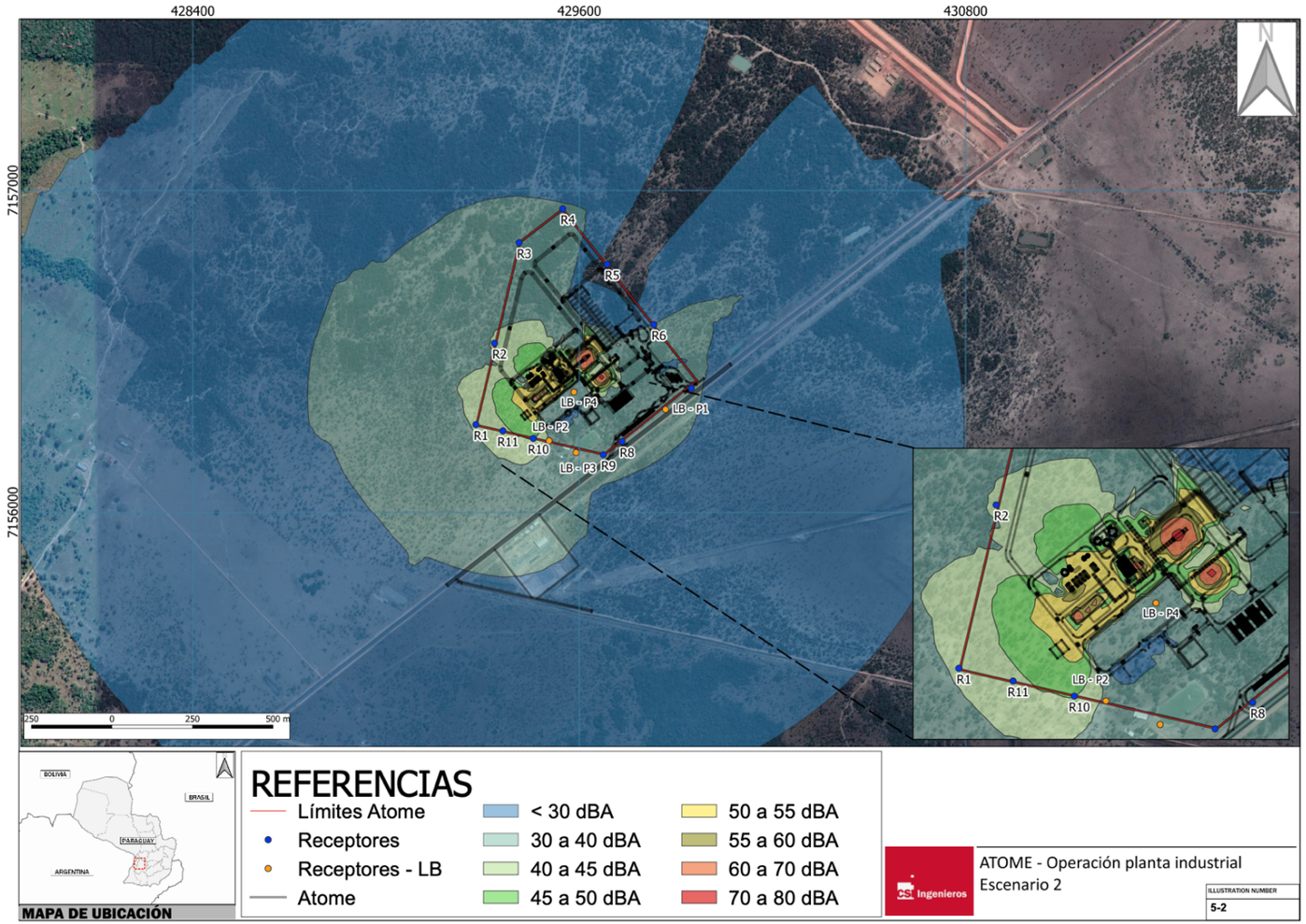


Table 6.1.3.3.d

Expected NPS values and comparison with standards and reference guidance

Receiver	Period	Project contribution L_{Aeq} (dBA)		Baseline (dBA)	Representative baseline point** (dBA)	Future scenario: project + baseline (dBA)		Law 1100/97 (dBA)	IFC Guide (dBA)
		Sc 1	Sc 2			Sc 1	Sc 2		
R1	Daytime	41	41	56	LB-P4*** LB-P4*** LB-P4*** LB-P4*** LB-P4	56	56	75	70
	Noct.	41	41	53		53	53	60	70
R2	Daytime	41	41	56	LB-P4	56	56	75	70
	Noct.	41	41	53		53	53	60	70
R3	Daytime	34	33	56	LB-P4	56	56	75	70
	Noct.	34	33	53		53	53	60	70
R4	Daytime	31	30	56	LB-P4	56	56	75	70
	Noct.	31	30	53		53	53	60	70
R5	Daytime	25	19	56	LB-P4	56	56	75	70
	Noct.	25	19	53		53	53	60	70
R6	Daytime	35	31	56	LB-P4	56	56	75	70
	Noct.	35	31	53		53	53	60	70
R7	Daytime	33	30	66	LB-P1	66	66	75	70
	Noct.	33	30	62		62	62	60	70
R8	Daytime	34	31	66	LB-P1	66	66	75	70
	Noct.	34	31	62		62	62	60	70
R9	Daytime	33	31	65	LB-P3	65	65	75	70
	Noct.	33	31	67		67	67	60	70
R10	Daytime	45	45	58	LB-P2	58	58	75	70
	Noct.	45	45	55		55	55	60	70
R11	Daytime	44	44	58	LB-P2	58	58	75	70
	Noct.	44	44	55		55	55	60	70
LB - P1	Daytime	34	31	66	LB-P1	66	66	75	70
	Noct.	34	31	62		62	62	60	70
LB - P2	Daytime	40	39	58	LB-P2	58	58	75	70

Receiver	Period	Project contribution L_{Aeq} (dBA)		Baseline (dBA)	Representative baseline point** (dBA)	Future scenario: project + baseline (dBA)		Law 1100/97 (dBA)	IFC Guide (dBA)
		Sc 1	Sc 2			Sc 1	Sc 2		
	Noct.	40	39	55		55	55	60	70
LB - P3	Daytime	32	31	65	LB-P3	65	65	60	55
	Noct.	32	31	67		67	67	45	45

Source: CSI Engineers, 2023.

* Given that the Paraguayan regulations and the IFC guide consider different time bands for day and night periods, the lowest value corresponding to each period is selected.

** Baseline point considered representative of the acoustic environment of the assessed receptor. A criterion of proximity and distance to the route was used for its determination.

***LB-P4 is not assessed as it is within the industrial site.

According to the conclusions of the study in **Annex 6** (CSI Ingenieros, 2023), the assessment of the potential impact on the acoustic environment of the area due to the future operation of the Plant indicates that no significant negative impact on the environment will be generated, as the acoustic quality will continue to be determined by the current (baseline) condition. Under the assumptions made in the modelling, the sound pressure level contribution from the operation of the project alone (without any ambient noise) is substantially less than the current (baseline) condition, with values of less than 10 dBA at all point receptors assessed.

Regarding compliance with the target quality values established in the Paraguayan regulations and IFC guidelines in the future scenario, it is not expected that there will be a change in the current compliance of the surveyed receptors. In other words, those receptors where the current NPS exceeds the target quality values will continue to exceed them in the future situation, and no specific receptor assessed is expected to change its level of compliance when the project starts operating.

If the IFC guidelines are considered, the LB-P3 receptor (point located in the nearest dwelling) is the only point receptor where the target quality value for daytime and night-time periods is not met in the current situation and will not be met in the future situation. If the Paraguayan regulations are considered, the same receptor LB-P3 also does not meet the target quality values for both periods, and the same happens for receptors R7, R8, R9 and LB-P1 in the nighttime period.

It should be noted that for the LB-P3 receptor, the residential limits of the Paraguayan regulations and IFC guidelines were considered. Despite the above, it should be noted that this receptor corresponds to a productive rural dwelling where farming activities are carried out and that the NPS values surveyed in the baseline are currently high.

Monitoring Measures

According to the modelling study, the noise abatement measures that Atome has already incorporated in its engineering design and were considered in Scenario 2 will further reduce the project's contribution. In the testing phase prior to commissioning, measurements will be taken to ensure that the noise levels emitted by the equipment comply with the limits indicated in the warranty for each piece of equipment. The actual effectiveness of the designed noise attenuation measures will be confirmed during the testing and commissioning phase, as a confirmation check will be carried out by the EPC contractor prior to the start of operations.

However, in the operational phase, noise monitoring will be carried out as part of the **Operation Phase Environmental and Social Management Programme** to demonstrate that the non-existence of impacts, i.e. baseline levels recorded prior to the start of plant operation remain as before.

Rating of the resulting impact

This is a negative impact of the operation phase, restricted to the portion of the AID closest to the ADA, but extending to the IIA due to access. It has an indirect impact, immediate induction and long-term duration. According to modelling studies, it has a low probability of occurrence and is reversible due to noise reduction measures included in the project design. It has a

cumulative potential (see **Section 6.1.5**). The magnitude and significance are considered low and being easily mitigated, the residual significance is also low.

Impact rating (attributes) **Noise nuisance in the operation phase**			
Nature	Negative	**Location and spatialisation**	IDA/IIA
Stage of occurrence	Operation	**Advocacy**	Indirect
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Baja		
Importance	High		
Mitigability	Fully Mitigable		
Residual importance	Baja		

8.04 - Odour nuisance in the operation phase

Impactful actions	A.1.03 Studies of locational and technological alternatives A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.05 Environmental controls during operation
Impact Component	C.3.03 - Quality of Life of the Population

Residents of the house next to the Plant may be affected in the operation phase by odour emissions, mainly related to the operation of the following plant structures:

- Wastewater Treatment Plant (WWTP);
- NH synthesis unit$_3$;
- NH main tank$_3$.

This odour emission, depending on the proximity and wind direction, may cause nuisance to neighbours. In this respect, it is worth mentioning that these Plant facilities will be between 200 and 300 m from the neighbouring house and that the north-westerly winds during the summer may contribute to the nuisance of neighbours caused by ammonia gas leakage at the NH plant$_3$ and the NH main tank$_3$, or by odours from malfunctioning of the WWTP.

Mitigation Measures

Odour control measures are proposed as part of the **Operation Phase Environmental and Social Management Programme**, and the necessary measures to be implemented will be assessed.

It also mentions the follow-up of complaints registered through the Complaints Handling Mechanism to be implemented in the operation, within the scope of the **Stakeholder Engagement Programme,** and the implementation of the necessary corrective measures.
Rating of the resulting impact

This is a negative impact of the operation phase, restricted to the portion of the AID closest to the ADA. It has indirect impact, immediate induction and long-term duration, but intermittent.

It has a low probability of occurrence and is reversible. The magnitude is considered medium and the significance moderate, but medium to high for the residents of the neighbouring house. Having a medium mitigation potential, it results in low residual significance.

Risk Rating (attributes) Odour nuisance in the operation phase			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Operation	**Advocacy**	Indirect
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term, intermittent
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Media		
Importance	Moderate and Medium to High for neighbouring residents		
Mitigability	Moderately Mitigable		
Residual importance	Baja		

6.1.4
Identification of Risks Associated with the Project

This section analyses the risks associated with the Project on the Physical, Biotic and Socio-economic Environment components, which will not necessarily materialise in the form of negative impacts if the proposed measures are effective. At the end, the rating of the eventual impact associated with this risk, should it materialise, is assessed.

As can be seen, 11 risks associated with the project were identified, 3 in the physical environment, 2 in the biotic environment and 6 in the socio-economic environment.

Matrix 6.1.3.a in **Section 6.1.3** shows the risks and associated preventive measures.

6.1.4.1
Physical Environment

9 - Risks of impacts on Surface and Groundwater Resources

9.01 - Risk of impact on groundwater quality during construction phase

Impactful actions	A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.05 Flows of vehicles, equipment and workers A.2.06 Earthworks A.2.07 Execution of foundations A.2.08 Civil works A.2.09 Assembly A.2.12 Operation of construction support facilities A.2.13 Demobilisation of support areas A.2.15 Recovery of direct intervention areas
Impact Component	C.1.02 - Surface and groundwater resources

Risk analysis

As well as the risk impact of soil contamination during construction, potential leaks of hazardous and/or toxic products or improper disposal of contaminated effluents have the potential to negatively impact soil and, consequently, groundwater.

However, according to the diagnostic data, as well as the above, the Alfisols, which predominate in the AID and AII, present an impermeable layer that determines a low natural vulnerability to contamination of the aquifers under this layer.

On the other hand, the impermeable layer favours surface water accumulations, mainly in areas of Typic Albaqualf occurrence (A1.4 in **Map 5.2.6.a**), located in low and floodplain relief. As highlighted in **Section 5.2.6**, this soil type is distributed from the east of the Esteros del Ypoá region to the surroundings of the Paraguay River, including the IIA along the Villeta-Alberdi Route, from where part of it is directed to rice cultivation.

In the AID, due to the prevalence of Aquic Paleudalf (A7.4 in **Map 5.2.6.a**) water accumulations occur on the surface, mainly after more intense rainfall events, but not for such prolonged periods as in areas of Typic Albaqualf occurrence.

Studies on the main hydraulic and hydrological characteristics in the ADA confirmed that stormwater is the main source of water on the site with surface runoff following the general outward and westerly pattern and with maximum depth between 25 and 30 cm for a 25-year recurrence (**Section 5.2.2.4**).

As for groundwater levels, according to the results of the borehole drilling report on the plant site, these were identified at two depths: between 30-42 m and between 48-50 m, in sandstone strata interspersed with more clayey layers. In the area of the Buey Rodeo substation, in boreholes with depths of 8.45 m, carried out in August 2019, the presence of groundwater was

not detected, possibly located at a greater depth. At the same time, in the Omega Green Project area, the water table was found to be between 6.3 m and 7.8 m deep. In relation to the geotechnical studies of the ATOME Plant ADA, the water table was found to be between 8.0 m and 8.7 m deep, it being noted that this position is dependent on the rainfall regime and the level of the Paraguay River.

From the above, it is considered that in the area of the Plant the possibility of altering the quality of the water quality of the deepest aquifer (below the most clayey layers) is low, especially in the case of possible leaks of hazardous and/or toxic products or inadequate disposal of contaminated effluents, as the clayey soils act as an impermeable barrier. The exception may occur in the case of contaminant inputs at deeper excavation points or even through existing wells that are unprotected. However, this possibility is greater in the case of the phreatic aquifer, due to its shallower depth of occurrence, but, in general, this water is not captured in wells.

Regarding groundwater quality in the Plant area, analyses carried out in January 2023 on a sample taken from a deep well dug in the ground, and in June 2023 on a sample taken from a piezometer, found that the groundwater is already contaminated. The well sample showed organic matter and coliform values above the reference values, as well as several other non-compliant parameters, including turbidity, solids, ammonia nitrogen and chloride. In the piezometer sample, values for BOD, solids, DO, total nitrogen, phosphorus and some metals extrapolated the limit, confirming contamination.

For the works, excavations of 102,000 m^3 are planned for foundations and buildings, which are considered to be the deepest excavations.

As already highlighted, the local aquifer, Quaternary Aquifer, has aquifer layers mainly restricted to sandy levels and which have a variable location in terms of depth and lateral dimensions. Thus, once the protective layer has been removed, extreme care must be taken to avoid contamination of groundwater during the execution of all activities involving diesel/combustion fuels, including the areas of movement of equipment, vehicles and machinery in construction areas, access and construction support areas. Therefore, special care should be taken in operations around construction sites, as well as in areas where potential leaks of hazardous products or improper disposal of contaminated effluents such as sewage overflows may occur.

Prevention and Control Measures

Given these potential conditions, the following measures are foreseen in the ESMP to prevent, control and mitigate this risk:

- **Environmental Construction Control Programme**
  - Prevention and control of soil contamination
  - Effluent management
  - Temporary facilities/construction camp management
  - Solid waste management
  - Hazardous materials handling
  - Construction traffic control
  - Management of earthmoving activities
  - Control of vegetation clearance activities
  - Recovery of areas degraded by the works
- **Environmental and Social Management Programme**
  - Construction Supervision, including Contractors and Subcontractors
  - Conformity Assurance Procedure
  - Coordination of Socio-Environmental Programmes of the GSAP
  - Environmental quality monitoring measures
- **Labour Management and Working Conditions Programme**
  - Job Training
- **Emergency Response Programme for the Construction Phase**
  - Emergency Action Plan in the event of a hazardous product spill

Risk rating

Considering the implementation of the proposed measures, this risk is considered to have a low probability of occurrence.

If the impact materialises, even with preventive and control measures, it is classified as negative in nature, with a potential impact on the IIA, direct incidence, immediate induction and short term duration. It is highly mitigable and reversible, being considered of low magnitude and low importance with the implementation of good construction practices.

Impact rating (attributes) **Impact on groundwater quality during the construction phase**			
Nature	Negative	**Location and spatialisation**	IIA
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		

10 - Soil/relief impact hazards

10.01 - Risk of soil contamination during construction phase

Impactful actions	A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.05 Flows of vehicles, equipment and workers A.2.06 Earthworks A.2.07 Execution of foundations A.2.08 Civil works A.2.09 Assembly A.2.10 Assembly of towers A.2.11 Launching of cables A.2.12 Operation of Construction Support Facilities A.2.13 Demobilisation of support areas A.2.15 Recovery of direct intervention areas
Impact Component	C.1.01 - Soil / Relief

Risk analysis

Possible leakage of hazardous and/or toxic products or improper disposal of contaminated effluents has the potential to negatively impact soil and, consequently, water.

Their magnitude, however, depends on several factors, including: type of substance, volume of leakage, product characteristics (viscosity, volatility, reactivity, solubility, etc.) and environmental characteristics (effective soil porosity, water table depth, type of constituent material, type of aquifer, presence of geological structures), etc.

In this case, any leakage that occurs first will reach the ground, but not necessarily the water table and surface drainage, which will depend on the characteristics of the product and the properties of the medium. The greatest risk of reaching the water exists in the area where the water catchment infrastructure will be installed on the banks of the Paraguay River, but this will have to be installed during the low water period and for a very short period due to the small size of the pumping house.

During the construction of the Plant, installation of the TL towers and intake, pumping and piping structures for water supply and effluent discharge from the Paraguay River to the Plant, the risk of soil contamination is associated with the presence of equipment, vehicles and machinery in construction areas that use diesel/fuel/oil, on access roads and in construction support areas.

As for the type of terrain where the interventions will be carried out, it should be noted that it is mainly of Low Plains relief, made up of soft Quaternary alluvial sediments, formed by silty clays, sands, clays and silts.

The presence of an impermeable clay layer in the subsoil of the ADA and AID, characteristic of the Aquic Paleudalf types (A7.4 on **Map 5.2.6.a**), as discussed in **Section 5.2.6**, helps to protect the deeper groundwater levels.

Therefore, special care must be taken in operations at construction sites, in addition to areas where possible small leaks of hazardous and/or toxic products or improper disposal of contaminated effluents may occur.

Pollution is also associated with inadequate disposal of hazardous solid waste (oil contaminated waste, concrete waste, lubricant and solvent containers and containers, etc.) and inadequate effluent management, whether domestic (toilets and canteens at the work and camp fronts) or industrial (mixer nozzle wash effluent and workshop floor effluent). In **Section 2.7.4 the** quantities of construction and demolition waste are indicated, including an indication of those considered hazardous according to Directive 91/689/EEC.

Thus, in temporary construction facilities, the risk of soil contamination is higher due to the presence of structures such as the waste plant, chemical storage areas, site workshop, kitchen, canteen, septic tank, among others, according to the description given in **Section 2.7.1.5. In** addition, as reported, a tank to power a portable diesel generator for construction work is foreseen.

Prevention and Control Measures

Given these potential conditions, measures are considered in the ESMP to prevent this risk, including the following:

- **Environmental Construction Control Programme**
  - Prevention and control of soil contamination
  - Effluent management
  - Temporary facilities/construction camp management
  - Solid waste management
  - Hazardous materials handling
  - Construction traffic control
  - Management of earthmoving activities
  - Control of vegetation clearance activities
  - Recovery of areas degraded by the works
- **Environmental and Social Management Programme**
  - Construction Supervision, including Contractors and Subcontractors
  - Conformity Assurance Procedure
  - Coordination of Socio-Environmental Programmes of the GSAP
- **Labour Management and Working Conditions Programme**
  - Job Training
- **Emergency Response Programme for the Construction Phase**

- Emergency Action Plan in the event of a hazardous product spill

Risk rating

Considering the implementation of the proposed measures, this risk is considered to have a medium probability of occurrence.

If the impact materialises, even with preventive measures, it is classified as negative in nature, restricted to the construction phase, of direct incidence and coverage restricted to the Directly Affected Area (DAA). The induction is immediate and the duration is short term. It is considered an impact of low magnitude and importance.

Risk Rating (attributes) **Soil contamination during the construction phase**			
Nature	Negative	**Location and spatialisation**	ADA
Stage of occurrence	Construction	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Media
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		

10.02 - Risk of soil contamination in the operation phase

Impactful actions	A.1.03 Studies of locational and technological alternatives A.3.02 Plant Water Catchment A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.04 Transport of inputs and outputs A.3.05 Environmental controls during operation
Impact Component	C.1.01 - Soil / Relief

Risk analysis

The options for land transport of Atome's final product are still under evaluation, with alternatives such as transport from the plant to the cities of Cascavel or Dourados, in Brazil, and by land to the Terport Port of Villeta, following the Paraguay-Paraná waterway to the Port of Nueva Palmira, in Uruguay.

Thus, both in the case of transport on the access roads to Cascavel and Dourados, and along the 15 km that separate the plant from the port of Terport, the increased circulation of trucks and also of buses for the transport of workers will increase the risk of accidents and possible soil contamination in the event of fuel and/or other hazardous product leaks.

The ATOME Plant Project also foresees the operation of raw water and wastewater treatment stations, a waste facility, as well as the operation of a substation, car parks, warehouse and workshop, among other structures. Thus, possible leaks of hazardous and/or toxic products or improper disposal of contaminated waste and effluents at these sites have the potential to

negatively impact the soil, but the likelihood is low due to the design of each facility for storage, handling and treatment of effluents, hazardous substances and wastes. All facilities will have secondary containment and drainage to contain spills and prevent soil contamination.

Effluents generated in the operation of the Plant and to be treated at the WWTP include water treatment effluents, sanitary water treatment effluents, oil separator effluents, non-oil network effluents and cooling tower blowdown. Taking these types of effluents into account, the total estimated flow is 77.3 m^3 /h, as explained in **Section 2.8.1.6**. Effluent treatment also involves the use of chemicals, including sulphuric acid and sodium hydroxide.

Among the solid wastes to be generated (**Section 2.8.1.7**), the following are highlighted due to the risk of contamination: domestic waste from bathrooms and canteens; used oil, used light bulbs and batteries; oil-contaminated waste from machinery and equipment maintenance activities; sludge from the water and effluent treatment system; electrodes from electrolysis equipment; ammonia reactor catalyst; and maintenance waste.

Their occurrence, as in the construction phase, depends on several factors, including: type of substance, volume of leakage, product characteristics, and soil or floor characteristics. In any case, unlike the construction phase, most operational activities with a potential risk of soil contamination will be carried out mainly in impermeable and better prepared areas from a contamination control point of view. The design of each storage, handling and treatment facility for effluents, hazardous substances and wastes will have secondary containment and drainage to contain spills and prevent soil contamination.

Therefore, during the construction phase, special care should be taken for activities in areas of exposed soil, as well as areas where there is an increased risk of accidents with hazardous products, e.g. in road transport or areas where there may be possible leakage of a higher volume of hazardous and/or toxic products or improper disposal of contaminated effluents.

Prevention and Control Measures

As prevention measures, the secondary containment of waste and chemical substance processing and storage areas is mentioned, with a capacity to contain 110% of the total volume in the event of a spill or leak. In addition, the storage of hazardous substances and waste will not be carried out directly on the ground, using the areas provided for this purpose.

The Plant's own storm water drainage system, which will contain all discharges, is also considered a preventive measure. The system will have flow separation, preventing any spillage in the process area and chemical storage areas from mixing with stormwater in areas where no pollutants are present.

In addition to these, the following measures are mentioned to control this risk:

- **Environmental and Social Management Programme for the Operational Phase**
  - Solid waste management
  - Hazardous waste management
  - Hazardous materials handling

- Supervision of contracted companies

- **Labour Management and Working Conditions Programme**

  - Job Training

Risk rating

Considering the application of the proposed measures, this risk from the operation stage is considered to have a low probability of occurrence, as each facility at storage and handling of wastes, effluents, and hazardous products will have secondary containment and drainage for spill containment.

If the impact materialises, even with preventive measures, it is classified as negative in nature, direct impact, and coverage restricted to the ADA mainly, but extending to the IIA because it includes the accesses. The induction is immediate with the start of the operation and the duration is long term. It is a reversible impact, being considered of low magnitude and importance.

Risk Rating (attributes) **Soil contamination in the operation phase**			
Nature	Negative	**Location and spatialisation**	ADA and AII
Stage of occurrence	Operation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		

6.1.4.2
Biotic Environment

11 - Risks of impacts on Flora and Vegetation

11.01 - Risk of spreading invasive species

Impactful action	A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.15 Recovery of direct intervention areas
Impact component	C.2.01 - Flora and Vegetation

Risk analysis

Invasive alien species are one of the main drivers of biodiversity loss worldwide. According to the 2019 global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) the rate of introduction of invasive alien species is unprecedented and shows no signs of abating. These high rates occur because of the increasing volume of international shipments containing live organisms and propagules, in

addition to other factors such as changes in trade patterns and consumer behaviour and habits.

The construction and assembly period of the Project will require the procurement of goods and services for the works, including construction inputs such as iron, ready-mixed concrete, fuels, paints, varnishes, etc., as well as the hiring of local workers and other workers from outside the region for jobs related to activities requiring technical qualifications.

In this sense, the constant traffic of machinery and workers during the works may favour the entry of invasive alien species into the native habitats of the region.

Millennium Development Goal 15.8 calls for the implementation of measures to prevent the introduction and significantly reduce the impact of invasive alien species on terrestrial and aquatic ecosystems and to control or eradicate priority species. The first national database with information on the occurrence of invasive alien species in Paraguayan territory was developed in 2001, and identified the occurrence of 410 species of invasive alien flora and fauna.

It should be noted that, despite the presence of exotic weeds on the boundary of the land near the road, the wildlife sampling carried out for the ESIA baseline identified the predominance of native species on the Project site.

Preventive measures

The overall objective of the **Construction Environmental Control Programme** is to provide technical guidance to minimise the negative environmental impacts of construction. The measures foreseen in this programme include control practices and monitoring of construction activities at the construction sites and in the construction camp and other support areas.

To ensure effective compliance with these measures, the **Environmental and Social Management Programme** includes environmental supervision, monitoring and documentation of the works, using a tool to control the activities carried out by the Contractors, accompanying the implementation of the pre-established mitigating measures.

The **Biodiversity Conservation Programme** to be elaborated as part of the **Biodiversity Action Plan (BAP)** includes the monitoring of the flora and fauna of reserved fragments as compensation for biodiversity impacts, with the objective of monitoring, among others, the presence of possible agents impacting the natural habitat, such as invasive alien species.

Risk rating

Considering the implementation of the ESMP measures mentioned above, the risk of this impact occurring is considered to be medium.

If the impact materialises, even with the proposed measures, it is rated as low in magnitude and of medium importance. Although there will be an increase in the movement of people and machinery, and the possible introduction of new invasive alien species, measures will be taken that can reduce and control this risk. This impact has a negative character, geographical scope in the AID, occurrence in the implementation and operation phases, and indirect incidence. Its induction and duration are medium term, being reversible.

Risk Rating (attributes) Propagation of invasive species			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Implementation and operation	**Advocacy**	Indirect
Temporariness (induction)	Medium Term	**Temporality (duration)**	Medium Term
Reversibility	Reversible	**Probability of occurrence**	Media
Magnitude and Importance			
Magnitude	Baja		
Importance	Media		

12 - Risks of Impacts on Wildlife

12.01 - Risk of impacts on wildlife during construction

Impactful actions	A.1.02 Initial operational structuring A.2.01 Mobilisation of construction workers A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance A.2.04 Implementation / Adequacy of accesses A.2.05 Flows of vehicles, equipment and workers A.2.06 Earthworks A.2.07 Execution of foundations A.2.08 Civil works A.2.09 Assembly A.2.10 Assembly of towers A.2.11 Launching of cables A.2.12 Operation of construction support facilities
Impact Component	C.2.02 - Fauna

Risk analysis

With the interventions for the construction of the Plant, the risk of direct impacts on low mobility fauna, such as leaf litter amphibians, increases. However, even for the most mobile fauna, the disturbance caused by the increased noise associated with the operation of machinery, including chainsaws, pile drivers, generators, etc., the movement of vehicles, and also the presence of workers on the construction sites, will act as an inducement for the displacement of fauna to adjacent regions. Consequently, this process will temporarily change the habits of the fauna species, generating a change in the patterns of occupation of the available micro-environments.

In addition, this scaring may increase the risk of accidents with fauna due to being run over during construction, taking into account that the Project is located on the edge of National Route PY19 and that it was possible to verify some records of fauna being run over due to the current use of this road (see **Photos 01 and 02** below).

The increase in environmental noise caused by the works, with the consequent scaring off of the most sensitive wild vertebrates, will be more intense at the peak of the works and at work fronts with a higher concentration of workers and activities.

It is also important to consider the risk of workers killing wildlife species, either out of precaution or fear, as in the case of snakes, or for food.



Photo 01: *Procyuon cancrivorus* (Aguara pope) run over.



Photo 02: *Cerdocyon thous* (Aguara'i) run over.

Preventive measures

To prevent this impact, the following measures are proposed as part of the ESMP programmes:

Environmental Construction Control Programme

- Construction traffic control
- Control of vegetation clearance activities

Programme for the Prevention of Impacts on Flora and Fauna

- Wildlife rescue and removal

Labour Management and Working Conditions Programme

- Job Training
- Environmental education of workers
- Code of Conduct for Employees

Environmental and Social Management Programme

- Construction Supervision
- Conformity Assurance Procedure
- Coordination of Environmental and Social Programmes of PGAS

Risk rating

Even with the proposed preventive measures, the risk is considered to be high and the impact has a high probability of occurring.

If the impact materialises, even with the proposed measures, it is classified as negative, direct, with a reach in the AID, immediate induction and short duration. It is reversible, of low magnitude and medium importance.

Risk Rating (attributes) Impacts on wildlife associated with the presence of workers during construction			
Nature	Negative	**Location and spatialisation**	AID
Stage of occurrence	Implantation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Some
Magnitude and Importance			
Magnitude	Baja		
Importance	Media		

6.1.4.3
Socio-economic environment

13 - Risks of impacts on Infrastructure, Social Facilities and Public Services

13.01 - Risk of increased demand for health services

Impactful actions	A.2.01 Mobilisation of construction workers
Impact Component	C.3.03 - Infrastructure, social equipment and public services

Risk analysis

As indicated in **Section 2.7.1.5**, the planned construction camp will have a first aid room / infirmary. However, these facilities will not have sufficient structure to handle serious accidents that may occur during construction, and a hospital will be required for these cases or in case of laboratory examinations. Thus, there may be an increased demand for health infrastructure during construction, related to the risk of occupational accidents inherent to this type of work, even with the preventive measures taken and the health and safety training foreseen in the **Occupational Health and Safety Programme** of the ESMP. If it occurs, the search for these services must be carried out mainly in Villeta, or even in Asunción in more serious cases.

As stated in **Section 5.4.1.6.1**, the health infrastructure in Villeta consists of a district hospital (HD) and 4 Family Health Units - USF (Cumbarity, Tacuaty Rugua, Naranjaisy and Naranjaisy II), in addition to the regional IPS unit. The Villeta HD has only 20 beds.

Preventive measures

Considering the scenario described above, the following measures are proposed, systematised in the **Occupational Health and Safety Programme** of the ESAP:

- Contractors and subcontractors must ensure health facilities with sufficient response capacity at the construction camp to minimise the risk of overloading health services in Villeta and nearby towns;

- In addition to the first aid/nursing room in the camp, the main measure to mitigate the

increased demand for health services is to implement appropriate occupational accident prevention and health and safety risk management programmes by implementing an Occupational Health and Safety Programme, in accordance with Paraguayan legislation and international requirements in this area.

- Have a safe worksite, with properly trained employees, with personal protective equipment, tools and equipment suitable for the execution of each activity. The EPC Contractor shall develop an Occupational Health and Safety Programme to ensure safe conditions at all times.

The complaints handling mechanism of the **Stakeholder Engagement Programme** is also mentioned.

The effective implementation of the measures will be verified through the measure *Supervision of the Construction of* the **Environmental and Social Management Programme**.

Risk rating

Considering that the Contractors will provide the necessary health care infrastructure at the construction camp and adequately implement accident prevention measures, have a relatively small workforce, and the vast majority already reside in the region, the risk of increased demand for health services in Villeta and neighbouring towns, or even in Asunción, is considered to be of low probability of occurrence.

If the impact materialises, even with the proposed measures, it will be negative, with geographical coverage in the IIA or diffuse, related to the implementation phase. It has an indirect impact, short-term induction and also short-term duration. It is reversible, and of low magnitude and significance.

Risk Rating (attributes) **Increased demand for health services**			
Nature	Negative	**Location and spatialisation**	IIA or diffuse
Stage of occurrence	Implantation	**Advocacy**	Indirect
Temporary (Induction)	Short Term	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Baja		
Importance	Baja		

14 - Community and Worker Health and Safety Impact Risks

14.01 - Risks to the health and safety of workers during construction

Impactful actions	A.2.01 Mobilisation of construction workers A.2.02 Mobilisation of construction support areas A.2.03 Vegetation clearance and site clearance

	A.2.04 Implementation / Adequacy of accesses A.2.05 Flows of vehicles, equipment and workers A.2.06 Earthworks A.2.07 Execution of foundations A.2.08 Civil works A.2.09 Assembly A.2.10 Assembly of towers A.2.11 Launching of cables A.2.12 Operation of construction support facilities A.2.13 Demobilisation of support areas
Impact Component	C.3.04 - Community and Workers' Health and Safety

Risk analysis

Construction work will involve a number of activities with specific risks to the health and safety of workers, of which the following are highlighted as high risk:

- Transport, handling and storage of machinery, equipment and work tools;
- Transport, handling and storage of hazardous materials, including fuels and flammable materials;
- Operation of machinery and equipment;
- Transport of persons;
- Contact with dangerous animals;
- Exposure to high noise levels when operating machines and chainsaws;
- Excavations;
- Work at height;
- Tree felling;
- Work with electrical hazards;
- Work at high temperatures;
- Use of welding with radioactive material.

The risks resulting from these activities vary significantly, ranging from minor injuries to more serious life-threatening cases. The significance of these risks will largely depend on the implementation of appropriate management measures, training, availability of protective equipment, risk analysis and work permits for each activity, and their compliance by workers.

Part of the workforce to be recruited is local and most of these workers, despite being aware of the risks identified above, may not be in the habit of adopting appropriate protective measures, including the use of personal protective equipment (PPE). Thus, the likelihood of some accidents occurring during the works is not ruled out.

In relation to the risk of contact with dangerous animals mentioned above, it is important to highlight the possible presence of venomous snake species on the Project site, such as coral snakes (*Micrurus frontalis*) and jararas (*Bothrops alternatus* and B. *diporus*), as well as invertebrates such as scorpions and spiders, which can cause accidents with the workers who will carry out the vegetation removal and site clearance activities.

The transport of equipment, machinery, inputs and workers has also been mentioned as a risk activity during the construction phase. During construction, it is estimated that the flow of heavy vehicles along National Route PY19 will increase. As reported in **Section 2.3.6**, there will be more than 1,000 workers hired for the construction of the Plant in the peak months, in addition to another 40-50 workers for the works and assembly of the LT and the water intake structure and water and effluent pipelines. Of these, the workers from outside the region will use hotel accommodation and flats in Asunción, and the others will be hired locally, so it is expected that they will live in the area.

Workers will be transported every day from Villeta or Asunción to the site by bus. It is estimated that transport will involve up to 8 round trips in the peak months in this phase (see **Table 2.7.6.a** in **Section 2.7.6**).

There will also be truck trips between the gravel quarry and the site for transporting fill material, totalling 5,430 trips, and 450 truck trips for transporting containers of imported goods between Terport and the site.

This increased flow of vehicles along the roads will increase the risk of traffic accidents with pedestrians and other vehicles. Pedestrian accidents are more likely in the sections where the Ruta Villeta - Alberdi passes through areas with higher residential occupation in the surroundings, which would be in the passage through the Guasu Korá settlement and through the Surubi'y community.

In the rest of the route, as already mentioned in other impacts, the use of the route's surroundings is more dispersed and is mainly made up of industries and service companies.

Despite their proximity to the Ruta Villeta - Alberdi, the Don Bosco and Sol Naciente settlements are located on the margins of another road, the Ruta Villeta - Nueva Italia. In any case, this risk is also mentioned for these two communities, and also for the residents of houses located on the margins of the Acceso Sur, on the route of the workers' transport buses. However, there are only two times of the day when this traffic is expected.

Preventive measures

Due to the potential risk identified, the following prevention measures are proposed, in addition to mitigation measures if impact occurs:

- Implement the Integrated Health and Safety Plan (PISS) for the construction phase, which complies with the requirements of Paraguayan legislation, as well as international requirements on working conditions, health and safety. This plan must be prepared by the Contractors and must be approved by ATOME. The Contractors will be responsible for the implementation of the ISSP and for the internal monitoring of its compliance (in particular by subcontractors). ATOME will be responsible for external monitoring of compliance with the ISSP, including the identification of situations of non-compliance, and for their corrective actions;

- Ensure that Contractors have employees appropriately qualified in Occupational Health and Safety;

- In the construction camp, ensure adequate hygiene and safety conditions in the social areas, in particular in the dining area and toilets;

- Ensure adequate housing conditions for workers from outside the region;

- Before commencing work, workers should be trained in: (a) potential hazards associated with the activities they will undertake; (b) safety measures; (c) first aid;

- Ensure that all workers have PPE and make permanent use of it during the works, according to the types of activities carried out;

- Develop and implement traffic management measures in the construction phase, including adopting less populated routes, complying with established speed limits, among others.

- Training on defensive driving and speed control devices in vehicles.

These measures are systematised in the ESMP, mainly in the **Occupational Health and Safety Programme**, but also in the Construction Traffic Control and Temporary Facilities/Construction Camp Management measures of the **Construction Environmental Control Programme**; and in the Labour Training, Code of Conduct for Workers and Grievance Handling Mechanism for Workers measures of the **Labour and Working Conditions Management Programme.**

The effective implementation of the measures will be verified through the Construction Supervision of the **Environmental and Social Management Programme**.

The Stakeholder Engagement Programme measures are also mentioned, mainly the communication measures and the Community Complaints, Grievances and Concerns Mechanism.

Finally, as part of the **Emergency Response Programme for the Construction Phase**, protocols

are established to be followed in case of fires/explosions and extreme events, such as severe storms and droughts.

Risk rating

Considering the correct and effective implementation of the proposed measures, this risk is rated as medium probability of occurrence.

If even with the proposed measures accidents with workers occur during the construction phase, i.e. if the impact materialises, it will be considered as negative, direct, mainly affecting the ADA, but extending to the IIA due to the risk of traffic accidents during the flows of vehicles, equipment and workers. It is an impact of immediate induction and short term duration, generally reversible. It is of medium magnitude and moderate importance, but has been upgraded to medium because it is an impact whose consequences may be irreversible.

Risk Rating (attributes) **Accidents involving workers during construction**			
Nature	Negative	**Location and spatialisation**	ADA/AII
Stage of occurrence	Implantation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Short Term
Reversibility	Reversible	**Probability of occurrence**	Media
Magnitude and Importance			
Magnitude	Media		
Importance	Media		

14.02 - Risks to the health and safety of workers during operation

Impactful actions	A.1.03 Studies of locational and technological alternatives A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.04 Transport of inputs and outputs A.3.05 Environmental controls during operation
Impact Component	C.3.04 - Community and Workers' Health and Safety

Risk analysis

In the operation phase, the risks exist mainly for workers who will work or circulate near the installations listed below and shown in **Figure 6.1.4.3.a** (the codes are the same as in **Figure 1.4.a - General Layout**, plus the letter Z):

- Z04: NH_3 Buffer Tank
- Z13: Electrolysis building
- Z20: Nitric acid plant (AN)
- Z20B: ammonium nitrate solution (ANS) plant
- Z21: H tank farm$_2$

- Z24A: synthesis gas compressors
- Z25: NH synthesis unit$_3$

For these facilities, an analysis of the risks and types of accidents that could occur was carried out. **Table 6.1.4.3.a** shows the types of risks that the facilities could present, the accidents that could occur and the levels of concern for three different zones: Intervention, Alert and Domino Effect Zones, according to the following definitions:

- ZI - Intervention Zone defined as a zone where the consequences of accidents produce a level of damage that justifies the immediate application of protective measures.
- ZA - Alert Zone, defined as a zone in which the consequences of accidents produce effects which, although perceptible to the population, do not justify intervention, except for critical population groups.
- ED - Domino effect zone, defined as the area in which potential accident propagation could occur.

Figure 6.1.4.3.a
Plant facilities that present a risk in the operation phase

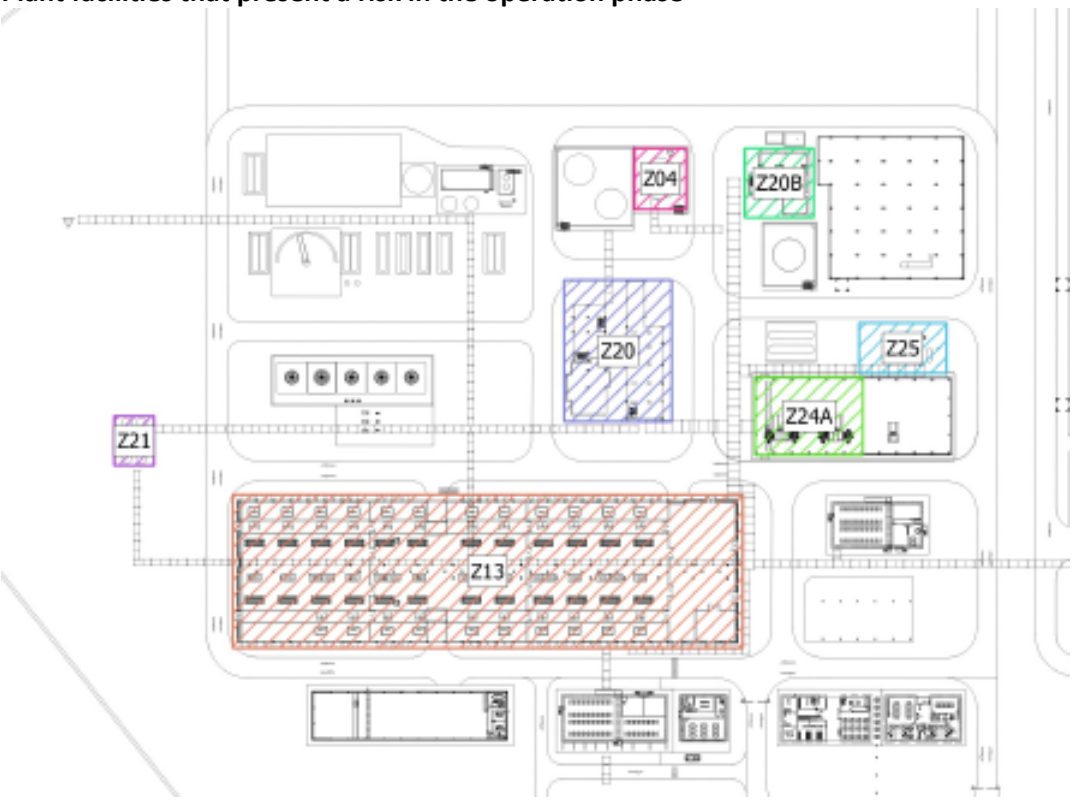


Table 6.1.4.3.a
Hazard types, accident types and levels of concern for ZIs, ZAs and EDs

Types of danger	Type of accidents	Acronym	Level of concern	Remarks
Thermal (thermal radiation)	*Pool fire* - PF	ZI	5 kW/m^2	Indicative of second degree burn after 30 seconds of exposure (less than 1% of fatalities).
	Jet fire - JF	ZA	3 kW/m^2	ZA for an exposure time of 30 seconds
		ED	12.5 kW/m /^{2} Flame spread	Ripple effects on specific equipment are possible depending on the duration of the phenomenon.
Thermal (thermal radiation)	*Flash Fire* - FF	ZI	LIF	Lower Flammability Limit (LIF)
		ZA	50% LIF	50% of the LIF
Mechanical (overpressure)	Explosion (VCE*, physical explosion) - VCE	ZI	125 mbar	Possible collapse of ceiling panels or walls
		ZA	50 mbar	Minor structural damage
		ED	160 mbar	Possible domino effect on specific equipment

* VCE = vapour cloud explosion.

To determine the consequences and extent of each accident scenario, the SAFETI tool (DNV) was used. For the physical explosions, the calculation was performed using the CHEMS-PLUS programme[1] , with the vapour properties included in the database of this software.

The frequency of occurrence of each of the accident initiating events is adapted to the actual usage time of the installation. The frequencies used are derived from the sum of the frequencies of the different causes that can give rise to the initiating events. The frequencies of the causes used were obtained from the BEVI Guide[2] .

To convert the physical variables (thermal radiation and overpressure) into exposure levels for the population that could be affected by the accidents considered, the PROBIT analysis tools were used, starting from a given exposure time to the harmful effects.

Risk acceptability was defined according to the criteria included in SHEM-02.01[3] .

As a result of the risk analysis, reach distances were defined for each facility for each type of accident, taking into account the different levels of concern. The areas defined by the distances for each risk are shown in **Table 6.1.4.3.b** below and in **Figures 6.4.1.1.3.b-1** to **6.4.1.3.b-35** of **Annex 13**.

As can be seen in **Table 6.1.4.3.b** and in the Figures in **Annex 13**, the accident scenarios with the largest accident range (max ZI) are all in NH Synthesis Unit structures$_3$, which are highlighted in red in **Table 6.1.4.3.b**. In these cases, the maximum ZI values are such that the effects of the accident can affect not only the area where it has occurred, but have a higher extrapolation to the surrounding areas.

[1] CHEMS-PLUS 2.0. *Consequence modeling software*. Cambridge, MA: Arthur D. Little (1991).
[2] Reference Manual BEVI Risk Assessments, version 3.2, National Institute of Public Health and the Environment (RIVM), Centre for External Safety, Bilthoven, the Netherlands, 2009.
[3] SAFETY, SECURITY, HEALTH & ENVIRONMENT MANAGEMENT (SHEM) STANDARD. SHEM-02.01. Process Safety Risk Assessment. Rev. No. 01. December 2013. SABIC.

As described in **Section 2.4**, with the properties and risks associated with the raw materials and products that will be handled in the operation of the plant, both H_2 and NH_3 are flammable gases that can explode if heated. H_2 can also form explosive mixtures with air, while NH_3 is dangerous in case of direct contact or inhalation by workers, as it is toxic and causes severe skin burns and eye injuries.

In the case of HNO_3 and $NH_4\ NO_3$, both can aggravate a fire and should be kept away from heat sources, ignition sources and incompatible materials and not mixed with combustible materials. Both are dangerous if workers come into contact with them. HNO_3 causes severe skin burns and eye injuries and $NH_4\ NO_3$ can also cause severe eye irritation.

Table 6.1.4.3.b
Distances from the ZI, ZA and ED for each accidental scenario at each facility of the Plant

Scenario	Figure from Annex 13	4D weather condition			Weather condition 2F					
		ED	ZI	ZA	LD01	ED	ZI	ZA	LD01	Max ZI
Z13/SEP1/H2/G2/FLASHF	Figure 6.4.1.3.b-1		0	23				22		0
Z13/SEP1/H2/G2/VCE	Figure 6.4.1.3.b-2	12	13	19	10	14	15	22	12	13
Z13/SEP1/H2/G2/JFIRE	Figure 6.4.1.3.b-3	8	9	10	8	9	9	10	8	15
Z13/SEP2/H2/G2/FLASHF	Figure 6.4.1.3.b-1		0	23				22		4
Z13/SEP2/H2/G2/VCE	Figure 6.4.1.3.b-2	12	13	19	10	14	15	22	12	13
Z13/SEP2/H2/G2/JFIRE	Figure 6.4.1.3.b-3	8	9	10	8	9	9	10	8	15
Z13/SEP3/H2/G2/FLASHF	Figure 6.4.1.3.b-1		0	23				22		9
Z13/SEP3/H2/G2/VCE	Figure 6.4.1.3.b-2	12	13	19	10	14	15	22	12	13
Z13/SEP3/H2/G2/JFIRE	Figure 6.4.1.3.b-3	8	9	10	8	9	9	10	8	15
Z13/SEP4/H2/G2/FLASHF	Figure 6.4.1.3.b-1		0	23				22		9
Z13/SEP4/H2/G2/VCE	Figure 6.4.1.3.b-2	12	13	19	10	14	15	22	12	13
Z13/SEP4/H2/G2/JFIRE	Figure 6.4.1.3.b-3	8	9	10	8	9	9	10	8	15
Z13/LIN/H2/G2/G2/JFIRE	Figure 6.4.1.3.b-4	3	3	3	3	3	3	3	3	9
Z13/LIN/H2/G2/VCE	Figure 6.4.1.3.b-5					5	6	8	5	3
ZXX/TAN/H2/G3/JFIRE	Figure 6.4.1.3.b-6	0	3	4		0	4	4		6
ZXX/TAN/H2/G3/VCE	Figure 6.4.1.3.b-7	6	6	9	5	7	7	11	6	6
Z21/TAN/H2/G3/FLASHF	Figure 6.4.1.3.b-8		0	30			0	28		7
Z21/TAN/H2/G3/VCE	Figure 6.4.1.3.b-9	16	17	25	14	19	20	30	16	17
Z21/TAN/H2/G3/JFIRE	Figure 6.4.1.3.b-10	10	11	12	10	11	11	12	10	20
Z24A/LIN-H2-NH3/H2/G2/FLASHF	Figure 6.4.1.3.b-11		0	15			0	15		11
Z24A/LIN-H2-NH3/H2/G2/VCE	Figure 6.4.1.3.b-12	9	9	14	7	11	11	17	9	9
Z24A/LIN-H2-NH3/H2/G2/JFIRE	Figure 6.4.1.3.b-13	6	7	7	6	6	7	7	6	11
Z25/C1CA/H2/G2/G2/FLASHF	Figure 6.4.1.3.b-14		50	72			44	61		50
Z25/C1CA/H2/G2/G2/JFIRE	Figure 6.4.1.3.b-15	30	32	35	29	30	33	35	29	44
Z25/C1CA/H2/G2/VCE	Figure 6.4.1.3.b-16	52	56	82	46	56	61	89	49	56
Z25/REA/SYN/SYN/G3/FLASHF	Figure 6.4.1.3.b-17							18		61
Z25/REA/SYN/G3/JFIRE	Figure 6.4.1.3.b-18	15	16	18	15	16	17	18	15	16

Table 6.1.4.3.b

Distances from the ZI, ZA and ED for each accidental scenario at each facility of the Plant

Scenario	Figure from Annex 13	4D weather condition			Weather condition 2F					
		ED	ZI	ZA	LD01	ED	ZI	ZA	LD01	Max ZI
Z25/REA/SYN/G3/VCE	Figure 6.4.1.3.b-19	7	8	12	7	8	9	13	7	17
Z25/LIN/SYN/G2/FLASHF	Figure 6.4.1.3.b-20		0	36			0	36		9
Z25/LIN/SYN/G2/VCE	Figure 6.4.1.3.b-21	13	14	21	11	14	15	23	12	14
Z25/LIN/SYN/G2/JFIRE	Figure 6.4.1.3.b-22	27	29	31	26	27	29	31	27	29
Z25/SEPH/G3-LIQ/G3/VCE	Figure 6.4.1.3.b-23	8	9	14	7	9	10	15	8	29
Z25/SEPH/G3-LIQ/G3/JFIRE	Figure 6.4.1.3.b-24	45	49	54	44	52	56	61	52	49
Z25/SEPA/NH3/G2/FLASHF	Figure 6.4.1.3.b-25		4	19			15	29		56
Z25/SEPA/NH3/G2/JFIRE	Figure 6.4.1.3.b-26	33	33	37	33	37	37	37	0	33
Z25/SEPA/NH3/G2/PFIRE	Figure 6.4.1.3.b-27	22	25	29	21	22	25	29	20	37
Z04/TAN/NH3/G3/G3/FLASHF	Figure 6.4.1.3.b-28							9		25
Z04/TAN/NH3/G3/G3/JFIRE	Figure 6.4.1.3.b-29	16	16	17			19	19		16
Z04/TAN/NH3/G3/G3/PFIRE	Figure 6.4.1.3.b-30	13	15	17	13	13	15	17	12	19
Z04/PUM/NH3/G3/G3/FLASHF	Figure 6.4.1.3.b-31							9		15
Z04/PUM/NH3/G3/G3/JFIRE	Figure 6.4.1.3.b-32	17	17	18			19	19		17
Z04/PUM/NH3/PFIRE	Figure 6.4.1.3.b-33	13	15	17	12	13	15	17	12	19
Z20/LIN/NH3/G2/PFIRE	Figure 6.4.1.3.b-34	4	5	6	3	4	5	5	3	15
Z20B/LIN/NH3/G2/PFIRE	Figure 6.4.1.3.b-35	3	4	5	3	3	4	5	2	5

Caption:

Weather condition 4D: neutral atmosphere and a wind speed of 4 m/s Weather condition 2F: stable atmosphere without vertical mixing and wind speed of 2 m/s Z04: Buffer NH_3 Z13: Electrolysis building Z20: Nitric acid plant (AN) Z20B: Ammonium nitrate solution (ANS) plant Z21: H tank farm$_2$ Z24A: Synthesis gas compressors Z25: NH Synthesis Unit$_3$	PFIRE - *Pool fire,* Puddle fire JFIRE - *Jet* fire, Jet of fire FLASHF - *Flash Fire*, Flash Flash *Fire* VCE - Physical explosion	SEP1, SEP2, SEP3 and SEP4 - H separators$_2$ LIN - Line REA - reactor SEPH - NH separator$_3$ at high pressure SEPM - NH separator$_3$ at medium pressure SEPA - NH separator$_3$ at atmospheric pressure PUM - bomb COM - compressor TAN - buffer tank C1CA - Syngas Compressor and Circulator LIN - line/pipeline G2, G3 - generic accident-initiating events

In addition to these risks mentioned in **Table 6.1.4.3.a**, there is also a risk of leakage of NH_3 , HNO_3 and NH_4 NO_3 . In this respect, it should be noted that leaks are generally led to the emergency flare for flaring. In case of other leaks, they are detected and the plant personnel are warned by means of an acoustic signal. Plant personnel will be equipped with a gas mask, which must be worn in these situations to avoid health problems such as breathing difficulties, bronchospasm, burns to the nasal mucosa, pharynx and larynx, chest pain, pulmonary oedema and other complications. The scope is limited to the immediate vicinity of the storage areas of NH_3 , HNO_3 and NH_4 NO_3 .

According to INRS (2021)[4] and WHO (1986) if there is a sudden release of liquefied ammonia under pressure from a container, and if there are no obstacles near the source, all of this residue will become and remain suspended in a mixture of vapour and fine droplets of the liquid. If inhaled at low concentrations, ammonia dissolves mainly in the mucosa of the upper respiratory tract. The initial lung retention rate is 80% in humans and less than 30% after 27 minutes. Clinical signs observed are cough, pharyngitis, laryngitis, tracheobronchitis, nausea, vomiting, asthenia, headache, hypersalivation and possibly bradycardia.

Inhalation of high concentrations of ammonia is characterised by severe respiratory distress associated with bronchospasm of varying intensity and the development of airway mucosal oedema with cough and asthmatic dyspnoea. In the short term, the prognosis depends on the evolution of respiratory complications and the late appearance of an acute pulmonary oedema lesion after a phase of apparent attenuation. Subsequently, bronchial hypersecretion and mucosal desquamation are responsible for pulmonary trunk obstruction and atelectasis, aggravated by bacterial infections. The most frequent sequelae are bronchial stenosis, bronchiolitis obliterans, bronchiectasis, pulmonary fibrosis, corneal opacities, cataracts or glaucoma (INRS, 1997; WITHERS, 1986).

For short-term exposure, HNO_3[5] is corrosive to eyes, skin and respiratory tract. Inhalation may cause asthma-like reactions. Exposure may cause asphyxiation due to swelling of the throat. Inhalation of high concentrations may cause pneumonitis and pulmonary oedema. Symptoms of pulmonary oedema usually do not appear for several hours and are aggravated by physical exertion.

Harmful contamination of the air can occur very quickly by evaporation of HNO_3 at 20°C. Repeated or prolonged inhalation may cause effects on teeth, leading to erosion. The substance may have effects on the upper respiratory tract, such as chronic inflammation, and on the lungs, with reduced lung function. Mists of this strong inorganic acid are carcinogenic to humans. However, no information is available on the carcinogenicity of other physical forms of this substance.

NH_4 NO_3[6] , in case of short-term exposure, is irritating to eyes, skin and respiratory tract. The substance may cause blood effects, leading to methaemoglobin formation. Effects may be delayed. Harmful concentrations of airborne particles can be reached rapidly by dispersion, especially if in the form of dust, which can be inhaled by workers.

[4] Institut National de Recherche et de Sécurité (INRS) - Fiche toxicologique n°16 - Ammoniac et ses solutions aqueuses.2021.
[5] https://www.ilo.org/dyn/icsc/showcard.display?p_card_id=0183&p_version=1&p_lang=pt
[6] https://www.ilo.org/dyn/icsc/showcard.display?p_lang=pt&p_card_id=0216&p_version=2

In addition to the risks mentioned above, other operating activities can also cause accidents with workers, such as working at heights, electrocution, slips and falls, moving heavy loads, etc.

It is important to note that the quantitative risk analysis (QRA) and the hazard and operability analysis (HAZOP) will be performed after the technical design has been finalised. The QRA recommendations are based on the mitigation system to reduce consequence/probability and overall risk. HAZOP recommendations will be based on risk-based prioritisation of corrective actions.

Preventive measures

The design of the Plant has been carried out taking into account the best available technologies in the market (BAT), the necessary specifications to prevent accidents during the operation phase and all the necessary controls to detect any abnormal operation early. It is also important to mention the training of the O&M team and the supervision of contracted companies to be carried out as part of the **Operation Phase Environmental and Social Management Programme**, in addition to the grievance handling mechanism for workers as part of the **Labour and Working Conditions Management Programme**.

Risk rating

With the precautions already established in the design phase of the Plant and its equipment, with the control and warning systems and in addition to the planned training measures, this risk is considered to have a low probability of occurrence.

If even with the proposed measures accidents with workers occur during the operation phase, i.e. if the impact materialises, the **Emergency Response Programme for the Operation Phase** establishes protocols to be followed in case of the occurrence of the above mentioned accidental scenarios. The impact will be negative, from the operation phase, of scope in the ADA, but extending to the IIA due to possible traffic accidents. It has a direct impact, immediate induction with the start of the operation and long term duration. It is reversible, and has a high magnitude and medium importance, but has been upgraded to high because it is an impact whose consequences can be catastrophic.

Impact rating (attributes) **Accidents involving workers during operation**			
Nature	Negative	**Location and spatialisation**	ADA/AII
Stage of occurrence	Operation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	High		
Importance	High		

14.03 - Risk to the health and safety of workers of other stakeholders during operation (inland waterway and land transport workers, Terport workers, other)

Impactful actions	A.3.03 Operation and maintenance of the plant, LT and water catchment

	system and pipelines A.3.04 Transport of inputs and outputs
Impact Component	C.3.04 - Community and Worker Health and Safety

Risk analysis

In the operation of the ATOME Plant, in addition to the direct workers of the company that will be employed, there are also activities of other stakeholders/service providers, such as the workers of the CAN fertiliser inland transport companies, the crew of the fertiliser river transport barges (if you choose this mode of transport), and the workers of the Terport Port.

As mentioned in impact 7.02, 50 Scania tractor + semi-trailer truck trips per day (25 loaded and 25 empty) are foreseen to transport the fertiliser from the plant to the Terport of Villeta.

With this increased flow of trucks on the Villeta - Alberdi road (and also other roads, including Brazilian roads, if 100% overland transport of fertiliser is chosen), accidents with other vehicles may occur, putting truck drivers at risk.

In river transport, with the increase in the flow of barges through the waterway, the risk of accidents with the workers involved, more specifically with the barge crew, will increase. These possible accidents involve collision between barges; collision with fixed obstacles, such as bridges; explosion of the barge caused by eventual spark in the fuel tank; among others. This can cause injuries of varying severity to the crew, falls into the river with possible drowning, and even death.

For port workers, the risk is associated with the possibility of accidents related to activities such as the operation of cranes and other equipment used to move cargo, such as forklifts, overhead cranes, hoists, winches, hoists, munck trucks and lifts; working at heights, among others. These accidents can cause injury to workers, including the risk of death.

The risk of accidents with ANDE workers during maintenance activities on the transmission line and the substation of the Plant is also mentioned.

Preventive measures

The measure specifically foreseen to prevent this risk is the contracting of qualified companies, from the **Environmental and Social Management Programme of the Operation Phase**, through which ATOME will ensure that only companies that comply with Paraguayan legislation related to health and safety and working conditions and also the procedures of ATOME's environmental, social and OSH management system are contracted. It will also verify whether companies have their own emergency response protocols. These conditions should be attached to the service contracts with these companies, including measures for worker training, self-monitoring, OSH training, use of Personal and Collective Protection Equipment (PPE and CPE), among others.

In addition to this, it should be ensured that these companies have a channel to receive complaints from their workers, so that they can anonymously report any insecure situations they witness in relation to their activities. Workers of contracted companies should also be informed

about the channels and have direct access to ATOME's complaints, grievances and concerns management mechanism, as part of its **Stakeholder Engagement Programme**.

The measures of the **Transport Management Programme in the Operation Phase** are also mentioned, as this activity involves a small increase in the risk of accidents with road and river transport companies**.**

Risk rating

By ensuring that companies have all the prevention measures in place and that ATOME will verify that companies are qualified, this risk is considered to have a low probability of occurrence.

If, even with the proposed measures, accidents with workers of other stakeholders occur during the operation, i.e. if the impact materialises, it will be negative, diffuse, of direct incidence, immediately induced with the start of the operation and of long term duration. It is reversible, high in magnitude and of medium significance.

Impact rating (attributes) **Accidents with workers of other stakeholders during operation**			
Nature	Negative	**Location and spatialisation**	Fuzzy
Stage of occurrence	Operation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Media
Magnitude and Importance			
Magnitude	High		
Importance	Media		

14.04 - Risk to the health and safety of the community during construction and operation

Impactful actions	A.2.05 Flows of vehicles, equipment and workers A.3.03 Operation and maintenance of the plant, LT and water catchment system and pipelines A.3.04 Transport of inputs and outputs A.3.05 Environmental controls during operation
Impact Component	C.3.04 - Community and Workers' Health and Safety

Risk analysis

As mentioned in Impact 7.01, during construction an incremental increase in heavy vehicle traffic is expected on the access roads to the Project, mainly the National Route PY19 (Villeta - Alberdi Route), in addition to worker bus traffic on this route and on the Acceso Sur. There is also mention of more occasional traffic associated with the transport of oversized loads. In addition to the impact already discussed, this increased traffic may cause an increased risk of accidents with vehicles and pedestrians, especially in the sections where there is occupation in the vicinity. This risk will be minimised through the use of appropriate signage, among other traffic management measures.

In operation, as mentioned in impact 7.02 and risk 14.03, the land transport of CAN fertiliser between the Plant and the Terport Port will generate 50 truck trips per day, 25 loaded and 25 empty, with an average of 6 trips per hour considering an 8-hour working day. This will cause a small increase in heavy vehicle traffic on this stretch of about 15 vehicles along National Route PY19, and consequently could increase the risk of traffic accidents with pedestrians and other vehicles in the operation phase of the Project, being higher when passing through the populated area of Surubi'y. In the rest of the route there are only isolated dwellings and mainly industries and service companies. The residents of Surubi'y, therefore, will be the most susceptible to this higher risk of accidents due to truck traffic. In the case of the buses that will transport workers during the operation stage, in which 8 daily trips are estimated, there are more sections where this risk exists, also mentioning the community of Suruby'i, as well as the sections of the Southern Access and the section of the Guarambaré - Villeta Route, where the occupation of the environment is much greater than in the Villeta - Alberdi Route.

Regarding the health risk to the community associated with the operation of the Plant, it is mentioned that the facilities will be completely fenced off and only authorised personnel will have access to them. Therefore, members of the community would not go near the process facilities and chemicals at the plant.

With regard to the risk to the health of the community associated with the possible effects of electromagnetic fields emitted by the TL during operation, it is noted that the parameters for the limits of public exposure to electric and magnetic fields established by the ICNIRP (*International Commission on Non-Ionizing Radiation Protection*) for the frequency of 50 Hz were taken into account for the calculation of the width of the easement. These are:

- For population exposure: electric field 5 kV / m, magnetic field 100 µT;
- For occupational exposure: electric field 10 kV / m, magnetic field 500 µT

These same values are those defined by the IFC General EHS Guidelines, presented in **Table 6.1.4.3.c** below:

Table 6.1.4.3.c
IFC general guidelines on environment, health and safety

Frequency	Type of exhibition	Electric field (V/m)	Magnetic field (µT)
50 Hz	General public	5.000	100
	Occupational exposure	10.000	500
60 Hz	General public	4.150	83
	Occupational exposure	8.300	415

Taking these values into account, it can be concluded that impacts can only occur in cases of long-term exposure, immediately under the cables of the TL, i.e. in situations of encroachment of the easement strip by dwellings and other installations involving permanent or long-term occupation. In any case, there is no housing near the TL and it will not be allowed, neither under the cables nor in the rest of the 50 m easement strip area, so it is considered that the impact will not occur if this determination is respected. As for non-permanent and short-term activities,

such as cultivation work or grazing, it is not considered that this impact will occur even within the easement strip and immediately under the LT.

Preventive measures

As mentioned for workers (risk 14.02), the design of the Plant has already been carried out taking into account the specifications necessary to prevent accidents from occurring in the operation phase, including the complete fencing of the facilities, preventing access by unauthorised personnel, as mentioned above.

The measure Protection of the easement strip of the **Environmental and Social Management Programme of the Operation Phase** also applies, to avoid encroachments and prohibited uses, and the measure Supervision of Contracted Companies of this same Programme, since the traffic accidents will involve workers of an outsourced company, which will have to provide training to its workers, require defensive driving behaviours, comply with the Paraguayan traffic law and comply with the measures provided for in the **Transport Management Programme in the Operation Phase of** ATOME, which must be guaranteed by their inclusion in the contract. On the South Access, being an urban road, with a densely populated environment, it is necessary to respect the speed limit established by the transport authorities for public roads and the defensive driving measures to be implemented with the drivers of the workers' transport buses, to reduce the risk of accidents, and to carry out maintenance of the buses to reduce the nuisance caused by noise and emissions.

Also of utmost importance are the measures of the **Stakeholder Engagement Programme**, mainly outreach and communication measures and a mechanism for handling complaints, grievances and concerns for the community.

Risk rating

With the precautions already established in the design phase of the Plant and its equipment, with the warning systems and training measures in place, this risk is considered to have a low probability of occurrence.
If even with the proposed measures, accidents with the community occur during the operation phase, i.e. if the impact materialises, the **Emergency Response Programme for the Operation Phase** establishes protocols to be followed in case of the occurrence of the above-mentioned accidental scenarios.

If it occurs, the impact will be negative, IIA-wide, direct, immediately induced with the start of the operation and long term in duration. It is reversible, of medium magnitude and low significance.

Risk Rating (attributes) **Accidents and illnesses affecting the community during the operation**			
Nature	Negative	**Location and spatialisation**	IIA
Stage of occurrence	Construction and Operation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Reversible	**Probability of occurrence**	Baja
Magnitude and Importance			

Magnitude	Media
Importance	Baja

15 - Risks of impacts on Archaeological and Cultural Heritage

15.01 - Risk of damage to archaeological or cultural heritage during earthworks

Impactful actions	A.2.03 Vegetation clearance and site clearance A.2.06 Earthworks
Impact Component	C.3.05 - Archaeological and Cultural Heritage

Analysis of potential impact

As mentioned in **Section 5.4.9**, archaeological surveys of the site have not resulted in the identification of any archaeological, cultural or historical finds, but there is a potential risk of chance finds during vegetation clearance / land clearing activities and especially during earthworks for construction of the Plant structures, LT tower foundations, water intake pump house and for installation of water and effluent pipelines.

As this is an area where battles of the Great War took place, there is a risk of finding ballistic elements (rifles, bayonets and bullets, among others), supply carriages, skeletal remains and others during the execution of these construction activities.

The execution of vegetation clearance/land clearing and earthmoving activities without the support of a professional expert or the establishment of a procedure in case of chance finds may result in damage to elements of this heritage, if any.

Preventive measures

To prevent this impact, it is proposed to prepare a Preventive Archaeology Action Protocol, in addition to archaeological monitoring during earthmoving activities, both parts of an **ADA Archaeological and Cultural Heritage Conservation Programme.**

Also mentioned are the measures for the Management of earthworks activities and the Control of vegetation removal activities of the **Construction Environmental Control Programme**, to be implemented by the Contractors, in addition to the measures of the **Environmental and Social Management Programme**, especially the Construction Supervision.

Risk rating

Considering the implementation of the proposed measures, this risk is considered to have a low probability of occurrence.

If the impact materialises, even with preventive measures, it is qualified as negative, ADA-reaching, direct, immediately induced and of long term duration. It is irreversible, but with a low probability of occurrence. It is of medium magnitude and importance.

Risk Rating (attributes) Risk of damage to archaeological or cultural heritage during earthworks			
Nature	Negative	**Location and spatialisation**	ADA
Stage of occurrence	Implantation	**Advocacy**	Direct
Temporary (Induction)	Immediate	**Temporality (Duration)**	Long-term
Reversibility	Irreversible	**Probability of occurrence**	Baja
Magnitude and Importance			
Magnitude	Media		
Importance	Media		

6.1.5
Identification and Assessment of Cumulative Impacts

Initial consideration

According to the Practical Guide for the Assessment and Management of Cumulative Impacts in Latin America and the Caribbean (IDB Invest, 2023), "cumulative impacts generally refer to those modifications in the behaviour of the environment that are the result of multiple activities or projects over time, including those generated by the project being assessed".

According to the International Finance Corporation's Performance Standard 1 (IFC, 2012), cumulative impacts are those resulting from the successive, incremental or combined effects of a current action, project or activity, or produced by past and planned future activities.

The United States Environmental Protection Agency - EPA (1999) defines cumulative impacts as those resulting from the interaction and overlapping of environmental effects from one or more human actions over time and space. The International Association for Environmental Impact Assessment (IAIA, 2015) suggests that the term relates to the aggregate effects of actions that produce impacts that accumulate incrementally or synergistically over time and space.

The European Commission (1999) defines cumulative impacts as the result of incremental changes caused by past, present and reasonably foreseeable future actions acting together. This definition is clearly shared by Hegmann et al. (1999), who also associate cumulative effects with combined actions over time that cause changes in the environment.

The US Council on Environmental Quality (CEQ) regulations, implemented by the *National Environmental Policy Act* (NEPA, 1977; 2020), emphasise that, despite the possibility of being linked to individual actions, cumulative impacts are often the result of collective actions over a period of time.

In practical terms, it is recognised that the process of cumulative impact assessment is more complex than that usually practised in Environmental Impact Assessments, as the time horizon of the analysis includes past, present and reasonably foreseen future actions. In addition, the interaction between anthropogenic activities and the universe subject to alteration is increasing in number and complexity.

In these terms, and in line with the guidelines of the World Bank Group (IFC, 2013) and the above-mentioned IDB Invest Practice Guide (2023), the primary task of the cumulative impact

analysis process is to differentiate between naturally occurring changes in socio-environmental systems and those driven by the combined action of several projects in the intervention area.

The main objectives of the analysis include:

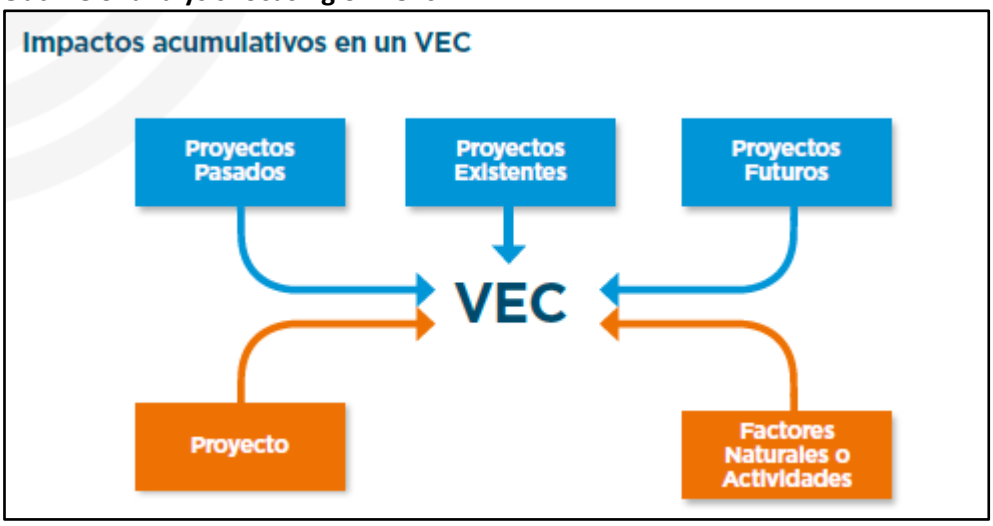
- Assess the potential impacts and risks induced by other projects given over time on a value component that will be affected by the project from which the analysis starts;
- Check whether the cumulative impacts identified have the potential to destabilise the identity of socio-environmental systems and, in particular, the resilience limits of certain analysis components;
- Confirm whether the viability of a project is not compromised or limited by the aggregate impacts that other developments may have on the site where it is to be implemented;
- Ensure that affected communities and groups have their concerns properly identified;
- Propose measures to optimise positive incremental effects and mitigate negative ones.

To achieve these objectives, the assessment to be carried out in this study will focus on VECs (*Valued Environmental Components*). This term, first introduced by Beanlands and Duinker (1983), refers to attributes of environmental and social systems that are considered by the community or group conducting the analysis to be important or sensitive to the incremental effects of a project or projects.

The World Bank Group (2013) defines SVAs as the final, sensitive and valuable (ecosystemically and socially) recipients of aggregate impacts, whose desired future condition determines the objectives of the cumulative impact analysis. **Figure 6.1.5.a** shows a schematic example of a cumulative impact analysis focusing on SVAs.

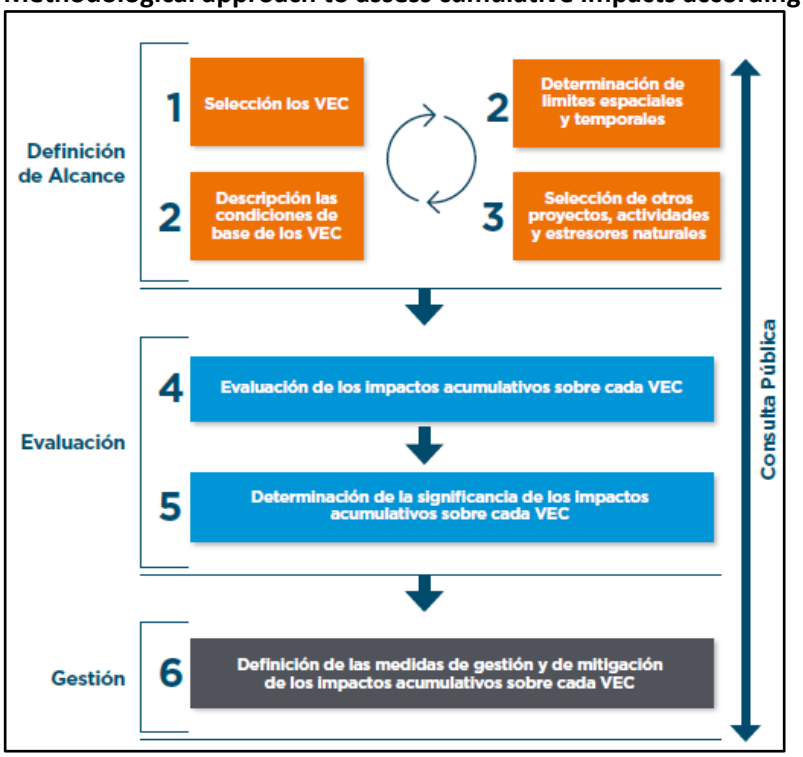
In the context of this definition, the methodological approach to be used in this study is the one proposed by IDB Invest (2023), which includes the following methodological steps (a) selection of the VECs; (b) definition of the temporal and spatial scales; (c) description of the baseline conditions of the VECs; (d) identification of other co-located projects and natural and social variables affecting the VECs; (e) identification and assessment of cumulative impacts; (f) assessment of the degree of significance of cumulative impacts; and (g) definition of management and mitigation measures for cumulative impacts in each VEC (**Figure 6.1.5.b**). It should be noted that the public consultation process extends throughout the entire methodological perspective, in order to ensure the direct involvement of stakeholders.

Figure 6.1.5.a
Outline of analysis focusing on LCAs



Source: Adapted from *IDB Invest* (2023).

Figure 6.1.5.b
Methodological approach to assess cumulative impacts according to *IDB Invest* (2023)



Source: *IDB Invest* (2023).

The specific impact analysis (Step f), however, will be carried out using established methodological approaches to impact assessment, including those proposed in studies by Morgan (2002), Porter & Fittipaldi (1998), Canter (1996), Wood (1995), Morris & Therivel (1995), Turnbull (1992), World Bank (1991), Sanchez (2002) and Leopold *et al*. (1971), as well as those available in the assessment guides of the world's main environmental agencies (SNH, 2013; EPA, 1999; CEAA, 2012), among others.

The matrix method proposed by Páez Zamora (2013) stands out, which differs from the proposal presented by Leopold et al. (1971) precisely because it focuses on the VECs and according to the geographical/temporal space delimited, as well as the projects identified.

These procedures are described in detail in the following sections, and the results are presented together.

- **Definition of Scope**

(a) Selection of VECs

Analysis of existing environmental baseline information

The ESIA baseline analyses elucidated the main characteristics of the environmental and social components susceptible to adverse effects, such as:

- Main characteristics of the project site area, including those related to physiographic aspects and water characteristics, as well as its dynamic processes;
- Main aspects of the surrounding vegetation cover;
- Main species of terrestrial fauna;
- Existence of protected or important habitats;
- Existence of endangered species;
- Main characteristics related to human occupation and living conditions of the population.

In addition, information was collected on the main environmental and social impacts identified and assessed in the ESIA, as well as information related to the proposed Environmental and Social Plans and Programmes for the prevention, control, mitigation and compensation of these impacts.

This information, taken together, shapes the evolution trends of the environmental components possibly affected by the Project in relation to the adverse cumulative effects. Likewise, it shows the possibilities of controlling such effects, either by the efficiency of the proposed Environmental and Social Plans and Programmes or even by the resilience aspects of the natural systems.

Stakeholder consultation

The collection of social baseline information was based on interviews with Project stakeholders, the results of which contributed to the selection of the VECs. These interviews were conducted with the following persons: (i) representatives of the Municipality of Villeta (representatives of the General Secretary of the Municipality and the Directorate of Works of the Municipality); (ii)

residents of the community of Guasu Kora; (iii) residents of the Ypeka'e community, who worked at the FERTIMAX Fertilizer Factory; iv) the Vice President of the Ypekaʾe Fishermen's Association; v) representatives of the Puerto Lobato association (community downstream of the Project on the Paraguay River, where fishing takes place); vi) a resident and worker of the farm adjacent to the Plant's land; and vii) the owner of this farm, who uses the house on weekends.

During the interviews, in addition to the questions to obtain data for the social baseline, interviewees were asked if they were aware of the project. Information about the project was also shared with them, as well as information about possible impacts (including cumulative impacts) and control measures to be implemented. This allowed us to identify respondents' level of knowledge about the project and to find out what their main concerns were, i.e. which values were most important to them. For example, the interviewees from Puerto Lobato were asked whether they fished for subsistence or for trade, whether they were artisanal fishermen or practised sport fishing, in order to assess how important the conservation of water quality and aquatic fauna was to them; and the neighbour was asked whether he was bothered by the noise from the substation and which is the source of water supply for the residence, to find out how important a possible increase in noise level and deterioration of groundwater quality would be for his quality of life.

In addition to direct consultation with the above-mentioned stakeholders, press articles and other references published in the media on the development of future projects were sought (see Step d).

Selected VECs

Considering the projects that may be concurrent with the Project (see Step d) at the spatial and temporal scales (see Step b), the following *Valued Environmental* and Social *Components* (VEC) were defined, i.e. the environmental and social components susceptible to adverse effects from the Project and from past, present and future projects:

- Surface Water Resources
- Air Quality
- Vegetation and Habitat
- Employment and Local Economy
- Infrastructure (traffic)
- Quality of Life of the Population

(b) Identification of spatial and temporal scales

The identification of spatial and temporal scales is a key step in this assessment, as it establishes the scope of the analysis. The basic premise considered was that the spatial delineation of cumulative effects expands to a point where the environmental components considered are no longer affected by the actions that cause them, or where the intensity levels of the impacts are considered irrelevant or non-material.

For analysis purposes, the area of indirect influence (AII), as defined in the ESIA, was considered as a spatial coverage area. However, it is known that the most intense cumulative effects will occur in the vicinity or in the area directly used by the project.

For this delimitation, the following aspects were also considered:

- Size and nature of the area to be used by the project;
- Size and nature of the area of neighbouring projects;
- Availability and level of confidence of the information used;
- Relevant natural boundaries, in particular those defined by the order of magnitude of sub-basins;
- Administrative and institutional governance boundaries.

Despite the possibility and feasibility of using different geographical sections for each VEC, this assessment prioritised the homogenisation of data to include an integrated analysis of impacts. However, in the delimitation, it was ensured that all the areas of manifestation of the different VECs and impacts are included in the polygonal analysis.

The analysis excluded past and future activities that are outside the defined geographical boundaries, as it is considered that they do not or will not affect the order of importance of the impacts; as well as those for which the available information did not allow estimating the effects on the selected VECs.

With regard to the time scale, a five-year forward-looking approach was adopted, a period that is compatible with the likelihood of success of the impact monitoring and control programmes planned for the operation phase of the project. The same applies to the past time limit, since impacts generated more than five years into the future are already assimilated into the dynamic characteristics of the environment. Furthermore, it should be noted that the effects of past projects (in abandonment or in operation) are already considered in the determination of the "current" state of the VECs.

(c) description of the conditions (baseline) of the VECs

The diagnosis and characteristics of the selected VECs were developed in the baseline stage developed for this EIA. The information gathered and presented in the previous sections is sufficient to support the analysis of potential cumulative impacts, so it was not necessary, in the case under study, to apply additional efforts to complement the characterisation of the selected VECs.

(d) identification of other neighbouring projects and the natural and social variables affecting the VECs

At this stage, the main actions of the Project with the potential to cause undesirable impacts were identified. In relation to other projects already implemented, it is considered that their effects are already assimilated in the context of the current environmental organisation, reflected in the diagnostic chapter of the ESIA.

Regarding the effects of the projects planned for the future, a consultation with the main local and regional planning bodies was carried out, as well as a public consultation in the press, as recommended by BID Invest (2023).

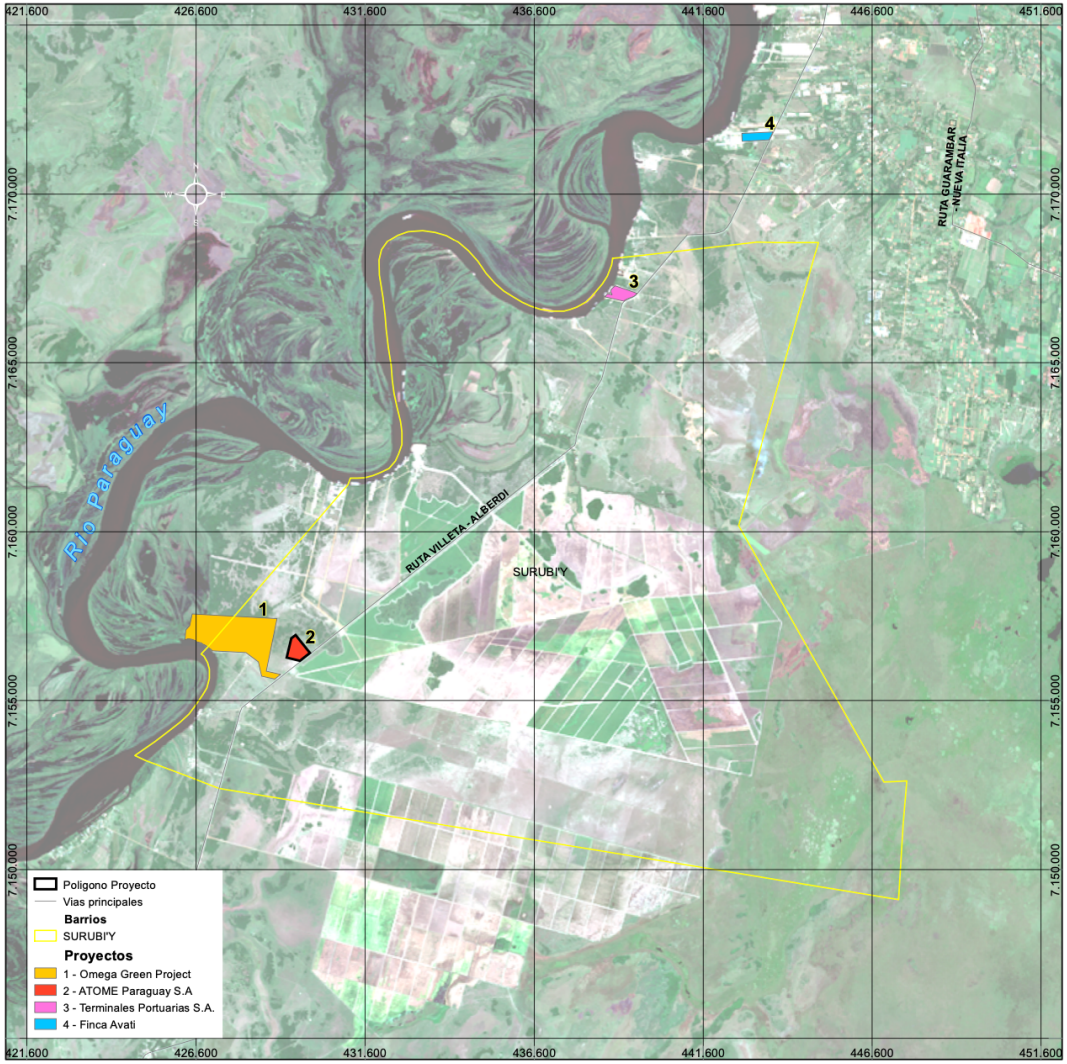
Based on the exercise carried out, the following publicly known development projects or programmes were identified, which are shown in **Map 6.1.5.a - Location of Projects with Potential Cumulative Impacts** together with the Atome project:

- The **Omega Green Project (by BSBIOS)**, a biofuel plant to be set up in the city of Villeta with an estimated investment of US$ 1 billion. This project is the largest private investment in Paraguay's history and will produce renewable fuels that emit less greenhouse gases.

- **Climate-Smart Agriculture Pilot Project (NGO Fundación Capital supported by the IDB),** focused on small producers, located in the Avatí experimental farm in Villeta. The pilot seeks to identify both challenges and opportunities to generate a more environmentally friendly production model, adapted to the needs of the population.

Map 6.1.5.a - Location of Projects with Potential Cumulative Impacts

ATOME	Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizante Verdes de ATOME Paraguay S.A. Estudio de Impacto Ambiental y Social (EIAS)	6.1.5.a – LOCALIZACIÓN DE PROYECTOS CON POSIBLES IMPACTOS ACUMULATIVOS





Carátula Juridica Legal

Proponente:	ATOME PARAGUAY S.A.
Lugar:	Puerto Sara
Localidad:	Central - Villeta
Distrito:	Villeta
Padrón:	16490
Superficie Total:	30 ha
Superficie a construir:	20 ha
Elaboración:	ATOME PARAGUAY S.A.
Fecha de Impresión:	27/10/2023

Fuente Cartográfica

Proponente, DGEEC 2012
2023

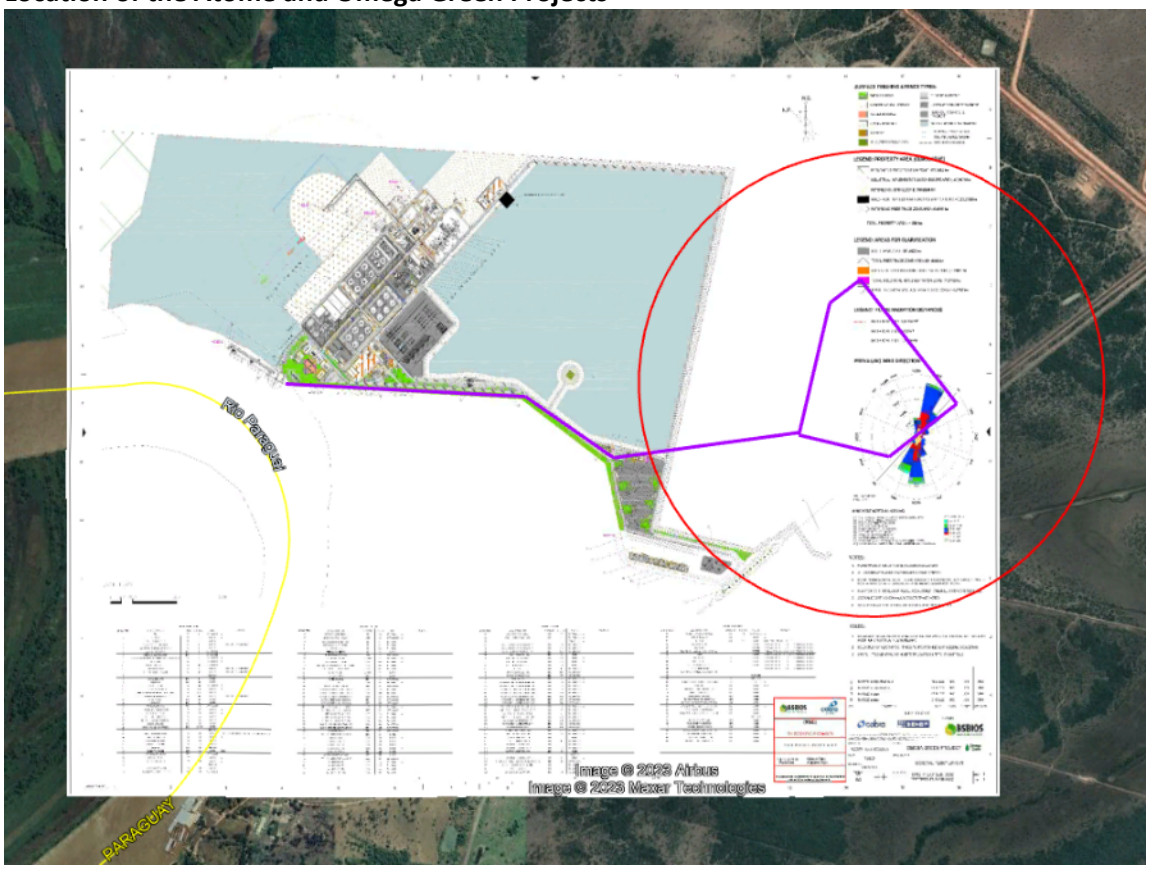
Parámetros Cartográficos

Proyección UTM
Elipsoide WGS 84
Zona 21 J
Escala 1:125.000

- **Puerto de Villeta (owned by the private company Puerto Caacupe-mí),** which is in the process of expanding its operations, plans to build Caacupe-mí/Villeta, a terminal that will operate to the same standards as Caacupe-mí/Asunción and Pilar in terms of cranes, machinery, equipment and the TOS Navis N4 information system. In addition to port operations, Caacupe-mí/Villeta will also have a logistics park within the terminal, very similar to the one currently fully operational at Caacupe-mí/Asunción, in the first phase, a fully equipped, state-of-the-art warehouse will be added. With Caacupe-mí/Villeta, Puerto Caacupemí will be the only port conglomerate geographically located in the three premium port operating zones within Paraguay, which are Asunción, Villeta and Pilar, offering its customers the Caacupe-mí level of quality service and with the option of location based on their geographical preference or convenience. The port of Villeta is the third most important terminal in the country in terms of turnover and, according to Customs figures, within the four ports with the highest revenue collection at national level (8.8% of the total as of December 2018).

Of these projects, the closest to the Atome Project is the **Omega Green** biofuel plant, which is still in the study phase. **Figure 6.1.5.c** shows the layout of the Omega Green plant together with the land on which the Atome plant will be built.

Figure 6.1.5.c
Location of the Atome and Omega Green Projects



Caption:

	Atome site and layout of water and effluent pipes for the project.

	Atome Project DAI

It can be seen that Atome's project AID, in red, even overlaps a small part of Omega Green's land, and that Atome's water and effluent pipelines pass through the boundaries of this property, as already mentioned in **Section 3.1.3.**

- **Evaluation**

(e) identification and assessment of cumulative impacts

Considering the list of impacts identified during the environmental studies and the projects that may have simultaneity with the ATOME Project on the spatial and temporal scales, those that have a cumulative character and may affect the VECs listed in step 1 were selected.

The identification of cumulative impacts was carried out in view of the interaction effects between the impacts and their implications for the quality of the environments.

Table 6.1.5.5 below lists the following environmental and social impacts selected for their cumulative effect:

Table 6.1.5.a
Project impacts with a cumulative effect

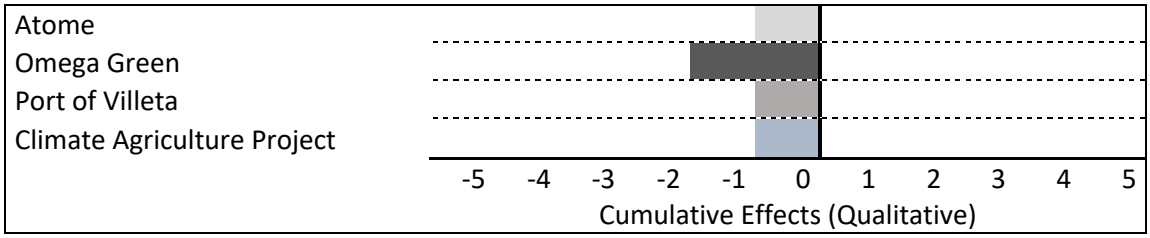
VEC	Impacts
Surface Water Resources	Impacts on the water quality of the Paraguay River due to reduced flow and discharge of treated effluents.
Air Quality	Impact on air quality during operation
	Reducing GHG emissions and carbon footprint in the ammonia-based fertiliser market (NH_3)
Vegetation and Habitat	Loss of vegetation cover and affectation of flora and fauna.
	Loss of terrestrial wildlife habitats
Employment and Local Economy	Generation of direct and indirect jobs in the operation phase.
Infrastructure (traffic)	Capacity appropriation of National Route PY19 in the operation phase
	Appropriation of the capacity of the Paraguay - Paraná Waterway
Quality of Life of the Population	Noise nuisance in the operation phase
	Odour nuisance in the operation phase

Regarding the methodology for assessing cumulative impacts, the assimilative capacity analysis proposed in the Practical Guide for the Assessment and Management of Cumulative Impacts in Latin America and the Caribbean (IDB Invest, 2023) was adapted. Given the unavailability of quantitative data on neighbouring projects, as well as some applicable legal parameters that could serve as a safety factor on the carrying capacity of some VECs, a qualitative assessment procedure was adopted. To this end, and in order to provide a context for incremental and cumulative effects, a comparative weighting scale was applied, taking into account the nature and size of the projects. The scale used ranges from -5 to 5, with numbers below zero being associated with negative effects. Milestone zero was adopted as the current condition, reflecting the interference of projects already implemented.

Cumulative impacts on the VEC Surface Water Resources

With regard to water abstraction, the combined extraction of water volumes and effluent discharge is cumulative in nature, the main effects of which will be associated with a decrease in seasonal flows and contamination of the watercourse. However, due to the size and magnitude of the Paraguay River (average flow of 3,500 m³/s), the volumes of raw water to be abstracted (0.0674 m³/s) and treated effluent to be discharged (0.0215 to 0.0234 m³/s) by the ATOME Project have a low degree of significance, as indicated in the impact analysis 2.01 (**Section 6.1.3.1**). Due to its size, it is the Omega Green Project that has the most incremental effects, as can be seen in **Figure 6.1.5.d**, although the Project's RIMA does not record the totals that will be captured. In the case of the Port of Villeta, the nature of the activity is not considered to be water intensive (it is restricted to effluent treatment and cleaning activities). Since the Climate Farming Project proposes a sustainable use of the resource, the incremental impact is estimated to be of low magnitude.

Figure 6.1.5.d
Cumulative effects on the SCV Surface Water Resources



Cumulative impacts on ECV Air Quality

The ATOME plant will cause atmospheric emissions, noise and possible odours. On the one hand, these emissions may alter the air quality and, on the other hand, cause nuisance to the residents of the neighbouring estate. The Omega Green Project would only be given in the contribution to the worsening of air quality, as the biodiesel plant has no potential to contribute to the nuisance to the neighbours of the ATOME Plant.

According to data provided by Omega Green (see **Section 5.2.8**), concentration levels above those permitted by law for suspended particulate matter parameters have already been recorded in the study area. In the ATOME Project AID the ambient levels of monitored and legislated air pollutants were always below the air quality standards set by SEAM Resolution N° 259/2015 and WHO 2021 - Global Air Quality Guidelines, according to measurement conducted (**Section 5.2.8.2**).

Another important aspect to highlight is the gas emissions derived from the fossil fuels used by the vehicles that will be used during the operation of the projects. For the Atome Plant, 50 daily truck trips are estimated for the transport of fertiliser and a further 8 bus trips for the transport of workers. In addition to these, 1 truck trip every 4 days is estimated to bring dolomite and 1 truck trip and 1 van trip per day to bring spare parts, consumables and others.

According to RIMA information, the Omega Green plant will have a processing capacity of 6,250 tonnes of grain per day, generating 1,200 metric tonnes of degummed oil, which added to another 1,200 metric tonnes of oils purchased in local and international markets, will allow the

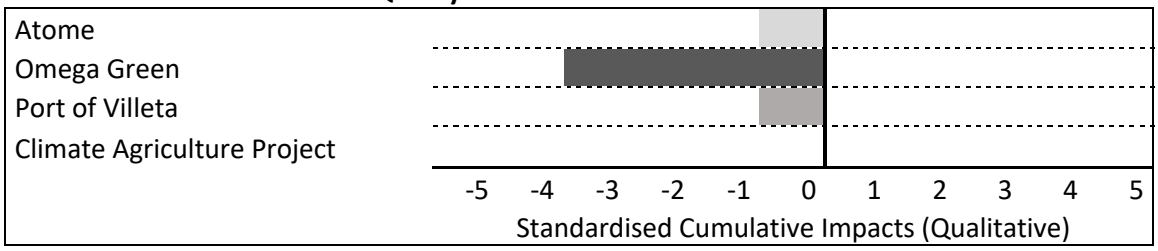
production of 2,700,000 litres of renewable fuels per day. Considering trucks with a capacity of 25 tonnes, it is estimated that 298 truck trips per day will be made to bring raw materials to the plant. In addition to these, a further 108 truck trips of the same capacity have been calculated to transport the biodiesel produced. Obviously, these calculations have been made for the worst case scenario, which is a 100% land-based traffic of raw material and final product, as the capacity of the river terminal planned for this plant is unknown. The scenario also considered the production capacity limit. For this scenario, the total number of daily trips would be 406. This traffic, associated with bus traffic for transporting workers, will constitute an increase in mobile sources in the study area.

Finally, the nature of the activities to be carried out at the Atome and Omega Green plants will contribute to a greater or lesser extent to the reduction of GHG emissions, helping to mitigate the effects of climate change.

No significant emissions are expected in the case of the Port of Villeta, nor associated with the Climate Agriculture Project, which contribute little or nothing to the cumulative incremental effects in the study area.

Figure 6.1.5.e shows the application of the weighting scale to compare the potential cumulative effects of the analysed projects on the VEC Air Quality.

Figure 6.1.5.e
Cumulative effects on VEC Air Quality



Cumulative impacts on VEC Vegetation and Habitat

The impacts on the vegetation cover and habitats in the study area derive from the need to remove them in order to carry out the projects. These are permanent, negative impacts that are difficult to reverse, although there is the possibility of compensatory planting and recovery of already degraded areas. As indicated in the previous sections, these impacts will occur during the construction phase and their effects will be long-term.

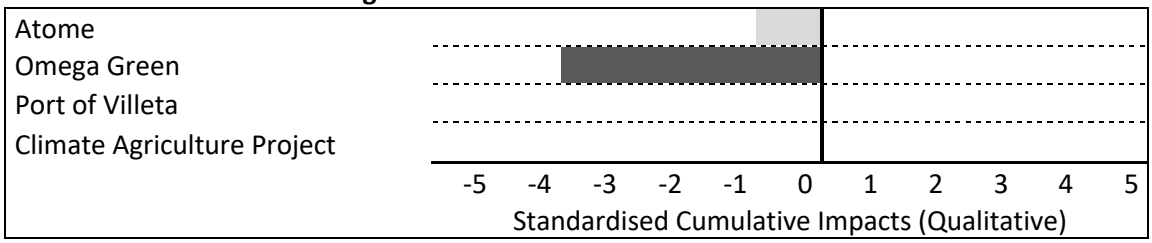
The cumulative nature of these impacts therefore derives from the increase in areas to be cleared in a landscape matrix that already exhibits fragmentation characteristics derived from previous activities. Unlike other effects already discussed throughout this assessment, it is not fortuitous to admit that the likelihood of effects on this VEC is certain.

In the case of the Atome plant, the need for intervention in the vegetation cover is estimated at 30 hectares between savannahs and forests for the construction of the plant, 0.07 ha of savannahs for the TL and 0.69 ha between savannahs and forests for the water and effluent pipes. In the case of the Omega Green project, the need for intervention is of greater magnitude and could reach 266 hectares, including the areas where the project's industrial zone, future

industrial facilities, support areas and free zone structures will be located. In quantitative terms, both the Port of Villeta and the Climate Agriculture Project have a low potential to contribute incremental effects in terms of habitat conversion.

Figure 6.1.5.f shows the incremental comparative analysis of the effects on the VEC Vegetation and Habitat.

Figure 6.1.5.f
Cumulative effects on VEC Vegetation and Habitat



Cumulative impacts on the VEC Employment and Local Economy

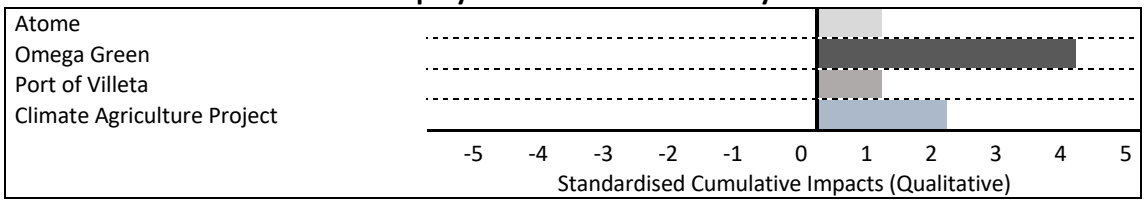
With regard to the economic dynamics of the region, it is important to highlight that the generation of jobs during the operation of the projects will contribute to the increase in the wage bill of the region of insertion, with the consequent increase in the circulation of goods and merchandise.

The ATOME Project is expected to generate 225 direct jobs, of which 195 will be permanent and 30 temporary. In addition, there will be workers involved in the land and river transport of the CAN fertiliser and a further 874 indirect jobs will also be generated.

In the case of the Omega Green production plant, it is estimated that 400 direct jobs will be created during its operation. Added together, the incremental effect of the opening of some 600 direct jobs is indeed significant. In this respect, it is important to note that, according to the data presented in **Section 5.4.1.5.1**, Villeta has approximately 8,500 people actually employed and an unemployment rate of around 6%. In population terms, the number of jobs to be generated amounts to almost 7% of the total employed population of the municipality, and the need to import labour, especially for higher skilled positions, is not ruled out.

Despite the unavailability of data on job vacancies that will be induced or generated by the Port of Villeta and the Climate Agriculture Project, it is assumed that their effects will add to those presented here, resulting in the effective dynamisation of the municipal economy. Considering the size of the evaluated projects, **Figure 6.1.5.g** shows the cumulative incremental evaluation of these on the VEC Employment and Local Economy.

Figure 6.1.5.g
Cumulative effects on the VEC Employment and Local Economy



Cumulative impacts on the VEC Infrastructure (traffic)

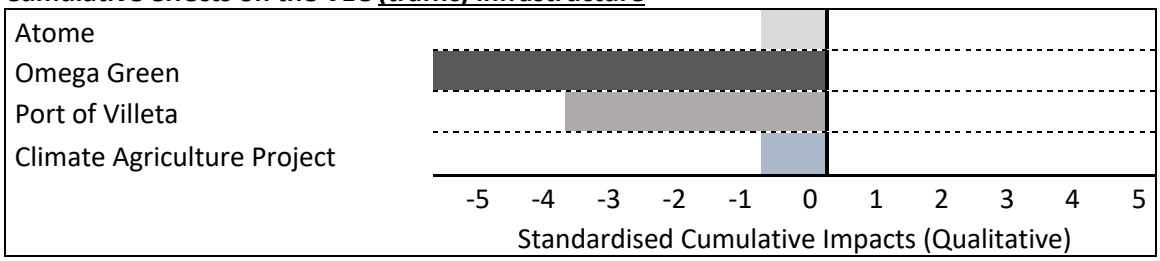
The main cumulative impacts considering the implementation of the ATOME Project and the Omega Green biodiesel plant in the same area of influence are the intensification of truck traffic on National Route PY19 (Villeta - Alberdi Route).

In the case of road infrastructure, as mentioned in **Section 6.1.3.3** (impact 7.02) there is a projection of 50 truck trips per day (between empty and loaded) in the case of the Atome Project, and around 400 trips per day in the Omega Green Project considering the arrival of feedstock and departure of biodiesel, in the worst case scenario (by road route only). These quantities will be in addition to current traffic volumes, indicating their cumulative nature. It should be noted, however, that even with these projections, the road will be maintained at good levels of service, as it is currently well below capacity.

Similarly, the analysis carried out for the case of the road system applies to the impact on the Paraná-Paraguay Waterway, in the case of Omega Green using the same routes and sections of the Atome Project.

The analysis of the comparative incremental effects for the VEC Infrastructure (traffic) is shown in **Figure 6.1.5.h**.

Figure 6.1.5.h
Cumulative effects on the VEC (traffic) infrastructure



Cumulative impacts on the VEC Quality of Life of the Population

In the case of VEC Quality of Life of the Population, the cumulative impacts would be related to noise and odour emissions resulting from the operation of the Projects. In the case of the ATOME Plant, the modelling carried out indicates a slight increase in noise levels during the night, which could exceed, in small quantities, the limits established by Law 1100/1997.

The same reasoning applies to odour emissions, which, depending on proximity and wind direction, may cause nuisance to neighbours. In this respect, it is worth mentioning that Plant facilities such as the WWTP and the NH storage area$_3$ will be about 200 m from the neighbouring house and that north-westerly winds during the summer may contribute to neighbour nuisance caused by odour emissions.

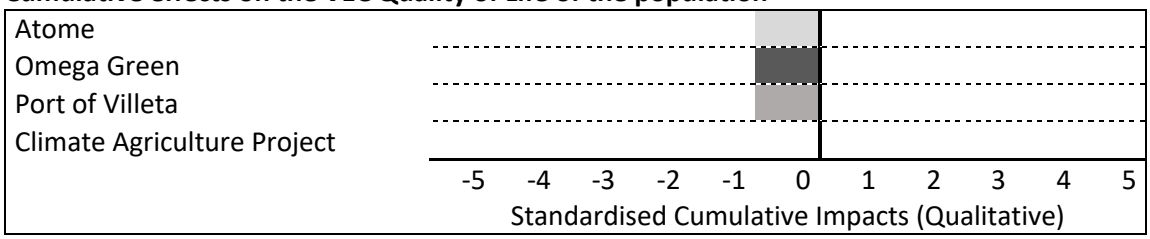
According to the data available for the Omega Green plant, the impacts associated with odour emissions would only be associated with the improper disposal of solid waste.

In any case, and due to the fact that this is a permanent and incremental effect, the possibility of an impact on the VEC derived from these emissions is not ruled out. The joint effects, however, will be of low intensity, as the study area has a low density of occupation, with only one neighbouring property remaining as a critical receptor.

In the case of the Port of Villeta, located slightly further away from the aforementioned plants, the impact will have a low incremental character and should not reach the same critical receptors. Additional impacts arising from the activities of the Climate Farming project are ruled out in the context of this analysis, in particular due to the nature of the actions to be carried out, which have a low potential to generate this type of impact.

Figure 6.1.5.i shows the analysis of the comparative incremental effects applied to the VEC Quality of Life of the Population.

Figure 6.1.5.i
Cumulative effects on the VEC Quality of Life of the population



In summary, the Project under study has the potential to cause some cumulative and synergistic impacts, as these are inherent to its implementation and mainly operational activities. Although these are cumulative impacts, they are of low significance, low intensity and can be mitigated and controlled.

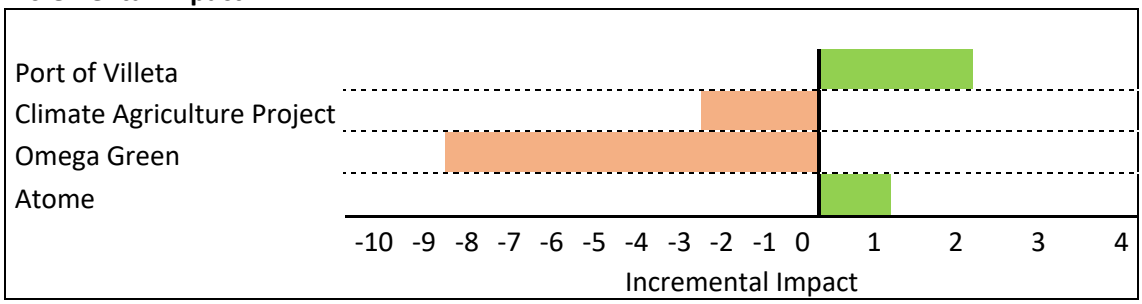
Cumulative Impact Assessment Summary

Table 6.1.5.a summarises the cumulative effects on the assessed VECs and **Figure 6.1.5.j** shows the induction potential of each project.

Table 6.1.5.a
Summary of the Cumulative Impact Assessment

Projects / VECs	Atome	Omega Green	Climate-Smart Agriculture	Port of Villeta	Total effect on VEC
Surface Water Resources	0	-1	0	0	-1
Air Quality	0	-3	0	0	-3
Vegetation and Habitat	0	-3	0	0	-3
Employment and Local Economy	1	4	1	2	8
Infrastructure (traffic)	0	-5	-3	0	-8
Quality of Life of the Population	0	0	0	0	0
Total impact per project	1	-8	-2	2	-7

Figure 6.1.5.j
Incremental Impact



The SCVs most likely to receive higher cumulative impacts are Employment and Local Economy (8) and Infrastructure (traffic) (-8). The positive impacts are associated with the possibility of generating employment and increasing the wage bill, which will have direct implications for the dynamics of the local economy. The negative impacts include the possible effects on the overloading of road infrastructures which will have to receive the heavy vehicle traffic generated by the operation of the projects. The generation of some 300 daily journeys, estimated for the Omega Green project, which, added to the current traffic and the demands of the other projects, could have a negative impact on the service levels of the roads.

No less important are the potential negative impacts on the VEC Vegetation and Habitat and Air Quality, which had total final vectors of (-3). Negative cumulative effects also have the potential to occur in the VEC Surface Water Resources, but with less intensity, due to the relationship between the total flows used by the projects and the average monthly discharges into the Paraguay River, which exceed 3,000 m^3/s. As for the VEC Quality of Life of the Population, the analysis indicated that the resulting intensity was low, or practically zero, given that the area where the projects are located (particularly ATOME and Omega Green) has a low population density.

In terms of individual potential to induce cumulative impacts, it is clear that the Omega Green project has the largest resulting vector, suggesting, in principle, that it has a similar prominence in terms of mitigation responsibility. In second place is the Climate-Smart Agriculture Project, in terms of its resource use and traffic demand. The Port of Villeta and the ATOME Project had positive final vectors, mainly related to the aforementioned impacts on VEC Employment and the Local Economy.

(f) assessment of the degree of significance of cumulative impacts

At this stage, the assessment of the significance of the identified cumulative impacts is consolidated. In the literature, there are several criteria used to assess the significance of impacts, which were already mentioned at the beginning of **Chapter 6.0.**

In addition to these attributes, and in the context of the assessment presented here, it is understood that "the significance of a cumulative impact is represented by a measure of the extent of change in the state of a specific VEC and its tolerance to such change, i.e. whether this change is reversible or whether a threshold condition (assimilative capacity) is exceeded" (Bid Invest, 2023).

The ecological context was also considered, a criterion that refers to the context in which the impact is embedded, i.e. identifying the integrity of environments. In environments that have already changed, cumulative impacts tend to have more intense effects than in environments that have not yet been altered by human activities.

In this context, and on the basis of the qualitative assessment presented, the following assessment assumptions were adopted, as shown in **Figure 6.1.5.k**. It should be noted, however, that in the case of positive impacts, the tolerance and resilience capacity of the LCAs is not taken into account, as these limits are not applicable to the type of analysis.

The degree of importance of the SVCs under study is shown in **Table 6.1.5.b**.

Figure 6.1.5.k
Assumptions for determining the degree of significance of impacts on SCAs

Importancia del Impacto	Descripción
Insignificante	VEC no experimentaría un cambio notable.
Moderado	El VEC experimentaría cambios apreciables, pero dentro de la variación natural.
Sustancial	El VEC experimentaría cambios más allá de la variación natural, pero dentro de su rango de tolerancia o resiliencia.
Alta	El VEC experimentaría cambios que superaran su rango de tolerancia y resiliencia, generando un deterioro irreversible.

Source: IDB Invest, 2023.

Table 6.1.5.b
Defining the degree of significance of impacts on VECs

VECs	Degree of Importance
Surface Water Resources	Baja
Air Quality	Moderate to Substantial
Vegetation and Habitat	Substantial
Employment and Local Economy	High
(Traffic) infrastructure	Substantial
Quality of Life of the Population	Baja

In summary, and as presented throughout the analyses, it can be inferred that the effects on the VECs are not capable of breaking the resilience of the systems to the point of causing irreversible effects. In the case of surface water resources, the determining factor is the size of the Paraguay River, whose average annual discharges mean that the combined extractions of the projects are minimal or negligible. With regard to air quality, the occurrence of episodes in which pollutant concentrations are exceeded is not ruled out in situations where these cannot be dispersed. Even so, these concentrations do not condemn the entire lower troposphere of the study region.

The same applies to the VEC Vegetation and Habitat. Although the combined known areas of habitat suppression and conversion may reach almost 300 ha, the resulting effects do not have the potential to irreversibly alter the identity of the local ecosystem. On the other hand, fragmentation of existing vegetation patches and localised loss of tree species are intensifying. For these reasons, the impacts on this VEC were considered to be of material significance, the alterations to which are more intense than would occur naturally, but within the range of elasticity and resilience of the system.

Considering the population employed in the municipality of Villeta, the jobs that will be generated during the operation of the projects together account for approximately 7% of the total, which justifies the High importance attributed to the Employment and Local Economy SVA. Finally, and in relation to the Quality of Life SVA, no incremental impacts of relative intensity are expected, so it is attributed a Low importance.

- **Management**

(g) definition of management and mitigation measures for cumulative impacts in each SCA

Cumulative Impacts Management Plan

All identified projects are or will be subject to individual environmental licensing processes before the MADES, which will establish mandatory environmental and social programmes and measures, as established in the respective environmental impact statements (EIS).

Thus, as a first step in the strategy to prevent, mitigate, control and compensate for negative cumulative impacts and maximise the effects of positive impacts, it must be ensured that each project considered in the analysis fully complies with the commitments established in their respective licensing processes. This compliance should be closely monitored by MADES. This is necessary because there are impacts that are beyond Atome's control and are the responsibility of the other project developers.

In addition to the measures to be carried out individually by the Developer responsible for each project, there are also measures that can be implemented jointly, which can optimise efforts and ensure that aspects that may not have been identified in the individual processes are covered. In this regard, the following programmes are proposed:

Institutional Cooperation Programme

As the impacts assessed in this study are cumulative, caused by several projects of different nature and different Promoters, it will be necessary to establish a way to involve all actors in order to join efforts and obtain better results in mitigating the negative or enhancing the positive impacts.

This involvement of the various parties can be achieved through the implementation of this Institutional Cooperation Plan, establishing conditions for each party to cooperate in the fulfilment of their respective actions.

The first step of this Institutional Cooperation Plan, which could be coordinated by MADES, would be to invite all the Promoters of the projects with cumulative impacts identified by this study (Atome, Omega Green, NGO Fundación Capital and Puerto Caacupe-mí) to discuss the impacts, the measures to be implemented, their willingness to participate in this joint strategy to manage these impacts, and the instrument to be established to subscribe to this commitment and monitor its fulfilment.

It is proposed to establish a Technical Cooperation Agreement, whereby the various Promoters undertake to carry out their share of the measures established to mitigate and control negative cumulative impacts and to enhance positive cumulative impacts, compliance with which will be monitored by MADES.

The Technical Cooperation Agreement must be signed by all the Promoters involved, thus assuming the different commitments related to the mitigation or enhancement of cumulative impacts. A structure for detailing this Technical Cooperation Agreement is proposed below:

1. Details of the participating companies and organisations, and of the corresponding projects
   Description of the proposed measures and actions based on the cumulative impacts identified.
3. Commitments of each participant
4. Timeline, indicating the stages or phases of implementation of the measures and the corresponding deadlines.
   Total duration of the Technical Cooperation Agreement
6. Manager of the Technical Cooperation Agreement, and related monitoring of the implementation of measures and actions.
   Declaration of Conformity with the Technical Co-operation Agreement

Distribution of Responsibilities

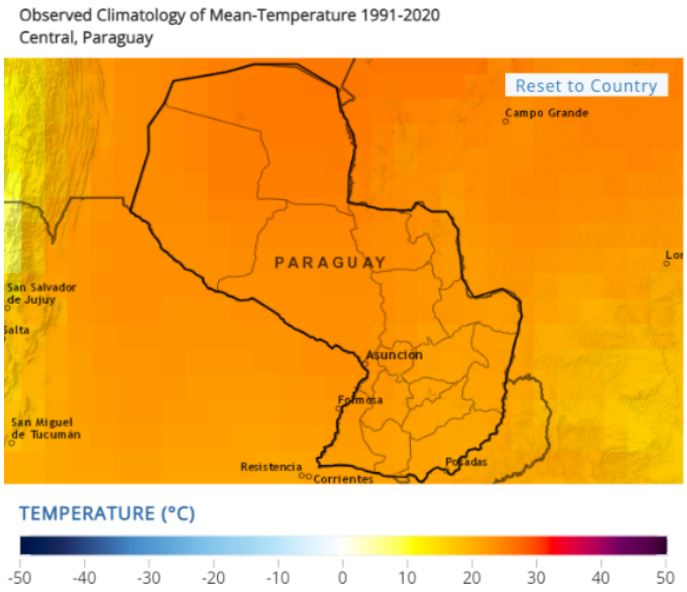
It is also important to mention that the vast majority of the cumulative effects analysed here are associated with the Omega Green Project which, due to its size and nature, has a greater potential to cause incremental alteration in the VECs. From this fact, it is feasible that the promoter of this Project (**BSBIOS company**) assumes the leading role in the strategies to control cumulative impacts. In the same way, it is suggested that the MADES takes on the role of overseer, to guarantee that the measures are being carried out and duly complied with.

6.1.6
Natural Disaster and Climate Change Risks

Paraguay's climate is classified as tropical to subtropical, with average annual temperatures above 20ºC in most parts of the country. In the eastern region the average temperature ranges between 20 and 24ºC, while in the western region the average annual temperature remains around 25ºC (**Figure 6.1.6.a**). The seasons are well defined, with winter from June to September, with a temperature rarely exceeding 20ºC, and summer from December to March, with an average temperature above 25ºC (**Figure 6.1.6.b**). Without a natural barrier, Paraguay is susceptible to the action of Patagonian cold fronts and Amazonian warm fronts. During winter

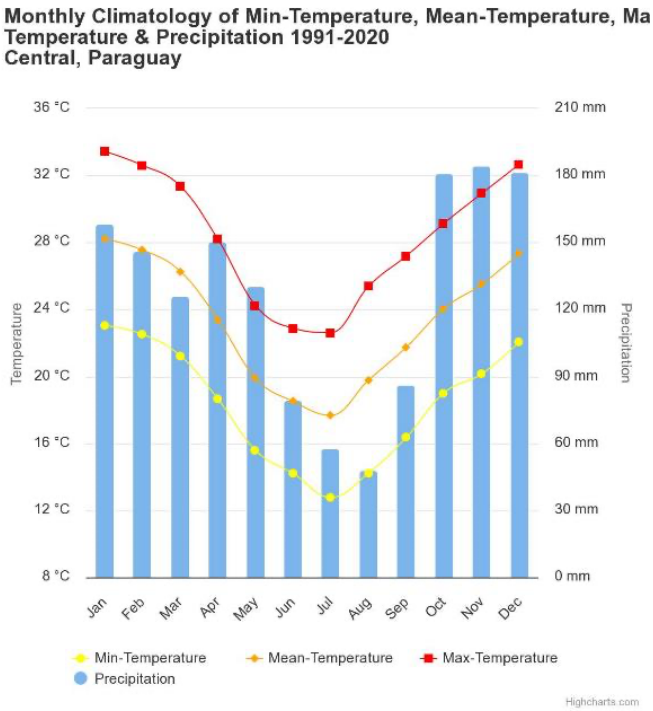
and spring the average temperature is reported to be 17ºC, with minimums approaching 10ºC (IBA 2, 2018).

Figure 6.1.6.a
Average annual temperature, 1991 to 2020



Source: World Bank Climate Change Knowledge Portal (CCKP). Accessed on 03/07/2023.

Figure 6.1.6.b
Mean, minimum and maximum monthly temperature and mean monthly precipitation, based on the historical record from 1991 to 2020.



Source: World Bank Climate Change Knowledge Portal (CCKP). Accessed on 03/07/2023.

Rainfall distribution follows a clear pattern in Paraguay, with dry winters and summers marked by widely spaced storms with dry periods. The period of highest rainfall tends to occur in two periods, from March to May and from October to December (**Figure 6.1.6.b**). The highest rainfall events are concentrated in the southern region, in the Paraná river basin, with an average of 1,900 mm per year of rainfall, and are regularly distributed throughout the year. Rainfall events are also intense in the central region, where the country's capital, Asunción, is located, with an annual average of 1,400 mm, distributed throughout the year, except in the months of June to August. From September to May, big storms are frequent, with heavy rainfall in a short period of time, causing rivers to overflow. In the Chaco-Occidental region the average annual rainfall varies from 500 to 1,000 mm, but is concentrated in the summer months, during the winter the region has a dry climate.

Paraguay's landscape is characterised by three distinct ecosystems. In the eastern part, the humid subtropical climate of green hills, grasslands and forests, including the Paraná plateau, with altitudes of 300-600 m above sea level. The low-lying plains of the far east, drained by rivers and subject to annual flooding, characterise a tropical savannah biome. In the west is the drier region, with vast alluvial plains and extensive dry grasslands, the Western Chaco, with a warm, semi-arid climate.

The World Bank's Climate Change Knowledge Portal (CCKP) database has historical climatological data for Paraguay covering the period from 1901 to 2020. With these data it is possible to assess the spatial and temporal distribution of average temperatures and average precipitation.
Table 6.1.6.a shows the consolidated seasonal mean temperature values for the periods 1901 to 1930, 1931 to 1960, 1961 to 1990 and 1991 to 2020. As can be seen, there is a gradual increase in seasonal mean temperatures over the periods analysed, in all regions.

Precipitation in Paraguay is subject to significant inter-annual variability due to the El Niño Southern Oscillation, which brings flooding and cooler weather, while La Niña episodes are associated with droughts and warmer weather in Paraguay. The data recorded in **Table 6.1.6.b** do not show an increase or decrease in seasonal precipitation averages, however, it is widely discussed in the literature that, although the averages do not change, intense precipitation events in a short period of time have been more frequent throughout the 21st century.

In this section, the climatic characteristics of Paraguay have been briefly presented, as well as an expeditious analysis of climate change over the course of the 21st century. In subsequent sections, the topic of climate change, based on mathematical models, and the effects of climate change on Paraguay's climate will be discussed in more detail.

Table 6.1.6.a

Observed seasonal average temperatures over the period 1901-2020

Observed seasonal mean temperature (ºC)																
	1901-1930				1931-1960				1961-1990				1991-2020			
Region	December, January and February	March April and May	June, July and August	September, October and November	December, January and February	March April and May	June, July and August	September, October and November	December, January and February	March April and May	June, July and August	September, October and November	December, January and February	March April and May	June, July and August	September, October and November
Paraguay	27.39	23.38	19.12	24.29	27.89	23.46	19.66	24.65	27.61	23.50	19.33	24.50	27.73	23.61	19.63	24.89
Highest: Alto Paraguay	28.29	25.05	21.64	26.63	28.46	24.90	21.94	26.73	28.36	25.06	21.76	26.68	28.40	25.08	22.01	26.88
Lower: Itapua	25.36	20.84	16.10	20.70	26.37	21.33	17.06	21.51	25.91	21.24	16.62	21.26	26.16	21.56	17.05	21.84

Table 6.1.6.b

Observed seasonal average precipitation over the period 1901 to 2020

Observed seasonal mean precipitation (mm)																
	1901-1930				1931-1960				1961-1990				1991-2020			
Region	December, January and February	March April and May	June, July and August	September, October and November	December, January and February	March April and May	June, July and August	September, October and November	December, January and February	March April and May	June, July and August	September, October and November	December, January and February	March April and May	June, July and August	September, October and November
Paraguay	227.17	290.19	130.30	308.32	237.57	300.60	138.85	310.60	247.45	303.79	143.48	306.54	265.24	308.21	128.96	332.55
Highest: Alto Paraguay	291.54	431.03	291.89	512.44	307.34	461.97	314.18	491.72	335.44	447.74	325.12	511.68	347.51	466.09	299.81	551.91
Lower: Itapua	165.57	152.4	29.56	126.54	169.33	139.9	29.93	140.69	171.40	165	32.73	134.34	181.52	157	26.37	141.92

Climate change

This section conveys concepts of climate change, as well as some methodologies applied to the formulation of models used to derive climate parameter curves.

The climatic phenomena of global warming and cooling, increased frequency and intensity of weather events (storms, typhoons, tornadoes, etc.) are part of the dynamics of the globe, have always occurred and will continue to occur. What has been studied in recent decades is how human activities, intensified after the industrial revolution, have accelerated and intensified climate change. There is now a consensus in the global scientific community that anthropogenic actions are the main cause of the intensification of climate change that has occurred in recent decades (UNFCCC, 1992 and IPCC, 2007).

The United Nations Framework Convention on Climate Change (UNFCCC) defines the phenomenon of climate change as climate variability attributed directly or indirectly to human activities that alter the chemical composition of the atmosphere, which is complemented by natural variability that has occurred over past time periods (UNFCCC, 1992). On this concept, the Intergovernmental Panel on Climate Change (IPCC) subsequently stated that the contribution of human action to climate change was greater than 90% (IPCC, 2007). The effects of global warming due to human action are estimated to be five times greater than those of climate change due to natural causes (MONGELÓS, 2018).
Current debates at meetings of scientists and political leaders revolve around what strategies and measures should be taken to ensure a healthy environment for future generations. To this end, scientific discussion is based on methods for mapping anthropogenic activities with the greatest potential to catalyse climate change, through inventories and calculations of carbon equivalent emissions, and sizing future risks through modelling future scenarios, the RCPs (*Representative Concentration Pathways*) proposed by the IPCC-AR5 in 2014.

The main scenarios include RCP 4.5 and RCP 8.5. RCP 4.5 was developed by the modelling team of the *Pacific Northwest National Laboratory's Joint Global Change Research Institute* (JGCRI) in the United States. It is a stabilisation scenario in which total radiative forcing stabilises shortly after 2100, where radiation stabilises at 4.5 W/m², corresponding to a concentration of about 650 ppm (CLARKE *et al.*, 2007). RCP 8.5 was developed by the integrated assessment framework of IIASA (*International Institute for Applied Systems Analysis*) in Austria. It is a pessimistic scenario and is characterised by increasing greenhouse gas (GHG) emissions over time, assuming a radiation of 8 W/m², which corresponds to a high GHG concentration (RIAHI *et al.*, 2007).

The most widely accepted theory is that, by the end of the 21st century, the Earth's surface temperature will increase by 1.5°C compared to temperatures in the period between 1850 and 1900. For the RCP 4.5 scenario the likely increase is more than 2°C, for the RCP 8.5 scenario the likely increase is more than 4°C, both with the end of the 21st century (year 2100) as the scenario.

This increase in temperature, in the global context, will lead to changes in the behaviour of atmospheric air masses and ocean currents. More intense and more frequent heat waves are very likely. The increase in average temperature is expected to lead to an increase in the intensity of precipitation effects in tropical regions and an increase in dry periods in other

regions. In the Arctic region, an increase in melting intensity is expected, with full melt scenarios (MEEHL *et al*., 2007), and consequent sea level rise. The analysis of future climate change scenarios in Paraguay will focus on the RCP 4.5 and RCP 8.5 scenarios.

Climate Change Scenarios for South America and Paraguay

The RCP 4.5 and RCP 8.5 scenarios were adopted as parameters of analysis in the study "Evaluation of vulnerability and capacity to face the challenges and opportunities of climate change in Paraguay", which served as the basis for the analysis constructed in this section. In both scenarios, the entire territory of Paraguay will be affected by climate change. **Figure 6.1.6.c** illustrates the spatial distribution of mean annual temperature observed between 1961 and 1990. **Figure 6.1.6.d** illustrates the spatial distribution of total annual precipitation observed between 1961 and 1990.

Figures 6.1.6.e and **6.1.5.f** illustrate the modelling result using RCP 4.5 and RCP 8.5 scenarios, respectively, for mean annual temperature, for the years 2021 to 2030, 2031 to 2040 and 2041 to 2050. **Figures 6.1.6.g** and **6.1.6.h** illustrate the modelling results using the RCP 4.5 and RCP 8.5 scenarios, respectively, for total annual precipitation, for the years 2021 to 2030, 2031 to 2040 and 2041 to 2050.

Figure 6.1.6.c
Average annual temperature between 1961 and 1990

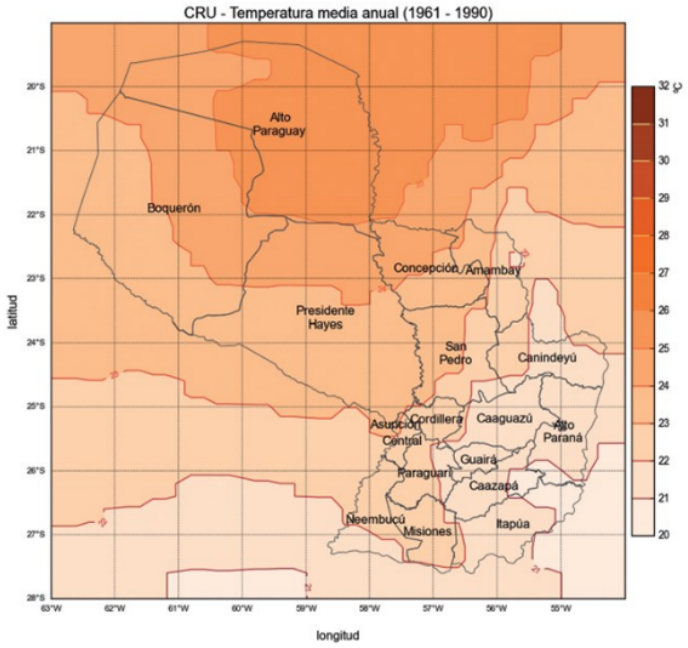


Figure 6.1.6.d
Total annual rainfall in the period 1961-1990

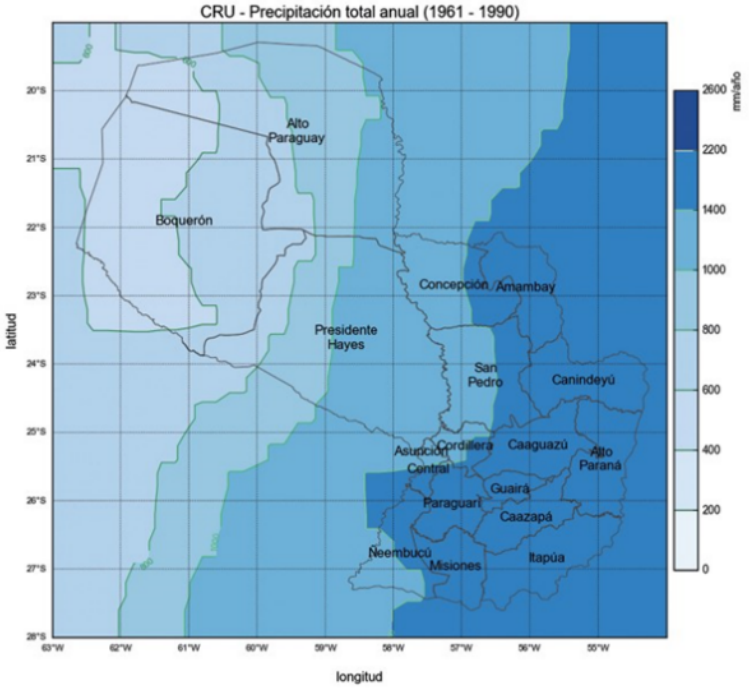


Figure 6.1.6.e
Mean annual temperature in RCP 4.5 scenario for the years 2021 to 2030, 2031 to 2040 and 2041 to 2050

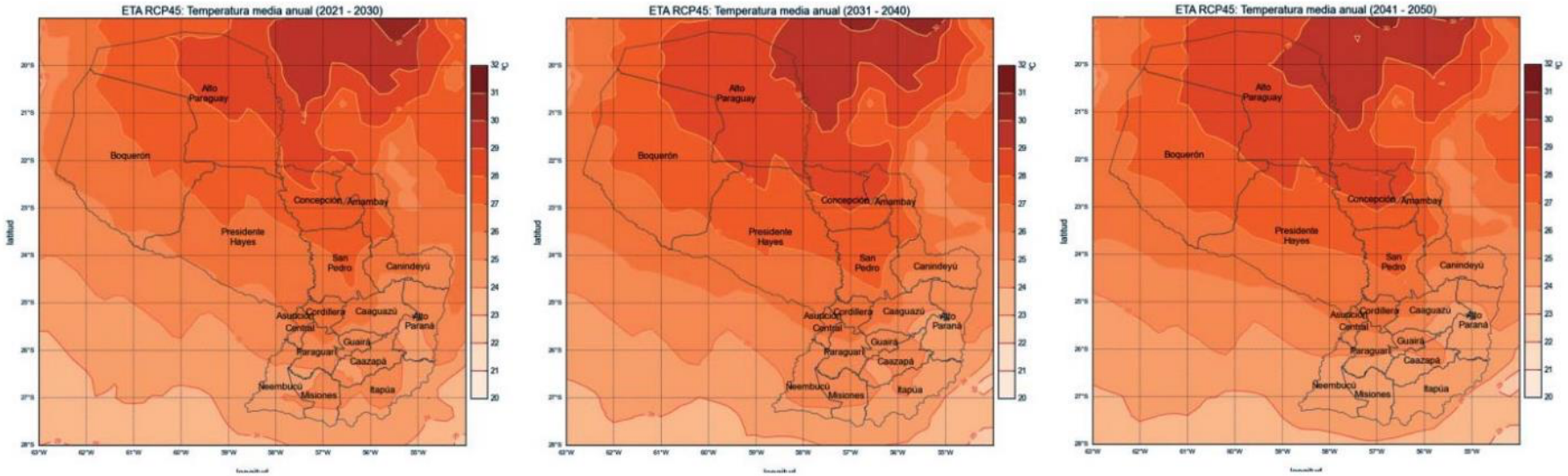


Figure 6.1.6.f
Mean annual temperature in RCP 8.5 scenario for the years 2021 to 2030, 2031 to 2040 and 2041 to 2050

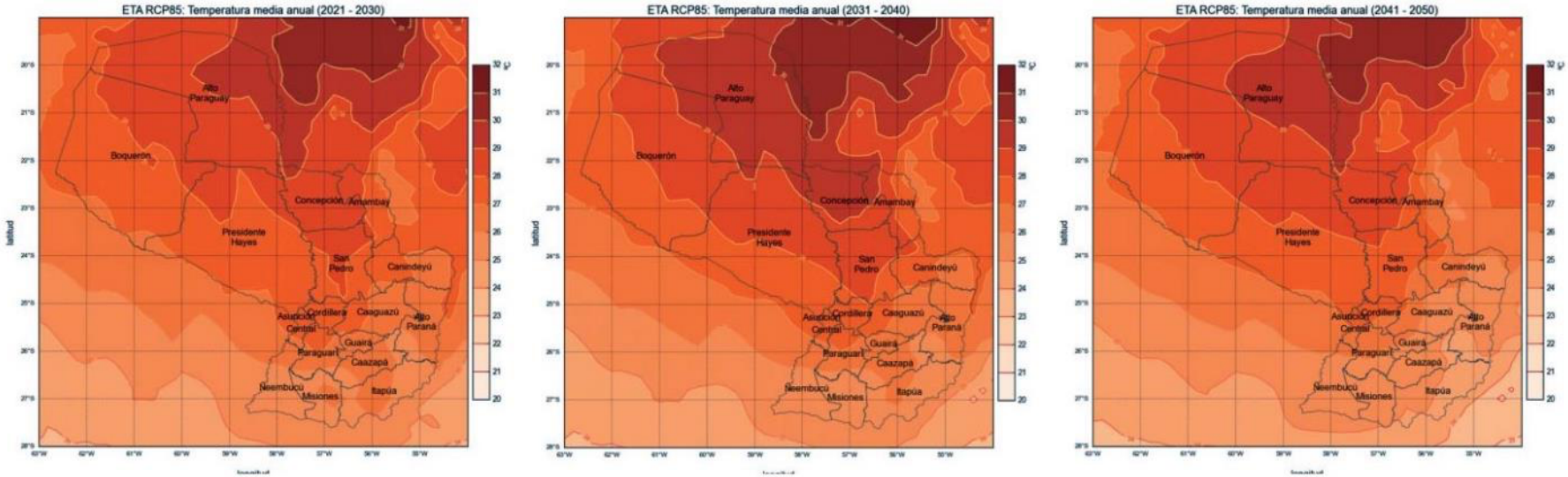


Figure 6.1.6.g
Total annual precipitation in RCP 4.5 scenario for the years 2021 to 2030, 2031 to 2040 and 2041 to 2050

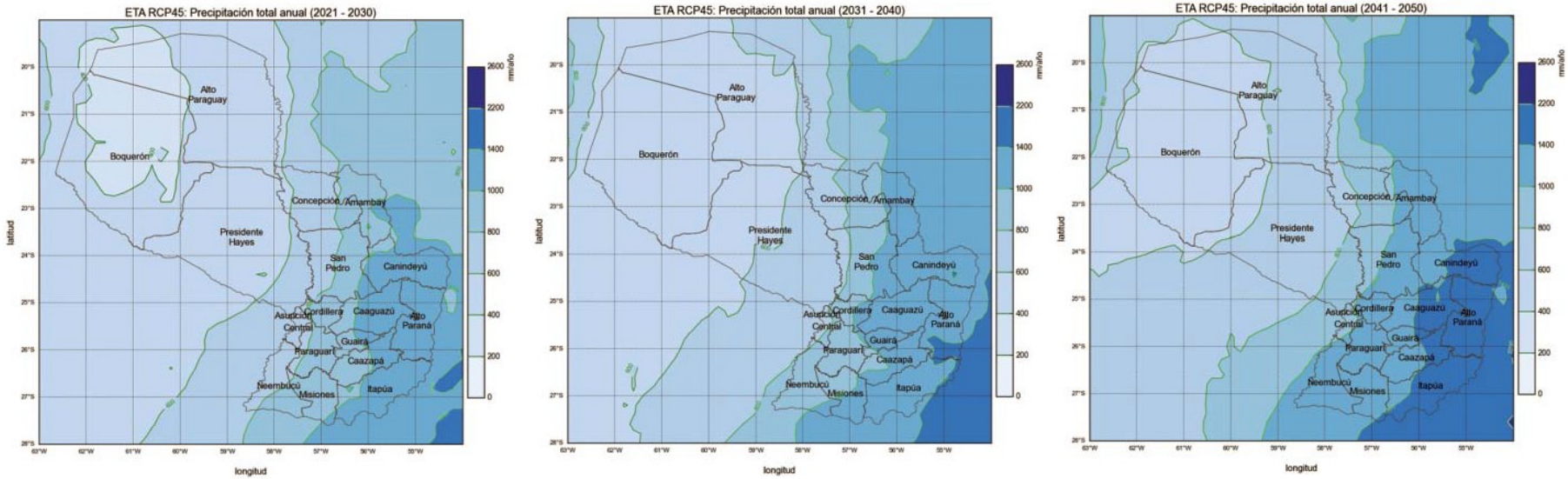
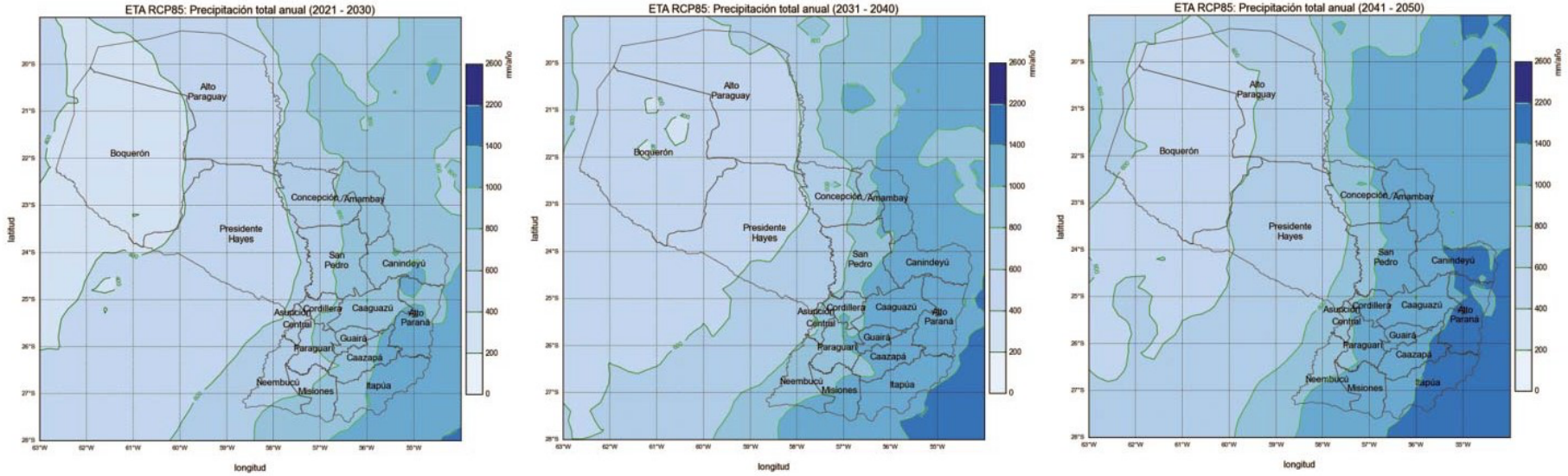


Figure 6.1.6.h
Total annual precipitation in RCP 8.5 scenario for the years 2021 to 2030, 2031 to 2040 and 2041 to 2050



Based on the modelled scenarios (RCP 4.5 and RCP 8.5), it is possible to visualise a gradual increase in temperature up to the year 2050, with greater intensity for the modelled pessimistic scenario, RCP 8.5. **Table 6.1.6.c** shows the comparative values for each scenario and for each time period analysed, considering all regions of Paraguayan territory. The normal value (annual average 1961-1990) (**Figure 6.1.6.c**) is the comparative basis for the modelling by decades, and the anomaly columns show the difference with respect to the normal.

In the column of temperature anomalies with respect to the normal (1961-1990) for the RCP 4.5 scenario, a considerable increase in mean temperature is observed; in all decades from 2021 to 2050, the one from 2031 to 2040 shows the highest increase in mean temperature. For the RCP 4.5 scenario, the temperature increase was close to 2.5ºC for most of the Departments, exceeding 3ºC only in the department of Amambay. Modelling using the RCP 8.5 scenario shows a considerably higher temperature increase, around 3.5ºC for most of the Departments, with Amambay and Canindeyú showing the highest observed temperature increase, reaching 3.9ºC in the decade from 2031 to 2040.

Table 6.1.6.d presents the comparative values of the Annual Cumulative Precipitation Variation for the RCP 4.5 and RCP 8.5 scenarios. The normal that serves as a basis for comparison is the historical annual cumulative precipitation obtained from measurements from 1961 to 1990. In both the modelling that adopts the RCP 4.5 scenario and the modelling that adopts the RCP 8.5 scenario, it is possible to verify the same behaviour, with a significant reduction in precipitation between the decades 2021 and 2030 (around 20% for the RCP 4.5 scenario and 25% for the RCP 8.5 scenario). Precipitation reduction also occurs in the decade 2031 to 2040, however, with less intensity, for the RCP 4.5 scenario the average reduction is 9%, while for RCP 8.5 it is 11%. In the decade 2041 to 2050 there is a reversal of the trend and precipitation shows a small increase compared to the parameter data, for the RCP 4.5 scenario the average increase observed was 8%, for the less intense RCP 8.5 scenario 4%.

Table 6.1.6.c
Annual mean temperature change for RCP 4.5 and RCP 8.5 scenarios

		Historical Annual Average Temperature (ºC)	RCP 4.5 Scenario						RCP Scenario 8.5					
			Modelled mean annual temperature (ºC)			Recorded temperature anomaly, based on historical measurements from 1961 to 1990 (ºC)			Modelled mean annual temperature (ºC)			Recorded temperature anomaly, based on historical measurements from 1961 to 1990 (ºC)		
Region	Department	1961-1990	2021-2030	2031-2040	2041-2050	2021-2030	2031-2040	2041-2050	2021-2030	2031-2040	2041-2050	2021-2030	2031-2040	2041-2050
Oriental	Asunción	24.1	26.2	26.5	26.3	2.0	2.3	2.1	27.5	27.7	27.1	3.4	3.5	3.0
	Concepción	25.3	27.7	28.0	28.0	2.4	2.7	2.7	28.6	29.1	28.4	3.3	3.8	3.1
	San Pedro	24.3	26.9	27.0	26.9	2.6	2.7	2.6	27.8	28.1	27.4	3.5	3.8	3.1
	Cordillera	24.0	26.5	26.6	26.4	2.5	2.6	2.3	27.6	27.7	27.0	3.5	3.7	3.0
	Guairá	22.9	25.7	25.6	25.3	2.8	2.6	2.3	26.6	26.6	25.7	3.7	3.6	2.8
	Caaguazú	23.0	25.8	25.7	25.5	2.8	2.7	2.5	26.8	26.8	25.9	3.8	3.8	2.9
	Caazapá	22.5	25.2	25.1	24.8	2.7	2.6	2.3	26.1	26.1	25.2	3.6	3.6	2.7
	Itapua	22.4	25.0	24.8	24.5	2.6	2.4	2.1	25.9	25.8	24.9	3.6	3.4	2.5
	Missions	22.6	25.0	25.0	24.7	2.3	2.3	2.0	25.9	25.8	25.2	3.2	3.2	2.6
	Paraguarí	23.2	25.5	25.6	25.3	2.3	2.4	2.0	26.6	26.6	26.0	3.4	3.4	2.8
	Upper Paraná	22.6	25.3	25.0	24.8	2.7	2.5	2.3	26.4	26.4	25.3	3.9	3.8	2.8
	Central	23.9	26.0	26.2	26.0	2.1	2.3	2.1	27.3	27.4	26.9	3.4	3.5	3.0
	Ñeembucú	22.8	25.0	25.1	24.8	2.2	2.3	2.0	26.0	25.9	25.6	3.1	3.1	2.7
	Amambay	24.3	27.3	27.5	27.4	3.0	3.1	3.1	28.0	28.2	27.4	3.7	3.9	3.1
	Canindeyú	23.3	26.1	26.0	25.8	2.8	2.7	2.5	27.1	27.2	26.2	3.8	3.9	3.0
Occidental	President Hayes	24.6	26.6	27.1	27.1	2.0	2.5	2.5	27.6	28.1	27.7	3.0	3.5	3.1
	Anchovy	24.9	26.8	27.3	27.4	1.9	2.4	2.5	27.7	28.1	27.9	2.8	3.2	2.9
	Upper Paraguay	25.8	27.9	28.4	28.4	2.1	2.6	2.7	28.7	29.3	28.9	2.9	3.5	3.1

Table 6.1.5.d
Variation in annual cumulative precipitation for RCP 4.5 and RCP 8.5 scenarios

		Cumulative annual precipitation Historical	RCP 4.5 Scenario						RCP Scenario 8.5					
			Modelled cumulative annual rainfall (mm)			Recorded rainfall anomaly, based on historical measurements from 1961 to 1990 (%)			Modelled cumulative annual rainfall (mm)			Recorded rainfall anomaly, based on historical measurements from 1961 to 1990 (%)		
Region	Department	1961-1990	2021-2030	2031-2040	2041-2050	2021-2030	2031-2040	2041-2050	2021-2030	2031-2040	2041-2050	2021-2030	2031-2040	2041-2050
Oriental	Asunción	895.5	706.4	747.9	905.5	-21.1	-16.5	1.1	651.1	779.7	906.3	-27.3	-12.9	1.2
	Concepción	901.3	706.6	792.6	867.9	-21.6	-12.1	-3.7	717.7	757.9	944.6	-20.4	-15.9	4.8
	San Pedro	1060.7	836.6	946.1	1079.2	-21.1	-10.8	1.7	787.8	897.0	1066.1	-25.7	-15.4	0.5
	Cordillera	1072.5	861.5	942.7	1123.0	-19.7	-12.1	4.7	772.7	927.0	1067.6	-28.0	-13.6	-0.5
	Guairá	1230.4	987.3	1097.5	1328.6	-19.8	-10.8	8.0	923.9	1104.4	1258.3	-24.9	-10.2	2.3
	Caaguazú	1290.3	1040.9	1190.7	1379.0	-19.3	-7.7	6.9	945.6	1116.3	1298.5	-26.7	-13.5	0.6
	Caazapá	1261.7	1035.3	1153.5	1420.2	-17.9	-8.6	12.6	967.0	1151.4	1325.5	-23.4	-8.7	5.1
	Itapua	1325.4	1110.3	1246.1	1543.8	-16.2	-6.0	16.5	1016.9	1235.3	1445.9	-23.3	-6.8	9.1
	Missions	1029.7	888.0	993.4	1244.5	-13.8	-3.5	20.9	812.7	1017.0	1115.3	-21.1	-1.2	8.3
	Paraguarí	1015.0	836.7	913.1	1139.5	-17.6	-10.0	12.3	773.2	938.6	1050.1	-23.8	-7.5	3.5
	Upper Paraná	1408.6	1126.0	1334.8	1570.2	-20.1	-5.2	11.5	1021.9	1198.3	1453.8	-27.5	-14.9	3.2
	Central	930.6	748.1	804.4	984.3	-19.6	-13.6	5.8	686.6	827.6	940.9	-26.2	-11.1	1.1
	Ñeembucú	922.8	790.9	893.1	1115.3	-14.3	-3.2	20.9	734.9	909.6	984.0	-20.4	-1.4	6.6
	Amambay	1146.7	913.7	1034.9	1134.9	-20.3	-9.8	-1.0	888.3	1004.3	1232.9	-22.5	-12.4	7.5
	Canindeyú	1327.3	1052.5	1256.8	1410.2	-20.7	-5.3	6.3	950.3	1128.9	1364.4	-28.4	-14.9	2.8
Occidental	President Hayes	675.2	547.3	603.3	699.3	-18.9	-10.6	3.6	510.7	574.0	695.1	-24.4	-15.0	3.0
	Anchovy	501.1	406.2	470.8	546.1	-18.9	-6.0	9.0	363.9	444.5	559.8	-27.4	-11.3	11.7
	Upper Paraguay	579.5	452.8	535.7	606.8	-21.9	-7.5	4.7	463.2	508.9	620.8	-20.1	-12.2	7.1

The climate changes modelled and discussed throughout this section highlight important changes in temperature and precipitation across the national territory of Paraguay. These changes catalyse and enhance high intensity climatic phenomena, such as prolonged periods of drought, increased intensity of extreme precipitation events and floods. According to the study *Vulnerability Index to climate change in the Latin American and Caribbean Region*, published in 2014, South American countries are less exposed to climate change than those located in Central America. Among the countries that make up South America, Paraguay is the most exposed to climate change and extreme weather events, ranking sixteenth among all Latin American nations classified in the Exposure Index as 'high risk'. The risks listed by the study are drought (difficulty of access to water due to prolonged droughts, increased desertification, fires, soil degradation), floods and severe storms, among the main risk factors in this region, along with some of the highest temperature increases predicted for the Latin American region, as an associated risk is the emergence of new tropical epidemics, in addition to the worsening of existing epidemics such as dengue fever and yellow fever.

Environmental risks associated with climate change

The World Bank's Climate Change Knowledge Portal (CCKP) provides a study on the occurrence of extreme natural climate events and the number of people affected between 1980 and 2020 (**Figure 6.1.5.i**). The increase in frequency of occurrence is evident from 2000 onwards, with epidemics, storms and floods standing out. Throughout the historical measurement, floods predominate, with 22 events, epidemics, with 9 events, storms and droughts, with 8 events each, complete the categories with the highest occurrence. Floods accounted for the highest proportion of people affected and the greatest cause of financial losses in the period analysed.

The increase in the frequency and intensity of extreme events has been associated with the worsening of climatic phenomena (El Niño and La Niña), in turn associated with global warming. The occurrence of floods and storms, given Paraguay's geographic characteristics, is associated with extreme precipitation events. **Figure 6.1.5.k** illustrates the projection of the average accumulation of the highest precipitation events in a month for the central region of Paraguay (considering the RCP 4.5 and RCP 8.5 scenarios), which is one of the indicators for analysing flood risk. The illustration in grey refers to the historical measurement data, 1995 to 2014, the projection in yellow to the RCP 4.5 scenario and the projection in red to RCP 8.5, the shadow covering the values above and below the middle line refers to the statistical treatment 10%-90%, where 10% of the events will have values below this range, and 90% of the events will have values below the maximum covered by the range.

Figure 6.1.5.i
Statistics on the main extreme natural events in Paraguay between 1980 and 2020

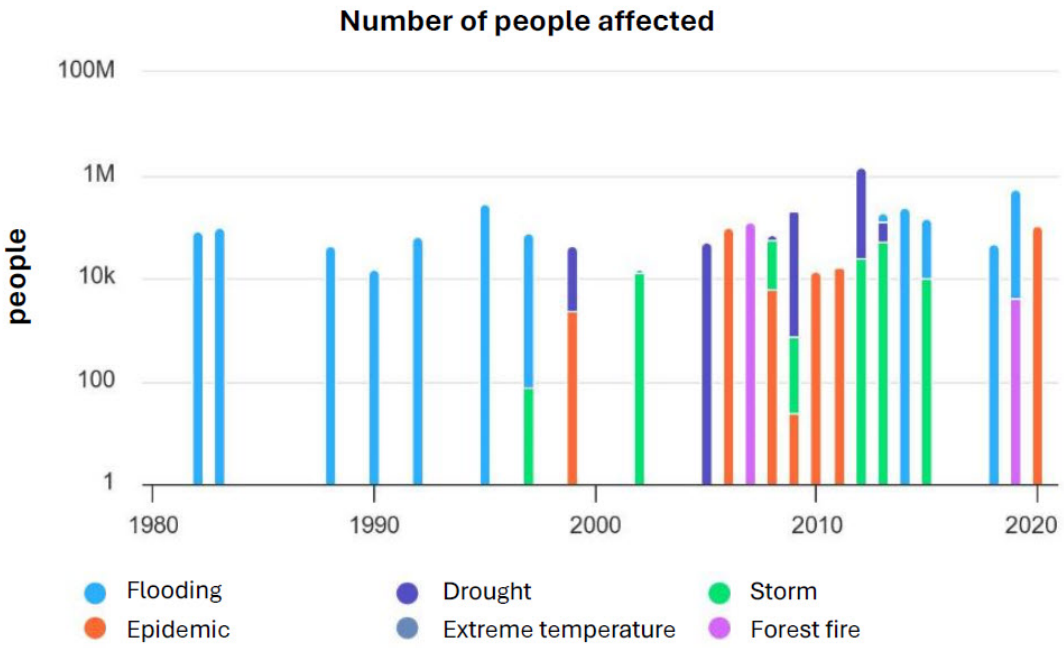
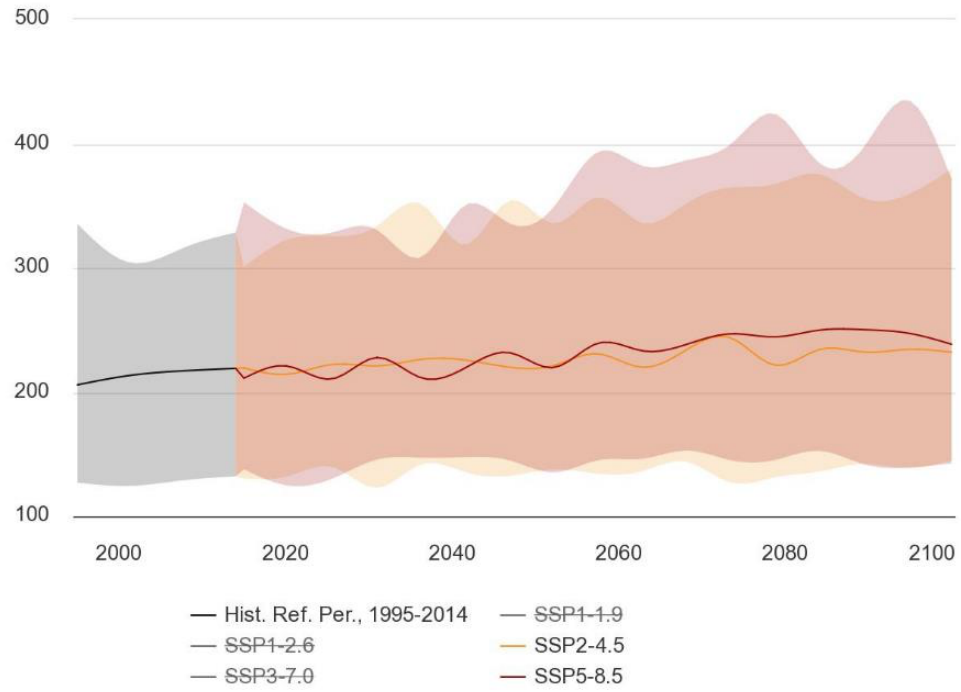


Figure 6.1.6.j
Projection of the average of accumulated rainfall events in a month for the central region of Paraguay.



The occurrence of floods is associated with extreme precipitation events, so the analysis of interest is the upper curve of the shadow, where the extreme (temporary) events with the capacity to generate floods would be located. In this way it is possible to verify that in the historical data the measurements did not exceed 350 mm, being barely above 300 mm of accumulated rainfall. The projection illustrates

a continuous increase in the values of extreme events, the RCP 8.5 scenario illustrates an alarming scenario, with a worsening of extreme events from 2040 onwards, reaching values above 400 mm after 2070, which would represent extreme events with precipitation occurrences 33% higher than historical measurements.

From the above, it can be considered that for the ATOME Project the risk of extreme events is associated with storms, droughts and floods. As discussed in the previous paragraphs, the worst-case scenario projections illustrate an increase of up to 33% in the intensity of extreme rainfall events over the next 60 years, which will certainly result in higher intensity flood events.

The project is located in the vicinity of the flood plain of the Paraguay River, about 2 km from one of its meanders. The Paraguay River is the longest river in the country and also has the largest watershed, receiving meltwater from the Andes Mountains. It is correct to infer that the worsening of extreme precipitation events will have a strong influence on the river's flood regime, resulting in a worsening of its intensity. The river bed in the meander close to the Project has an elevation of approximately 53 metres, while the Project area has an average elevation of 65 metres, with approximately 12 metres difference between the elevations. In view of this, the floodplain covered by this difference would certainly absorb large floods. On the other hand, extreme storms and the effects of wind and drought still need to be taken into account in the risk management of the Project.

7.0 Environmental and Social Management Plan (ESMP)

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Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

SUMMARY

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7.0
Environmental and Social Management Plan (ESMP)

The Environmental and Social Management Plan (ESMP) presents the prevention, mitigation, control and monitoring measures and compensation for the environmental and social impacts proposed for the ATOME green CAN fertiliser lant project, the TL and the water intake and pipeline infrastructure and effluent discharge pipeline The ESMP is subdivided into various Programmes, according to each stage of the project. The Programmes that make up the ESMP are those for which the need has been identified according to the impacts identified and assessed for the planning, construction and operation phases of the project in **Chapter 6.0**.

The ESMP Programmes, and related measures, ensure that all direct and indirect impacts of project implementation and operation are addressed, mitigated and/or compensated for.

As will be noted, the proposed Programmes require a number of environmental and social actions and measures to be implemented in accordance with Paraguayan legislation and IFC Performance Standards (PS 01, PS 02, PS 03, PS 04, PS 05, and PS 06), the IFC General EHS Guidelines, ILO Conventions and other applicable international requirements.

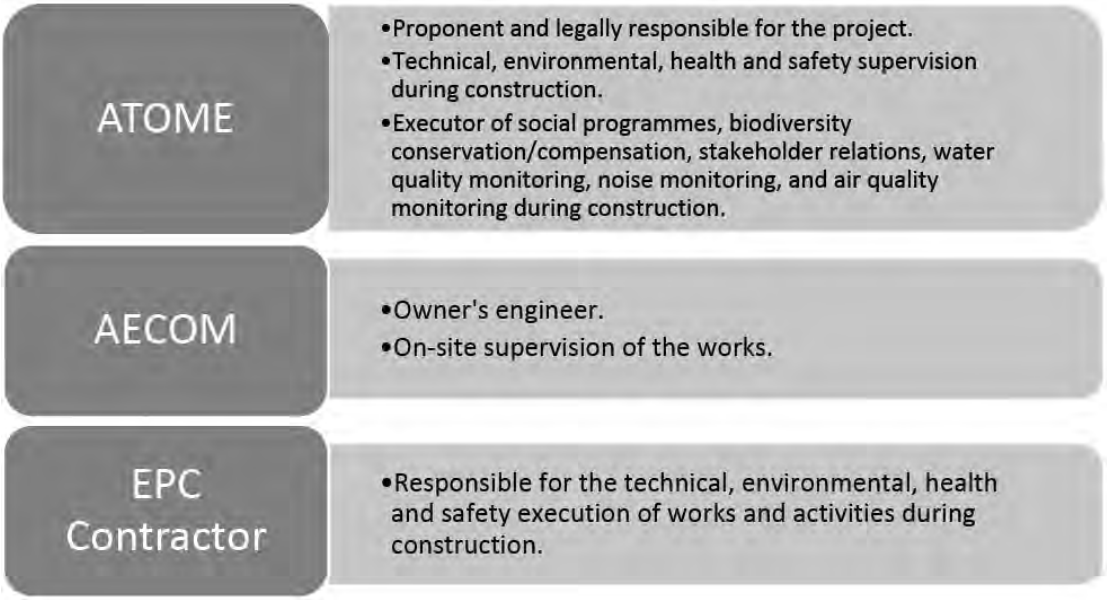
All activities required for the implementation of the ESMP must be considered in the project costs.

7.1
Organisation of Responsibilities

Responsibilities for implementation of ESMP programmes are established according to their stage of implementation, i.e. during the construction stage or during operation and maintenance (O&M) of the project. The responsibilities for environmental, social and health and safety management during the different stages are detailed below.

7.1.1
Construction Stage

Figure 7.1.1.a
Structure of execution and supervision of works and of the ESMP



EPC contractors will have Environmental, Health and Safety - MASS secialists as permanent staff on site who will be responsible for developing and carrying out the contractors' own MASS Management System policies and plans. These personnel will be available on site throughout the works to interact with AECOM and ATOME.

AECOM's responsibility in the environmental and social component is:

- Oversee and approve the activities carried out by EPC contractors within the framework of the environmental, health and safety requirements established in their contracts, which shall be in accordance with Paraguayan legislation and international standards. The environmental, health and safety programmes of the EPC Contractors' ESMPs will be prepared in accordance with these requirements.
- Verify compliance with environmental and health and safety measures on site.

For ATOME, the responsibilities are as follows:

- Approve the EHS programmes of the MASS Management System submitted by EPC contractors.
- Supervise compliance with the ESMP and MASS' obligations assumed through the contracts signed with EPC contractors.
- Implement social programmes, biodiversity offsets, stakeholder engagement and communication, and monitoring of river water quality, environmental noise and air quality.
- Submit annual environmental audit reports to the Ministry of Environment, in compliance with the provisions of the project's Environmental Licence.

- Provide performance reports to other institutions on request and to financial institutions and other interested parties.

7.1.2
Operation and Maintenance

Figure 7.1.2.a
O&M and ESMP implementation and monitoring structure



Operating companies will have MASS specialists as permanent staff on site who will be responsible for developing and carrying out their MASS Management System policies and plans. These personnel will be on site during O&M to interact with AECOM and ATOME. The O&M operator will have a trained emergency response team.

ATOME's responsibilities will remain similar to those of the construction phase, focusing on the approval of the MASS Management System of the operating companies, and the supervision of these companies. However, at this stage, ATOME will be limited to the implementation of the social and biodiversity conservation/compensation programmes. In addition, it will be in charge of reporting to relevant national institutions, financial institutions and other stakeholders.

7.2
Organisation of the Plans and Programmes of the ESMP

The ESMP is structured in plans and programmes to be implemented during the construction or operation and maintenance phase. This structure is set out in **Table 7.2.a** below, and each of these is described individually in the following sections.

Table 7.2.a
Organisation of the PGAS Programmes

PGAS programmes	Project phases		
	Design and Planning	Construction	Operation and Maintenance
P.01 - Environmental Monitoring Programme		X	
P.02 - Environmental and Social Management Programme for the Construction Phase		X	
P.03 - Stakeholder Engagement Programme	X	X	X
P.04 - Occupational Health and Safety Programme		X	X
P.05 - Management of Labour and Working Conditions Programme		X	X
P.06 - Emergency Response Programme for the Construction Phase		X	
P.07 - Biodiversity Action Plan	X	X	X
P.08 - Programme for the Prevention of Impacts on Flora and Fauna	X	X	
P.09 - Environmental and Social Management Programme for the Operation Phase			X
P.10 - Operational Phase Emergency Response Programme			X
P.11 - ADA Archaeological and Cultural Heritage Conservation Programme		X	
P.12 - Transport Management Programme			X

Each plan or programme is composed of the following parts: i) justification, ii) main objectives, iii) applicable legislation, iv) responsibilities, v) implementation methodology, vi) effectiveness indicators, vi) reporting, and viii) implementation schedule.

7.3
Programmes of the Environmental and Social Management Plan (ESMP)

P.01 - Environmental Construction Control Programme

1. Justification of Programme

The Construction Environmental Control Programme presents the guidelines and procedures to be followed by Contractors and subcontractors for the construction and erection works of the ATOME Plant, the LT and the water collection and supply infrastructure for the Plant and effluent discharge pipeline.

The Plan will be applied throughout the construction phase, focusing on the main construction activities and on the construction camp and other support areas, such as borrow areas and disposal areas for surplus excavation material. It also includes measures for the restoration and recovery of areas degraded by the works and measures for monitoring environmental quality parameters.

The environmental management procedures during construction will include a wide range of prevention, mitigation, control and monitoring measures for all construction activities and/or facilities involving specific environmental risks or impacts. They will also include guidelines for corrective actions as applicable. The measures listed in this Plan shall constitute binding contractual requirements and Contractors and all subcontractors shall comply with them on an ongoing basis throughout the construction cycle. Compliance shall be ensured not only by the Contractors' environmental and social management team, but also through the Construction Supervision to be implemented by ATOME within the scope of P.02 - Environmental and Social Management Programme.

2. Main Objectives

The general objective of the Environmental Construction Control Programme is to provide technical guidance to minimise the negative environmental impacts of the construction and assembly works of the Project components. To this end, the following specific objectives are defined:

- Provide technical guidance for the main construction activities that may generate negative impacts;
- Ensure that the construction camp and other support areas are implemented and operated in accordance with environmental control procedures that ensure effective prevention or minimisation of negative environmental impacts;
- Standardise environmental procedures to be adopted by Contractors and subcontractors;
- Ensure good traffic conditions for vehicles servicing the works, as well as for other vehicles using the Project accesses.

3. Applicable Legislation

All Paraguayan legislation and international standards related to pollution control apply (see **Section 4.2** of this ESIA).

4. Responsibilities

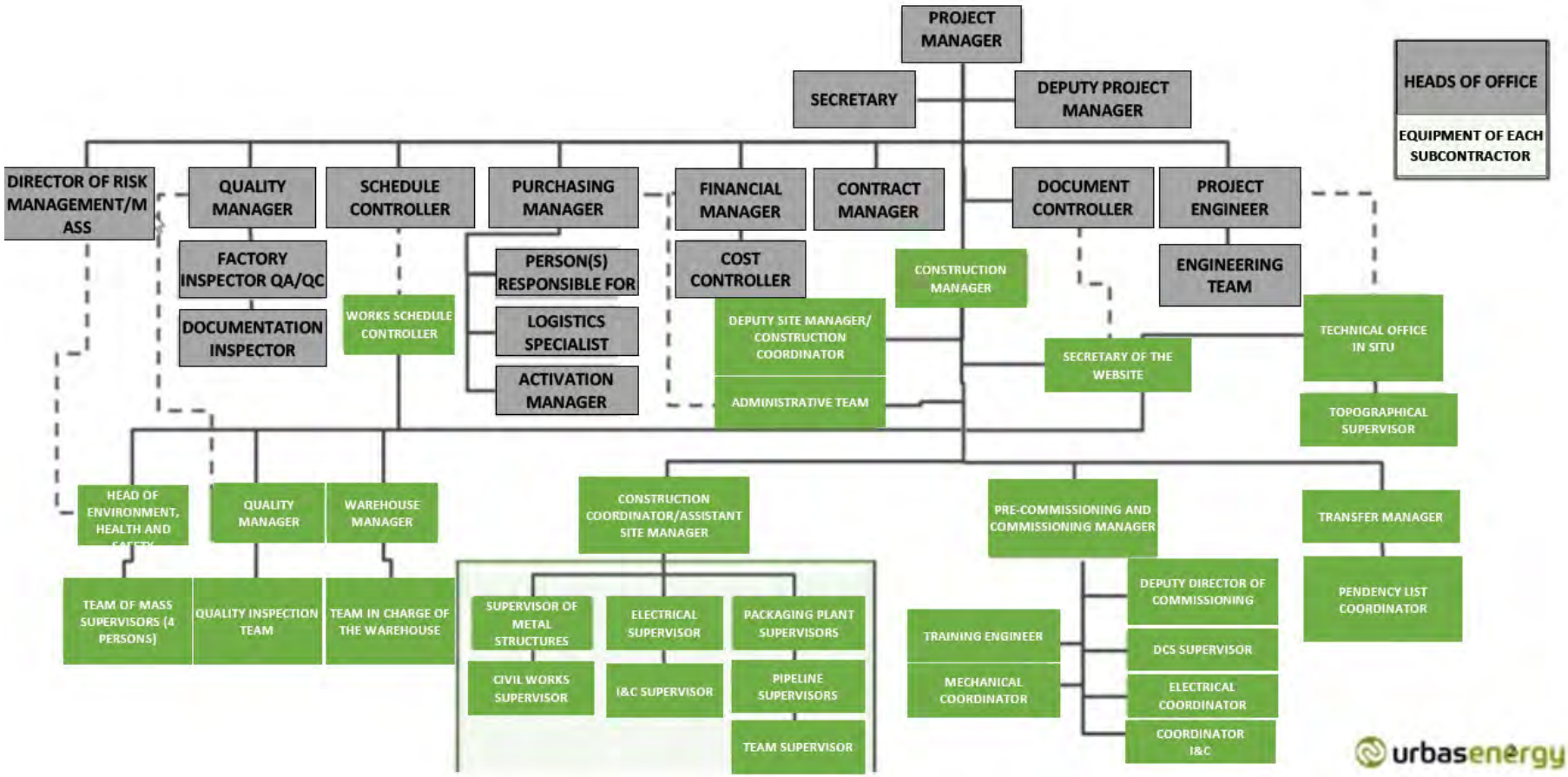
The Construction Environmental Control Programme (P.01) is the responsibility of the Contractors, under the monitoring/supervision of ATOME.

The Contractors who will execute the construction and erection of the ATOME Plant, LT and water supply and effluent discharge infrastructure will be responsible for carrying out the works activities in accordance with the prevention, control and mitigation measures foreseen in each section of this Programme P.01, under the supervision/monitoring of ATOME. **Figure 4.0.a of P.01** below shows the organisation chart of the team that will form the Industrial Plant EPC Contractor. The EPC Contractors for the other components (electrical LT and intake infrastructure and raw water pipelines and effluent discharge pipelines) will have smaller organisational structures appropriate to the size and nature of these components.

To ensure compliance with the measures foreseen in this and other Programmes under the responsibility of the Contractors, they shall be contractually obliged to have at least: 1

environmental specialist and 1 health and safety specialist on a permanent basis as part of the team in Figure 4.0.a. Contractors' and subcontractors' workers must be trained by the specialists of the EPC Contractors' team.

Figure 4.0.a from P.01
Contractors' Team Organisation Chart for the Construction Phase (Plant Construction)



The EPC Contractors for the other components (electrical LT and intake infrastructure and raw water pipelines and effluent discharge pipelines) will have smaller organisational structures appropriate to the size and nature of these components.

To ensure compliance with the measures foreseen in this and other Programmes under the responsibility of the Contractors, they shall be contractually obliged to have at least: 1 environmental specialist and 1 health and safety specialist on a permanent basis as part of the team in **Figure 4.0.a.** Contractors' and subcontractors' workers must be trained by the specialists of the EPC Contractors' team.

5. Implementation Methodology

The measures adopted in this programme are detailed below:

5.1. Management of earthmoving activities

The measures to be applied in excavation and earthmoving activities are as follows:

- The limits established for excavations and earthworks shall be respected, in accordance with good practice, strictly following the dimensions, quotas and slopes indicated in the project.
- Removal of vegetation and clearing of land shall be carried out to the extent necessary for the work to be carried out.
- Temporary drainage devices shall be installed to prevent erosion and soil transport processes outside the construction site.
- Loose soil piles shall only be permitted on flat sites and outside the preferential runoff course.
- Sediment retention devices in earthwork areas must be constantly cleaned.
- The orientation of the flow over the exposed soil areas must be constantly adjusted to ensure that it flows towards the drainage devices.
- Protection of areas of exposed soil will be carried out on a temporary basis with the installation of physical containment barriers made of geotextile blankets, for example, or with vegetation restoration.
- Vegetation cover in areas of exposed soil shall be restored as soon as possible.
- Possible erosion processes should be corrected or stabilised as soon as possible.
- The start of earthworks will be preceded by the removal and accumulation of organic soil, with mulching and a native seed bank, to be used in the re-composition of the land immediately after completion of the works.
- Continued surface protection of areas with exposed soil, including compaction and appropriate shaping, anticipation of vegetation cover re-composition and installation of emergency plastic cover in particularly unstable sections, shall be carried out. These measures shall be taken as soon as excavation and backfill construction work is completed, to prevent the onset of any erosion process before it begins.
- During excavation for foundations, excavated material that can be used for backfill shall be stockpiled close to the trench, at a distance of 2.0 m from the trench.
- When not in immediate use, material stockpiles will be covered and the height and slope will be limited to minimise erosion during rainfall.

- The material that cannot be used to fill the trench, due to its small volume, shall be dispersed on the ground, respecting its original characteristics. The material shall be spread evenly, so as not to produce slopes or unevenness that could increase erosion.
- During the time they remain open, trenches or manholes shall remain marked and fenced. Fences shall only be removed after the base has finished filling the trench with concrete.
- All trenches must have a barrier (such as fixed railings) and clearly displayed warning notices. Flashing lights are mandatory in case of poor visibility.
- When the excavation of the foundations reaches the water table and the trench needs to be drained, the pumped water must first be directed to an accumulation pit for solid retention before being released into the environment.
- The stability and safety of the excavation walls must be permanently inspected. In cases where intensely disturbed materials predominate, the necessary preventive measures must be taken to stabilise the trench walls (e.g. hessian lines, gabions, wooden containments, etc.).
- Backfills and cuttings must receive vegetation cover replanting immediately after implementation.
- Areas with exposed soil should be covered with topsoil stockpiled at the beginning of the activities, so that the presence of mulch and native seed bank favours a rapid re-establishment of native vegetation.
- Cleaning and soil removal of the temporary drainage devices in place shall be carried out on a permanent basis to ensure that they do not lose their function.
- Emergency stabilisation works must be carried out in all areas where erosion processes start to occur.
- In accesses that will remain in the operation phase of the Project, temporary drainage devices will be, as necessary, replaced by final drainage in accordance with the project.
- Storage of hazardous products in trenches shall not be permitted. Equipment located in trenches requiring fuel for their operation shall be gravity fed. Similar devices must be installed in case of additional demands related to hazardous products.
- For any excavation deeper than 1 m, a suitable ladder shall be provided which protrudes a minimum of 1 m above the edge of the excavations.
- Personnel carrying out excavation work must wear PPE.

Specifically for borrowing areas and surplus material depots, the measures to be adopted are:

- Borrow areas and stockpiles of surplus material to be used will have a valid environmental licence.
- In the surplus material depots - DME, unusable plant debris (mainly roots and stumps), as well as inert waste and demolition debris, can be disposed of in a controlled manner.
- Water puddles and low spots should be avoided, which can lead to the formation of environments favourable to the proliferation of disease-transmitting vectors.
- The organic soil layer will be removed and stored on a flat site for later use in the final reclamation of the area.
- Drainage devices shall be installed in each Borrow Area - PA or DME.
- Any occurrence of erosion and sedimentation will require immediate corrective action.
- In the DME, the raising of the backfill will always be carried out in a horizontalisation regime, just as the excavation in the PA must also progress in a horizontalisation regime.
- Excavation in PA must not exceed the limit of 1 m (one metre) above the highest water table.
- Cut and fill vegetation cover shall be anticipated wherever possible.

- After the rain, it will be mandatory to schedule inspections by the construction supervision team.

5.2. Prevention and control of soil contamination

In order to avoid soil contamination by fuels, oils and grease from the use of equipment such as generators, compressors and pumps, various non-degradable chemicals, solid waste and waste water, especially from concreting and washing of concrete mixer trucks, the following preventive measures shall be taken:

- All workers will receive specific spill control training.
- All equipment shall be in good working order and shall not leak.
- Defective or leaking vehicles such as trucks, tractors, etc. shall be removed from the work site or repaired on site after notifying the Environmental Inspectorate, who shall verify the conditions under which the work is carried out. The EPC Contractor shall be responsible for the implementation of good MASS practices on site. In all such cases, temporary leak retention devices, including rustic ones, shall be provided to prevent soil contamination. Oil changes or maintenance activities of construction vehicles and equipment will not be permitted outside the construction camp workshop unless unavoidable. Washing of vehicles and equipment will also be restricted to designated facilities at the camp. The washing facility shall be waterproofed, contained and have a separation/decanting system, ideally with closed loop operation, and with treatment and recirculation of wash water.
- Fixed equipment using fuel (generators, compressors, others) shall always have a dam, tray or other leak containment device with a capacity greater than the maximum possible volume of a leak.
- All lubricants, chemicals or hazardous products shall be stored in impermeable areas with a secondary containment tank in case of spillage.
- All hazardous waste, including empty containers, will also be stored with secondary containment.
- The disposal of solid waste on soils shall be prohibited in order to avoid contamination by organic or chemical substances. Solid waste shall be managed in containers appropriate to its nature, treated and disposed of in a safe manner, as detailed in item **5.8. Solid waste management**.
- In case of soil contamination, the following measures shall be taken: elimination of the source of contamination, scraping of the contaminated soil and collection of the material for disposal as hazardous waste. The measures to be taken shall be included in a **Contingency Plan** to be developed by the Contractors.
- Fuels and lubricating oils shall not be stored at the working face. These will be stored in workshop depots in the construction support facilities. Delivery of equipment will preferably be by truck, but other approved means may be used to transport smaller volumes.
- Chemicals considered hazardous to the environment shall be stored in the workshop or other designated area in the construction support facilities. At work fronts, only a reasonable amount shall be left for immediate use.
- Underground storage of fuels or other hazardous products will not be permitted in the Project areas.
- Emergency kits will be implemented in appropriate locations, with sufficient equipment to handle at least the initial levels of a spill.

- The site area should be properly planned, zoned and signposted to reduce surface disturbance, establishing specific areas for each type of activity such as materials handling (stockpiling, storage, loading/unloading), temporary waste disposal, toilet areas, staff rest areas, etc.
- For effluent management, the measures detailed in item **5.3 Water and effluent management** shall be followed.

5.3. Water and Effluent Management

- Water will be supplied to the construction camp by tanker truck and stored in a tank.
- Each work area shall have adequate sanitary facilities.
- Toilets in the construction camp shall be in good condition and sufficient for the number of workers in the area (at least 1 toilet for every 20 workers).
- The discharge of effluents generated at the Contractors' temporary facilities shall be carried out in temporary septic tanks of adequate size. Subcontractors shall have additional sanitary wastewater treatment facilities, which may be portable WWTPs, chemical toilets, etc., which shall be defined by the subcontractors themselves, who shall be contractually obliged to comply with MASS good practice in the same way as the EPC Contractors. The contractors will provide evidence that the contracted companies have the corresponding environmental permits and that the treatment and final disposal of effluents is carried out correctly.
- If possible, meters will be installed on septic tanks to monitor volumes and prevent overflows.
- Effluent removal will be carried out by third party companies accredited to carry out such work, which must treat the water according to its nature and guarantee a safe final disposal.
- The effluents generated in the water and oil separator box installed in the temporary workshop will be monitored monthly by the Plant Contractor, with verification of compliance with the emission standards for some of the parameters established in Resolution N° 022/2012 and the IFC General EHS Guidelines, adopting the most restrictive ones (**Table 5.3.a of P.01**). The final disposal of the effluents will be carried out by third party companies authorised for this purpose. The discharge of effluents from this system that do not comply with the release standards established by law is prohibited.
- The kitchen and canteen effluent shall have a grease box (siphon box) for the pre-separation of fatty substances.
- The discharge of all types of effluent shall be prohibited outside of the planned facilities and measures mentioned above, including the drainage system of the road located in front of the property.
- The Contractor and subcontractors of the Plant shall develop procedures for the demobilisation of temporary septic tanks upon completion of construction. This will ensure that no contamination of the area occurs during the demobilisation period.

Table 5.3.a of P.01
Effluent discharge limits

Substances, Conditions and Criteria	SEAM Resolution N° 222/2002	IFC General Guidelines	IFC Guidelines on MASS for nitrogen fertiliser production
pH	5 a 9	6 a 9	6 a 9

Substances, Conditions and Criteria	SEAM Resolution N° 222/2002	IFC General Guidelines	IFC Guidelines on MASS for nitrogen fertiliser production
BOD 5d 20° C	<50 mg/L	30 mg/L	
COD	<150 mg/L	125 mg/L	
Temperature	< 40°C, provided that the temperature rise condition is met.		
Receiving Body Temperature Elevation	Not to exceed 3°C		<3 ºC
Settleable matter (1 h test as Immhoff)	1 mg/L		
Mineral Oils	20 mg/L		
Vegetable Oils and Animal Fats	50 mg/L	10 mg/L	
Total Suspended Solids	-	50 mg/L	
Total Phosphorus (P)	4 mg/L	2 mg/L	
Faecal coliforms	4000 NMP/100 ml		
Ammonium nitrate	-	-	100 mg/L
NH_3	-	-	5 mg/L
Total Nitrogen	40 mg/L		15 mg/L
SST			30 mg/L

In the concreting activity, Contractors shall comply with the following measures:

- Temporary and properly marked premises will be set up for emptying the mixer trucks. Accumulated sediments must be periodically removed and properly disposed of in a sanitary landfill authorised for this type of waste.
- Only washing of the nozzle of mixer trucks shall be allowed at the working face. The washing place shall be defined in advance by the Contractors, shall have the necessary conditions to prevent contamination, and drivers shall be instructed to use this place only.
- Mixer truck drivers shall be trained not to empty concrete waste and not to wash the mixer nozzle outside this designated location.
- All wastewater from concreting shall be treated as industrial effluent, and uncontrolled runoff outside the intervention areas shall not be allowed.
- Within excavations to be drained by pumping, wastewater from concrete pouring shall be prevented from being pumped. Such effluent shall preferably be conveyed to segregation basins for subsequent removal and treatment as industrial effluent.

5.4. Control and monitoring of atmospheric emissions

The Contractors shall control the emission of pollutants and the level of airborne dust during all stages of the work. The main measures to control air pollution shall be as follows:

- Dust control in areas with exposed soil where there are houses in close proximity will be done by wetting the soil with water from water tankers, as often as necessary and especially in dry seasons.

- All trucks transporting dry earth outside temporary construction facilities, on roads where houses are in close proximity or on streets in the urban area, shall be protected with tarpaulins.
- Maximum speed limits will apply on unpaved roads during dry or windy conditions.
- In temporary construction facilities, piles of dry materials shall be located in an appropriately delineated area, away from neighbouring residence and areas with a high concentration of workers. When necessary, piles of material or debris shall be wetted during storage and prior to use/destination.
- Raw material loading and storage areas must be protected to prevent the dispersion of particles.
- In high wind situations, dust generating operations shall not be permitted within 200 m from inhabited areas located in the prevailing wind direction.
- The Contractor shall monitor dust conditions at the site on a monthly basis or less frequently during the rainy season. This monitoring shall be limited to the Plant site.
- All construction vehicles and machinery shall be maintained in good operating condition and with engines switched off when not in use.
- Visual emission monitoring (Ringelmann scale) of construction vehicles and machinery shall be conducted at least once a year. Vehicles and equipment emitting black smoke shall be removed for maintenance.
- Appropriate measures will be taken to limit exhaust emissions from construction vehicles and machinery and to ensure fuel efficiency.
- Emissions from motor vehicles shall comply with the limits set out in Villeta Municipal Ordinance N° 18/18 (see **Section 4.2.3** of the ESIA). For emissions from stationary sources such as engines and power generators (to be used only in case of emergency) the amount of fuel consumed shall be monitored and the CO_2 emitted annually shall be calculated.
- The air quality standards to be met are those of SEAM Resolution N° 259/2015, Municipal Ordinance N° 18/18, the IFC General EHS Guidelines and the WHO Global Air Quality Guidelines 2021 (see **Table 5.4.b of P.01**).

Table 5.4.a of P.01
Atmospheric emission limits for continuously operating generators

Atmospheric pollutants		Municipal Ordinance N° 18/18	IFC General Guidelines
$PM_{2,5}$ (mg/Nm)^3	Annual average	-	-
	Average 24 h	-	-
PM_{10} (mg/Nm)^3	Annual average	-	-
	Average 24 h	150	50 to 100 (engine) 50 a 150 50 a 150
O_3 (mg/Nm)^3	Average 8 h	-	100 µg/m^3
NO_2 (mg/Nm)^3	Annual average	-	-
	Average 1 h	-	200 (gas engine) 1,460 to 1,850 (engine) 96 ppm (3MWth turbine to < 15MWth power generation) 150 ppm (turbine 15MWth to < 50MWth mechanical drive) 320 460)

Atmospheric pollutants		Municipal Ordinance Nº 18/18	IFC General Guidelines
			650
SO_2 (mg/Nm)^3	Average 24 h	-	-
	Average 10 min	-	1.5 to 3% S (engine) 0.5% S or less (turbine 3MWth to < 15MWth) 0.5% S or less (turbine 15MWth to < 50MWth) 2,000 o) 2,000 mg
CO (mg/Nm)^3	Average 8 h	-	-

Table 5.4.b of P.01
Air quality standards

Air pollutants		Resolution SEAM N° 259/2015	Municipal Ordinance No. 18/18	IFC General Guidelines	WHO 2021
$PM_{2,5}$ (µg/m)^3	Annual average	15	15	10	5
	Average 24 h	30	30	25	15
PM_{10} (µg/m)^3	Annual average	-	-	20	15
	Average 24 h	150	150	50	45
O_3 (µg/m)^3	Average 8 h	120	120	100	100
NO_2 (µg/m)^3	Annual average	40	40	40	10
	Average 1 h	200	200	200	-
	Average 24 h	-	-	-	25
SO_2 (µg/m)^3	Average 24 h	20	20	20	40
	Average 10 min	-	-	500	-
CO (µg/m)^3	Average 8 h	10	10	-	
	Average 24 h	-	-	-	4,000

5.5. Noise and vibration monitoring and control

- The operation of all mechanical equipment and construction processes inside and outside the camp and work fronts shall not cause any unnecessary or excessive noise, and shall comply with the noise limits established by Law Nº 1100/1997 (Art. 9º) and by the IFC General EHS Guidelines, the most restrictive being adopted (see **Table 5.5.a of P.01** below). For this verification, the following monitoring will be carried out:
  - Monthly off-site ambient noise monitoring at a point located on the neighbouring property. This monitoring will serve to monitor noise levels at the neighbouring dwelling to ensure that levels are consistent with baseline conditions, i.e., there is no impact beyond existing conditions.
  - Occupational noise monitoring at the worksite where equipment, facilities and activities with high emission levels are located. This monitoring shall be carried out by the Contractor to verify compliance with occupational levels and to ensure that workers have adequate hearing protection.

Table 5.5.a of P.01
Noise limits

Land use	Law Nº 1100/1997			IFC	
	Night 20:00 a 07:00	Day 07:00 a 20:00	Day (Occasional peak) 07:00 a 12:00 14:00 a 19:00	Night 22:00 a 07:00	Day 07:00 a 22:00
Residential areas, specific use areas, public spaces: recreational areas, parks, squares and public roads.	45	60	80	45	55
Mixed areas, transition areas, town centre areas, specific programmes, service areas and public buildings.	55	70	85	-	-
Industrial area	60	75	90	70	70

- Measurements should be made when the equipment emitting the highest noise levels, such as concrete mixers, circular saws, pile drivers, generators and others, are in operation.
- A sound level meter with statistical data analysis shall be used for the measurements. The equipment must have a Calibration Certificate from an accredited laboratory.
- The minimum duration of the measurement shall be 20 hours or 24 hours, and may vary depending on the diversity of sources in the environment that make up the ambient noise.
- Contractors shall prioritise the choice of equipment with low noise levels.
- The Contractors shall carry out regular maintenance of vehicles and equipment to eliminate mechanical malfunctions and control noise emission. In maintenance, priority shall be given to the adjustment of machines and parts that produce excessive noise and vibration, such as compressors and breakers.
- Work near the neighbouring dwelling shall be carried out within limited hours, keeping activities between 7am and 5pm, if possible. In any case, noise-generating activities near the neighbouring dwelling shall be completed as soon as possible, communicated and recorded in advance.
- Equipment with excessive noise and vibration emissions in construction support facilities shall be located as far as possible from dining and administrative areas and the neighbouring residence (more than 200 m), and shall be surrounded by noise barriers where necessary.
- Prior to the works, a precautionary inspection will be carried out in the neighbouring house to record its condition prior to the works, in order to be able to compensate the owner for any possible damage caused by vibrations resulting from the works activities.

It should be noted that occupational noise monitoring falls within the scope of **P.04 - Occupational Health and Safety Programme in the Construction and Operation Phases**. For this purpose, the EPC Contractor shall implement hearing protection equipment in accordance with international good practice.

5.6. Monitoring of vegetation clearance activities

- Vegetation removal and land clearing will be limited to the areas strictly necessary and declared in the ESIA, and will be conducted in such a way as not to disturb the vegetation adjacent to the cleared perimeters.

- After the completion of the germplasm rescue and wildlife removal and rescue activities (see **P.08 - Flora and Fauna Impact Prevention Programme**), the Contractor contracted to carry out vegetation removal on the Plant site, in the water catchment area and along the water supply pipeline and LT service strip, shall pre-delineate the removal polygons with suitable material to allow quick visualisation by the implementation teams. The Contractor must submit a photographic record of the situation of the local landscape and the delimitation prior to the clearing and vegetation clearing actions, especially of the conservation area known as "Zone C". ATOME will negotiate compensation with the local authorities, in compliance with IFC ND6.
- If vines, creepers and other similar plants are observed before trees are felled, they should be cut before further removal. A clump of creepers on trees may cause unwanted trees to fall, resulting in the expansion of the clearing area and injury to workers.
- The removal of the felled material shall be done through the authorised intervention area and never passing through the remaining vegetation.
- Wherever possible, the use of tractors in clearing is only permitted where there is more than 10 metres from the boundary of the clearing area. Otherwise, chainsaws shall be used. Root removal in such areas, where necessary, will only be carried out later and may involve the use of tractors.
- All areas that are considered environmentally sensitive within the clearing perimeters will be delimited and marked in advance, and will be cleared with chainsaws, without the use of tractors.
- Fallen vegetation will continue to protect the ground in the cleared areas until construction equipment is ready to begin earthworks. At that time, fallen vegetation will be removed and trees will be uprooted.
- Clearing will begin at the edge of the area to be cleared, with the use of chainsaws and tree felling control. The use of tractors will be allowed for the rest of the clearing perimeter, subject to the prior measures of germplasm rescue and wildlife scaring and rescue mentioned above.
- The cleared vegetation will be used as much as possible in the works, and some of it can be donated to the neighbouring landowner, if this is in his interest.
- Pruned or cleared vegetation that does not constitute commercial timber shall be used according to its characteristics, either as timber stakes, preliminary protection works, erosion control, camp fencing, and other construction uses.
- If the timber is to be used for commercial purposes, it should be considered that the transport and marketing of timber and other forest products require permits issued by the National Forest Service, according to Law N° 342/95.
- Non-commercial timber, as well as large branches, could be cut to sizes suitable for sale to industries or other establishments using them in boilers or other applications.
- Tree roots, branches and leaves will be buried in the areas of excess soil deposits, after undergoing proper compaction and backfilling with soil before overburden is placed on top.
- The use of fire for vegetation suppression shall be strictly prohibited.
- An area must be designated for the stacking of the trees that will later be used. Also, the bush vegetation removed must be designated and properly disposed of in such a way that it does not constitute a potential source of fires or encourage their spread.
- Where possible, alternative uses for the biomass to be generated will be evaluated and implemented. The overburden will be removed from cleared areas using equipment that allows only the organic horizon to be extracted, without mixing it with the underlying material. The soil or organic material removed in this way will subsequently be used in the

reclamation of areas degraded by the works. The remaining organic soil that is not usable will be taken to the surplus soil deposit areas.

- The organic mulch (topsoil) to be used in reclamation at the completion of construction shall be collected and stockpiled in piles along the edge of the cleared areas. Temporary piles of excavated or cleared soil shall not be located in the flow of precipitation. All soil piles shall be surrounded by containment berms to prevent surface runoff from soil piles from occurring. The containment berms shall be constructed of soil sufficiently permeable to allow the passage of surface runoff water, but trapping the sediment contained in the surface runoff.

5.7. Management of temporary facilities/construction camp

- In the construction camp, sanitary control, cleaning and monitoring of hygienic conditions, with emphasis on toilets, changing rooms and canteen, should be in place.
- The camp will have a rainfall drainage system to control run-off, consisting of an interconnected perimeter system of ditch channels and grease traps. Periodic cleaning of drainage system components will be implemented.
- The area designated for parking vehicles and machinery shall be signposted and delineated to allow manoeuvrability for operators. Vehicles shall be parked in reverse.
- Water for human consumption will be supplied from a source that ensures the quality of service and potability, according to the recommendations of the World Health Organisation (WHO).
- Drinking water troughs shall be distributed in all work areas of a company that ensures the quality of drinking water, if this is not the case, the Contractors shall verify with a minimum of 10 monthly samples the quality of the water provided for consumption.
- Wastewater from toilets, kitchen, dining room and other areas of the construction camp will be directed to a septic tank, which will be periodically monitored to detect any infiltration or saturation problems.
- The kitchen effluent will pass through a grease trap before being directed to the septic tank. Grease shall be periodically removed, separated and sent to a suitable destination (approved company or landfill).
- At construction sites further away from the camp, portable (chemical) toilets supplied by a specialised company may be used, which will routinely remove the waste and transport it to an authorised disposal site. The company contracted for this service will comply with existing regulations. A minimum of one chemical toilet for every 20 workers will be implemented.
- All waste generated at the work fronts and construction camp will be sent to the central waste disposal facility at the camp, where it will be segregated for proper disposal.
- The camp workshop will be installed on a waterproof, covered surface and all work areas will have perimeter drainage leading to oil and grease traps.
- Washing of equipment and machinery shall be restricted to a specific area in the camp that is watertight and drains to a grease and sediment interceptor.
- The camp will not have a fuel storage area or concrete batching plant.
- For storage of chemicals, hazardous waste and potentially contaminating material the camp will have a special storage facility, which will have an impermeable floor and concrete berm to provide secondary containment. Adequate ventilation shall be ensured at all times. The depot will be locked and only authorised and trained personnel will be allowed entry. All product safety data sheets shall be available and organised at all times.

- The lubricating oil residue separated in the siphon decanter box shall be stored in suitable containers for subsequent delivery to a specialised company.
- For the management of solid organic waste within the camp, heavy duty plastic bags must be provided and placed in dustbins with lids in sufficient quantity. The collection shall be carried out by companies duly authorised for this purpose and shall guarantee that the final disposal of the waste is carried out appropriately.
- Emergency power generators will receive regular preventive maintenance to ensure proper operation and control emissions from the combustion system.
- Generators shall be located in covered and ventilated areas, on confined surfaces that prevent soil contamination in the event of fuel spillage during refuelling or maintenance activities, or due to system failure.
- Generators, as well as other noise sources, shall be as far as possible from the canteen and administrative areas. In addition to maintaining a minimum distance from these areas, the Plant Contractor shall conduct noise monitoring as specified in **Section 5.5.**
- All stationary equipment using fuel and lubrication systems shall be installed with secondary containment to prevent soil contamination in the event of a possible fuel or lubricant spill.
- Fire extinguishers will be placed in all storage areas for lubricants, chemicals and other hazardous substances, as well as in the administration building, kitchen, canteen and infirmary.
- Generator areas and generator fuel storage areas shall be provided with all elements to ensure the safety of the installations, fire prevention and fire control.

Labour aspects of construction camp operation

- Toilets, kitchen, dining room, infirmary and other facilities in the construction camp must comply with the Paraguayan Labour Code and the standards set out in the IFC's *Workers Accommodation: Process and Standards.* Hotel accommodations and flats in Asunción or Villeta rented to accommodate non-resident workers must also meet these specifications.
- Any work area in the camp must have access to toilets (with a toilet and sink) within 100 metres, separated by gender.
- The temperature in the camp facilities should be around 20° C, with adequate ventilation.
- The dining hall and administrative areas will have insect repellent treated screens on all windows and main entrances.
- Special cleaning procedures (fumigation or similar) shall be carried out, when deemed necessary, using products permitted by law. Products prohibited internationally shall not be used and the requirements of IFC ND 3 (paragraphs 14 to 17) shall be complied with.
- Fire prevention devices should be installed in all areas of the camp, at points where they can be reached quickly.
- Power generators will be installed as far away as possible from the canteen and administrative areas and will be fenced with noise barriers, if necessary, to comply with established noise limits.
- The camp will be fenced and will have a restricted main entrance with access and control registers.

Minimum requirements to be included in camp operating standards

- Arrival and departure times will be determined by the Contractors, in mutual agreement with ATOME. Working hours shall be in accordance with the national labour code.

- All Contractors' and Subcontractors' workers shall wear an identification badge and uniforms in good condition at all times when in the camp or work face.
- The Project's Code of Conduct will be distributed to all workers in writing and in training and will have contractual force, and any conduct in breach of the Code of Conduct will not be permitted. Failure to comply with the Code of Conduct may result in sanctions depending on the severity of the violation, including contractual termination or even activation of the police.
- The keeping of domestic animals is not permitted in the construction camp.
- Legally permitted products of low toxicity to humans must be used for pest control to prevent the spread of diseases in the construction camp. Internationally banned products should not be used and the requirements of IFC ND 3 (paragraphs 14 to 17) should be complied with.
- The conscious and economical use of water and energy will be promoted.

5.8. Waste management solid waste

- Waste management strategies shall be based on the following hierarchy: prevention and minimisation, sorting and reuse, and treatment and disposal in accordance with relevant legislation and good practice.
- All rubbish and general waste shall be cleared from all work areas on a daily basis.
- All waste generated at the work fronts and construction camp will be sent for sorting according to Art. 8º of Decree Nº 7391/2017 at the Camp Waste Central, where it will be packaged and stored, except for organic waste and non-recyclable common waste, which will be sent directly to a landfill. At the Waste Centre, the waste will be deposited in colour-coded collectors, as indicated below:
  - Brown: Organic waste;
  - Black: Wood;
  - Red: Clean recyclable plastics;
  - Yellow: Scrap metal;
  - Blue: Clean paper and cardboard;
  - Green: Clean glass;
  - Orange: Contaminated material (hazardous waste);
  - White: Health care waste, nursing waste;
  - Grey: General non-recyclable or mixed waste.
- The area works with EMAASA, which collects and disposes of waste in a sanitary landfill in the city of Villa Hayes.
- The storage conditions at the waste facility will depend on the characteristics of the waste. Some waste may simply be stacked on the ground, while other waste will be in covered containers, installed within impermeable areas with secondary containment. The Waste Centre will be fenced and only authorised and properly trained personnel will be allowed to enter.
- Non-inert materials, such as wood, glass, plastics, steel and metals, will be recycled as far as possible, and if recycling is not possible, then the waste will be sent to landfill.
- Recyclable waste may be donated to NGOs for social purposes or sold to authorised companies.
- Contaminated construction aggregates shall be considered hazardous waste and shall be disposed of as such.

- Waste paint, lubricants and oils will be classified as hazardous waste, and special controls will be imposed to regulate their storage, labelling, transport and disposal. All empty chemical containers and maintenance workshop waste soiled with oil and grease will also be considered as hazardous waste, as will contaminated soil.
- Septic tank sludge will also be treated as hazardous waste.
- All hazardous waste will be stored with secondary containment in accordance with the Hazardous Materials Management procedure (**Section 5.9**).
- Hazardous waste will be stored at the construction camp in a covered, waterproofed and enclosed area.
- Used lamps shall be separated from other waste.
- The transport of hazardous waste will require the contracting of a registered and licensed solid waste service provider. This company must have appropriate vehicles and trained personnel for this type of service, as well as the necessary equipment in case of possible emergencies. The company must have the necessary permits and licenses for the collection and transportation of hazardous waste and must carry the permit document at all times.
- Hazardous waste will be sent to industrial landfill or to duly authorised companies for treatment.
- Ordinary non-organic and non-recyclable waste (plastic plates, containers and cutlery with food waste, napkins, toilet paper) will be disposed of in the landfill.
- Used engine oils and lubricants shall be stored in properly sealed drums in a separate and identified area of the Central Waste Facility, which shall contain a secondary containment tank in case of oil spillage or leakage. An authorised waste disposal and/or recycling company shall collect the oil on a regular basis. The same procedure shall be adopted for oil and grease removed from grease traps.
- Drums with lids will be placed at all construction sites. Workers will be trained in waste sorting and will dispose of the waste in the sorting bins at the Waste Centre.
- Waste shall not be allowed to accumulate at construction sites. Waste shall be transported to the Central Waste Disposal Facility as often as necessary.
- The Contractors shall keep detailed records of all waste generated by type and entered into the Central Waste Facility, and of all waste sent to authorised recyclers/transporters. The loading manifests shall constitute evidence of the dispatch of the waste to the authorised waste handlers.
- Burning of waste shall not be permitted anywhere on the project site.

5.9. Handling of hazardous materials

- A continuous assessment of the level of risk posed by the management of hazardous materials used on site shall be carried out. The assessment shall consider: i) Name and description of the material, ii) Classification, iii) Maximum allowable quantity, iv) Quantity used per month, v) Characteristics that make the material hazardous, vi) Study of possible spill and release scenarios using available industry statistics, vii) Study of the possibility of uncontrolled reactions such as fires and explosions, viii) Study of the possible consequences depending on the physical and geographical characteristics of the project site. The assessment will be carried out through accepted methodologies such as HAZOP and HAZID, which are studies to be carried out for the Project.
- Written standard operating procedures will be prepared for filling containers, equipment, tanks, as well as for transport operations.

- Written standard procedures shall be prepared for the handling of secondary containment structures, specifically the removal of accumulated fluids, such as stormwater, or spills in the containment structure.
- Machine and equipment operators will be trained in spill/leak prevention and contingency response.
- All fuel, lubricant, chemical or hazardous product storage areas shall be covered and watertight, and have secondary containment tanks in case of spills / leaks. The secondary containment capacity shall always be at least 20% greater than the capacity of the largest container within the area.
- Chemicals, fuels and lubricating oils shall be stored in the camp, and a specific area shall be marked for this purpose. Only a reasonable amount shall be left at the work fronts for immediate use.
- Refuelling of vehicles and equipment should preferably be done by truck or using appropriate containers.
- Fixed or mobile equipment (generators, compressors or other) using fuels or other hazardous products shall always have a leakage containment tray.
- No oil changes or vehicle maintenance activities will be permitted outside the camp workshop, except where unavoidable. Washing of vehicles and equipment will also be restricted to the designated vehicle wash ramp at the camp.
- The ramp and other areas of the workshop for equipment maintenance services will have a cover and impermeable floor with a perimeter channel to collect spilled liquids. A siphon box shall also be provided for the separation of water and oil, with subsequent disposal of oil through suction trucks or appropriate devices, for subsequent destination for refining or appropriate final disposal.
- In case of repair of equipment/vehicles outside the workshop, temporary leakage retention devices, including rustic ones, shall be provided to avoid soil contamination.
- Hazardous materials shall only be used in accordance with the instructions given in a Safety Data Sheet which shall be available in all hazardous product storage areas and at construction sites when hazardous products are being used.
- Chemicals shall preferably be stored on wooden pallets and kept at least 1 metre away from the tank walls. Stacking limitations shall comply with manufacturers' instructions. Compatibility between products shall be checked and any product that may react chemically in case of mixing shall be stored at a distance. The space between product containers must allow, in case of leakage, the identification of the container with the leakage without the need to touch or manoeuvre any object.
- Storage sites shall be appropriately marked and/or identified.
- Appropriate fire extinguishers shall be placed in all storage areas for hazardous products.
- No repairs shall be carried out in the chemical store unless all explosive and/or flammable materials have been removed.
- No open fires, smoking, or localised heat of any kind shall be permitted near chemical/hazardous product storage areas.
- Mixing of chemicals shall be done outside the storage areas.
- A programme of inspection of storage containers and containment systems for rust, corrosion, cracks and leaks will be implemented.
- A chemical register shall be kept.
- Gas cylinders shall be stored away from direct sources of localised heat or flammable sources. Empty gas cylinders shall be stored with closed valves and shall always have safety

caps and shall not be exposed to any direct light. Gas cylinders shall not be lifted by the valve cap. Trolleys shall be used to transport gas cylinders to and from storage areas.

5.10. Construction traffic control

- All Project vehicle drivers will comply with Paraguayan driving requirements.
- Contractors shall require a "defensive driving course" for all workers and drivers.
- Project transport vehicles will not be used to transport local residents, except in the case of medical emergencies.
- Project transport vehicles shall not be used to carry more passengers than their estimated maximum load.
- On National Route PY19 or other accesses used by Contractors' and subcontractors' vehicles, if necessary or at the request of the community, speed bumps shall be installed, with appropriate signs, in accordance with Paraguayan traffic legislation.
- During the dry season, internal site entrances will be dampened to control dust emission.
- All drivers of construction vehicles will be instructed to use only the routes provided for the Project, to observe the stipulated speed limits and to strictly follow the instructions on the signs.
- All construction vehicles will have a tachograph and radio, and will be in constant contact with the logistics control at the construction camp. All journeys will be recorded in the appropriate form at the start of the journey, indicating destination, route and estimated time of arrival.
- All construction vehicles shall operate under optimum maintenance and safety conditions. The Contractor's Environmental Team shall require the removal of vehicles or equipment with excessive noise generation, black smoke emission or oil leaks.
- In coordination with the municipality and the Roads Authority, signage will be installed in the area at or near the entrance to the construction site, where Project activities may affect the normal flow of vehicles.
- If an accident occurs within the project site, all traffic will be interrupted. If necessary, first aid will be provided and medical assistance will be called. In case of serious life-threatening injuries, an ambulance will be called to the scene of the accident, in addition to the police. Any traffic collision resulting in non-life-threatening injuries shall be reported immediately to the police.
- Vehicles that have failed or are involved in minor collisions without casualties, provided they are at the entrance to the works site, will be temporarily moved to the side of the track as soon as possible after observing the details of the collision site. Details of all incidents will be reported to the police. All vehicles, machinery and heavy equipment will meet noise standards in accordance with the Noise Management procedure (**Section 5.5**), and will be fitted with silencers if necessary. Any accidents occurring on the road or other public roads will be the responsibility of the national authorities.
- As a measure to avoid the running over of wild animals, warning and environmental education signage will be installed, in coordination with the municipality and the Roads Department , in the area of access to the works site (to be evaluated beforehand, taking into account where the greatest risk exists, such as passing through areas with a high concentration of native vegetation on the edges of the road, crossings of watercourses, etc.). This signposting will be aimed both at workers on the worksite and at road users. Although this signage will be in place during construction, it will be maintained after completion of the works and incorporated into the normal road signs. The signs may contain

phrases such as the following: "Respect the speed limit"; "Take care when driving during twilight hours when animals are most active"; "Reduce speed when driving near watercourses".

- Periodic maintenance of vehicles, machinery and equipment will be carried out to ensure good synchronisation and calibration. Emissions will be monitored visually (Ringelmann) and any vehicle generating excess emissions will be removed for maintenance. Emissions for large vehicles and equipment will be measured annually.
- The movement of equipment or machinery such as backhoes or crawler tractors on main or secondary roads will be done by low loader trucks.
- Overloading of trucks during the movement of machinery and equipment shall be avoided. Exceptions are the oversized loads already indicated in **Table 2.3.6.d**. Where this is not possible, due to the shape or dimensions of the load, appropriate signage shall be provided, indicating whether the load is long, heavy or wide. Where required, authorisation shall be sought from the appropriate authority.
- Appropriate temporary signage shall be implemented for the release of the cables at the road crossing point. This procedure shall be carried out only once and for a few hours.
- Coordination with the municipality and the Road Directorate will be carried out and the necessary permits will be obtained prior to cable laying activities.
- Dumpers transporting construction materials, surplus excavated earth, cleared vegetation and solid waste or rubble shall be covered with tarpaulins or tarpaulins so that the material is protected from source to final destination.
- A limit of 25 km/hour shall be set as the maximum speed, or a lower speed to be determined by the Contractor, for vehicular traffic in the areas adjacent to the site entrance, driveway and internal roads. Speed limits on other streets or roads shall constitute those limits for each road as defined by the national authorities.
- Damage or deterioration of public roads will be reported to the ATOME EHS Management Team in a timely manner and processed through the complaint handling mechanism of **P.03 - Stakeholder Engagement Programme**.
- The Contractors shall obtain the prior approval of the local authorities for signage and in cases of need to close or restrict access to any road or urban street and for transport of oversized loads.
- Before works commence, Contractors must inform the ATOME HSE Management Team of the expected volume of construction vehicle traffic and the routes to be used.

5.11. Promotion and development of local suppliers

Through this measure, it is intended to maximise the purchase of inputs and contracting of services for the works and operation of the Project from local suppliers, contributing to boosting the economy of the Project's area of influence.

<u>Identification and dissemination of demands that can be supplied locally</u>

Prior to commencement of the works, the Contractors shall identify materials, inputs and services that can be supplied locally. Companies supplying inputs and services used in the works shall have an environmental licence.

The following is an illustrative list of goods and services that may be subject to this measure:

- Construction services:
  - Construction of civil works in conventional masonry;
  - Execution of piles;
  - Concrete supply;
  - Supply of construction materials (crushed stone/gravel, sand, clay, cement, bricks, tiles, etc.);
  - Supply of shackles for excavations;
  - Supply of electrical equipment;
  - Supply of hydraulic material.

- Marketing/distribution services:
  - Stationery/office supplies;
  - Fuels;
  - Gas;
  - Cleaning materials;
  - Foodstuffs.

- Operational services:
  - Accommodation services;
  - Transport services;
  - Health services, including hospital care;
  - Property surveillance services;
  - Mechanical and electrical workshop services;
  - Machinery and parts manufacturing services;
  - Food services;
  - Tanker truck services;
  - Effluent and sludge collection and disposal services;
  - Cleaning services;
  - Recyclable waste companies;
  - Special and contaminated waste disposal services.

The dissemination of the list of locally procured inputs and services will be done with the support of P.03 - Stakeholder Engagement Programme. The lists will be distributed in the municipality, in large commercial establishments, among other places.

To help identify potential suppliers for the project, lists of registered industries and businesses in Villeta are included in **Annex 15.**

The goods and services to be procured locally will be defined and listed in a formal document (Local Procurement List), which will constitute the initial target of the programme. Initially, the quantities/volumes highlighted for procurement/contracting may represent only a part of the total consumption foreseen for the Project. However, local procurement of the total demand for these goods and services is set as a medium-term objective of the measure.

The Contractors will develop criteria for the selection and contracting of local suppliers. During construction, ATOME will verify compliance with these criteria.

Register of existing local companies with the potential to supply goods and services to the Project.

The evaluation of local companies and suppliers will be an ongoing activity of the measure.

A Unified Register of Local Suppliers will be created, in which local companies identified as having the potential to supply any item on the Local Procurement List will be registered. The Register will mainly collect information on technical capacity (human resources, machinery and equipment, facilities, production capacity, etc.), financial situation and market (customers, geographical distribution).

Definition of the procedure for the selection and contracting of local suppliers

The selection process of potential local suppliers of goods and services will start with the adjustment of the basic procurement parameters and subsequent announcement of the intention to procure, supported by P.03.
Suppliers must present their legal regularity and comply with basic procurement parameters in relation to the goods and services to be procured, including adequate quality, availability and quantity required, and competitive prices.

Regular dissemination of the Local Procurement List

With the support of the P.03 team, the local supply contracts offered and the updated Local Procurement List will be disseminated on a quarterly basis. The team responsible for the measure will be organised to respond to enquiries from potential interested parties, received through the channels offered in P.03.

5.12. Restoration of areas degraded by the works

- All construction camp infrastructure will be dismantled at the end of the works, and its final state will depend on the intended use of the area (landscaped area or other facility foreseen in the project).
- All areas used for the storage of chemicals or other hazardous products, as well as the machinery and equipment washing area, shall be inspected for contamination. If necessary, contaminated soil will be removed and treated.
- All debris, contaminated materials and other waste such as concrete, wood, siding, plastics, equipment and general tools will be removed from the areas to be reclaimed. All waste resulting from clean-up and demolition activities will be sent to landfill or other appropriate disposal sites with all relevant permits and authorisations.
- Cleaning of the drainage system will be carried out at all construction sites.
- Final inspection of the septic tank and its deactivation by cleaning, disinfection using lime and filling with firm material for soil stabilisation will be carried out.
- Areas directly affected by excavation and earthworks, and which will not be occupied by permanent Plant facilities, will receive surface protection from rain and runoff. Surface protection activities may include the application of topsoil and the planting of grass and/or other native plants, primarily those native to the site. The protection provided by the planted vegetation should be sufficient to protect the soil against climatic agents and minimise soil loss through erosion. Verification of the success of vegetation restoration

activities, in the areas that fall under the Project design, will be carried out until complete consolidation.

- Existing road sections damaged by the works will be restored. These sections will be returned to normal conditions, compatible with their situation before the start of the works. Construction signage will be removed, reinstalling or restoring normal signage where appropriate.
- Perimeter tree planting of the ATOME site will be carried out in order to mitigate the visual impact and serve as a barrier between the neighbouring property/properties.

The demobilisation of construction fronts and the recovery of degraded areas will be supervised by the ATOME Monitoring Team, as part of **P.02 - Environmental and Social Management Programme**.

6. Effectiveness Indicators

The following indicators are proposed for monitoring the implementation of this Plan:

- Number of drainage devices implemented in relation to the total erosion risk areas mapped on the site;
- Areas of exposed soil reclaimed in relation to total areas of exposed soil on site;
- Evidence of regular maintenance of vehicles and equipment;
- Evidence of availability of emergency spill kits at all premises at risk of contamination;
- Evidence of installation of secondary containment tanks in storage areas for fuels, lubricants, chemicals or other hazardous products;
- Evidence of installation of secondary leak containment tank on all equipment using fuel or oil;
- Number of workers trained in the prevention and response to leaks and spills of hazardous materials in relation to the total number of workers employed;
- Certificate of final destination of septic tank sludge or portable toilets;
- Number of oil and water separator box effluent samples that comply with the limits of Resolution N° 022/2012 in relation to the total number of samples taken;
- Evidence of lime stabilisation of septic tanks to be demobilised;
- Periodic inventories of the types of waste generated at work sites and construction camps and waste transport manifests;
- Amount of solid waste destined in relation to total waste generated;
- Number of complaints related to construction traffic registered through the P.03 Complaints Handling Mechanism;
- Number of accidents involving construction vehicles;
- Number of areas reclaimed in relation to total areas degraded by the works;
- Evidence of installation of fire prevention and fire fighting devices;
- Evidence of black smoke emissions monitoring at the required periodicity and number of vehicles and equipment monitored in relation to the total;
- Dust level monitoring results;
- Number of equipment complying with the black smoke emission limits in relation to the total number of measurements performed;
- Evidence of monitoring of fuel consumed by stationary sources and number of monitored equipment in relation to the total;

- Number of equipment complying with the emission limits for stationary sources established by Municipal Ordinance N° 18/18 in relation to the total number of measurements carried out;
- Environmental noise levels recorded at the construction site and neighbour's property; Number of complaints related to construction noise recorded through the P.03 Complaints Handling Mechanism as well as complaints of other natures such as number of complaints from neighbouring residents due to construction related discomfort (dust, vibrations, traffic or workers' behaviour);
- Evidence of water potability monitoring at the defined periodicity and number of samples taken (if water is provided by the Contractor) or purchase invoices for bottled drinking water;
- Number of samples complying with the potability limits set by the legislation in relation to the total number of samples taken (if the water is supplied by the Contractor);
- Demonstration of the environmental regularity of the construction camp and other support areas;
- Evidence of perimeter tree planting;
- Number of non-conformities (NC) recorded through the Environmental and Social Management Programme (P.02);
- Number of non-conformities (NC) corrected within the established timeframe;

7. Reports

Contractors shall prepare monthly reports containing documents, information and evidence of adoption of all environmental control measures and procedures contained in this Programme, including monitoring results. The report shall contain the following:

- Air pollution control:
  - evidence of dust emission control;
  - evidence of measurement of vehicle emissions;
  - evidence of preventive and corrective maintenance to reduce black smoke emission;
  - results of fuel consumption monitoring and calculation of CO emissions$_2$ from stationary sources.

- Soil and water pollution control:
  - quantification and evidence of implementation and maintenance of soil and water pollution control equipment, such as septic tank, oil and water separation systems, grease separation box;
  - Evidence of measures taken in case of spills with soil contamination;
  - Results of water potability monitoring (if water is provided by the Contractor) or purchase invoices for bottled drinking water.
- Solid waste management: waste inventories and quantification and testing of waste collection, segregation, storage, transport and disposal manifests.
- Environmental regularity: operating permits, environmental licences under the responsibility of the Contractors.
- Recording of access maintenance actions and information on the state of conservation of streets and roads used by construction vehicles, until the effective termination of their use.
- Summary of the progress of construction activities, highlighting the activities of most interest for environmental monitoring;

- Data related to local worker recruitment and worker training activities for **P.05 - Labour Management and Working Conditions Programme**, indicating:
  - Number of workers hired, specifying the percentage of local hiring;
  - Number of female workers and other sexual minorities hired, in relation to total number of hires;
  - Records and evidence of training provided to contracted workers (attendance list, photographic record, among others);
- Data related to the training of workers, for P.05:
  - Number of workers trained for prevention and action in situations of leaks and spills of hazardous products;
  - Number of workers trained in environmental and social education modules in relation to the total number of workers hired;
  - Number of workers trained on the content of the Code of Conduct.
- Records of reclamation activities in degraded areas;
- Records of complaints/suggestions received through the Contractors' specific complaints mechanism and responses thereto, for P.03;
- Number of accidents, investigations and corrective actions;
- Record of vegetation suppression control measures, indicating:
  - Chainsaw licences;
  - Records and evidence of chainsaw operator training;
  - Summary of progress of vegetation clearance activities and fate of timber.

8. Implementation Schedule

The Environmental Construction Control Programme will be implemented throughout the works phase and assembly of the Project.

The periodicity of monitoring is indicated in each of the measures in **Section 5.0.**

P.02 - Environmental and Social Management Programme of the Construction Phase

1. Justification of the Programme

The implementation of the Project requires the implementation of measures to avoid and/or minimise the possible physical, biotic and socio-economic impacts derived from its implementation.

The Environmental and Social Management Programme (P.02) will be a tool for ATOME to have full control over the activities carried out by the Contractors, subcontractors and suppliers during the construction phase, following the schedule of works and the implementation of prevention, mitigation and control measures established in the ESMP.

It is also justified by the need to mitigate and/or compensate for impacts arising from the establishment of the easement strip.

2. Main Objectives

The main objective of the Environmental and Social Management Programme is to guarantee the environmental and social quality of the area where the Project is located, through the integrated management of all the Programmes of the ESMP and the actions proposed for the prevention, mitigation, control and compensation of the environmental and social impacts for the construction and assembly phase.

In addition, the Programme has the following specific objectives:

- Ensure that all construction activities, including civil works and erection, are carried out in accordance with best practice environmental and social control;
- Ensure that work starts only after all necessary licences and permits have been obtained;
- Monitor the progress of all ESMP Programmes and propose adjustments and/or improvements to environmental, social and health and safety measures as necessary during construction;
- Ensure that documentary evidence of the proper implementation of each environmental, social and health and safety commitment is available;
- Ensure the disclosure and correct understanding of all relevant environmental and social commitments and/or control measures with those directly and indirectly responsible for the construction and assembly process of the Plant, LT and water supply and effluent discharge infrastructures;
- Monitor and manage environmental and social impacts and/or risks and control actions or activities that generate these impacts and risks;
- Ensure that any changes to the Project take into account environmental, social and health and safety aspects and impacts;
- Avoid or minimise project-related greenhouse gas (GHG) emissions;
- Coordinate the process of interaction with the Ministry of Environment and Sustainable Development (MADES) and other institutions regarding the environmental and social aspects of the Project and with civil society in general;
- Ensure full compliance with all requirements established by MADES;
- Survey the property, improvements and land use types intersected by the easement strip, inform the affected landowner of the criteria and procedures adopted for compensation and land use restrictions, and institute the easement strip.

3. Applicable Legislation

All Paraguayan legislation related to the environmental licensing process, as set out in **Section 4.1** of this ESIA, and any specific legislation associated with each Programme of this ESMP that will be coordinated through this Programme P.02, applies.

From the applicable legislation, Resolution No. 201/2015 stands out, which establishes the need to periodically submit Audit Reports on compliance with the Environmental Management Plan to the General Directorate for the Control of Environmental Quality and Natural Resources (DGCCARN) of the Secretariat of the Environment (SEAM). For the Project, the environmental licence establishes an annual periodicity for the Audit Reports.

Law N° 6681/2020, which amends Law N° 976/1982, also applies. According to its Art. 1, the safety and service zone for 220,000 volt transmission lines is a distance of 50 m, 25 m measured on each side of the axis. Law No. 966/1964, in turn, establishes that, in the case of easements on private property, an electroduct easement may be established, which shall consist of the right to cross third party property (Art. 76). The personnel of ANDE will be authorised to access the easement of the TL to carry out construction and maintenance work, as this is foreseen in the agreement established between ATOME and the affected parties.

4. Responsibilities

ATOME will have an Environmental and Social Management Programme (P.02) and will have a team of professionals in the environmental, social and health and safety areas, or will contract a specialised consultancy firm for the supervision and environmental monitoring of the works.

This team to be formed by ATOME will be called the ATOME HSE Management Team in the course of this ESMP.

These are responsibilities of the ATOME HSE Management Team:

- In conjunction with Contractors and subcontractors, devise strategies and/or measures that can improve control over environmental, social and health and safety aspects and contribute to the improvement of the social and environmental performance of construction;
- Review and approve the Plans and Programmes that will form part of the Contractors' Environment, Health and Safety Management System;
- Coordinate relations with the population of the area of influence and other stakeholders, appropriate prevention, mitigation, control and monitoring measures as specified in the Construction Environmental Control Programme and the proper management of the enquiry and complaint handling system;
- Conduct environmental, social and health and safety performance audits, including that required by Resolution N° 201/2015, further reviewing related documentation, monitoring the results of ESMP Programmes under the Contractors' responsibility and verifying the adequacy of environmental, social and health and safety management and staff;
- Attend construction planning meetings as necessary to ensure that specific impacts and risks associated with future activities are adequately identified and that the full list of applicable mitigation and control measures is implemented in advance;
- Carry out site supervision to verify compliance by Contractors and subcontractors with all commitments contained in the Construction Environmental Control Programme (P.01);
- Organise all environmental, social and health and safety monitoring documentation in a database;
- Request corrective actions where relevant and monitor their implementation;
- Ensure that Contractors produce adequate documentation of impacts resulting from third party actions as necessary to clearly establish the limits of ATOME's liability;
- Know the environmental, social and health and safety legislation related to the Project;
- Monitor the overall construction schedule, identifying any necessary permits or authorisations from MADES or other institutions;
- Participate in inspections and meetings with government authorities responsible for environmental, social and health and safety issues and respond to requests from authorities regarding the construction process;

- To estimate GHG emissions for the construction (with input from the Contractors) and operation phases of the Project, using internationally recognised methodologies;
- Prepare simplified environmental, social and health and safety compliance reports, documenting the progress of works,
- Supervise the implementation of the ESMP Programmes and measures that are the responsibility of the Contractors and the measures executed by contracted teams of experts.

5. Implementation Methodology

5.1. Organisation and equipment

As mentioned above, for environmental, social and construction health and safety monitoring, ATOME will either have its own HSE Management Team or will contract a specialised consultancy firm for this function.
ATOME's HSE Management Team will monitor contractors and subcontractors involved in the construction of the Project, verifying compliance, requesting corrective measures and helping to design appropriate strategies and technical solutions to control environmental, social and OSH impacts and risks, including those not initially foreseen.

Construction supervision

The professionals of the HSE Management Team of ATOME responsible for the supervision of works will carry out inspections at the work fronts to verify compliance by the Contractors and subcontractors with all the commitments contained in the Environmental Control Programme for Construction (P.01). In addition, it will verify compliance with the monitoring of environmental quality parameters affected by construction (water quality, air quality, environmental noise, effluents, atmospheric emissions) and that they comply with the applicable Project standards and/or expected impact levels.

This will occur through systematic inspections of construction activities and review of associated environmental, social and health and safety documentation, which includes not only the work of Contractors, but also those within the contractual scope of subcontractors and key suppliers.

Routine inspections will focus on:

- Verification of compliance with all components of the Environmental Construction Control Programme.
- Verification of the scope and intensity of the environmental and social impacts induced by the Project.

The ATOME Supervision Team (in-house or contracted) will prepare detailed inspection checklists according to each type of Project site or activity. Demobilisation checklists will be developed during the final stages of construction. Key aspects of environmental and social construction management that will be routinely checked will include:

Main construction processes:

- Vegetation suppression;

- Excavations and other earthworks;
- Pipe installation;
- Concrete and cement works;
- Civil works;
- Assembly of structures and equipment;
- Demobilisation, recovery and recuperation.

General guidelines for environmental and social monitoring and management:

- Cleanliness and general organisation and prevention of contamination;
- Erosion and runoff control;
- Handling of hazardous materials and management of spills and other pollution;
- Waste management;
- Water and effluent management;
- Management of atmospheric emissions;
- Air quality management;
- Noise and vibration management;
- Damage to third party property;
- Traffic management;
- Failure to meet commitments and manage community expectations (hiring of local workers and suppliers);
- Other problems that generate complaints from the community.

Health and safety guidelines to be addressed:

- Proper use of personal protective equipment (PPE) and collective protective equipment (CPE);
- Adoption of the Safe Work Procedures (SWP) established as part of the Integrated Health and Safety Plan (HSSP) of P.04;
- Safety of earthmoving activities;
- Safety of civil works;
- Safety of assembly activities;
- Traffic control;
- Safety signage;
- Characteristics of response to accidents at work;
- Handling of OSH related non-conformities by Contractors;
- Investigation of Contractors' accidents;
- Accident statistics.

5.3. Conformity Assurance Procedure

All violations of the commitments set out in the Construction Environmental Control Programme (P.01) will be documented and trigger a corrective action request. The ATOME Monitoring Team will issue two levels of corrective action requests:

- Comments on environmental, social and health and safety issues;
- Notification of non-conformity (NNC).

Observations on environmental, social and health and safety issues will be issued for minor problems that do not result in any material impact and can be easily resolved. The observations will be consolidated in a follow-up table, which will contain clear specifications on the missing aspect, the location of the problem, the recommended corrective actions, the target date for implementation and the responsible person.

Observations that occur repeatedly will lead to the issuance of a Notification of Non-Conformity (NNC). The same applies to observations not resolved within the stipulated time. NNCs will be issued for more significant violations or those that require a more complex set of actions to resolve.

The NNC shall be issued in a standard format and, where possible, include photographic documentation. In all cases, it shall indicate the missing items on the Inspection Checklist and the corresponding location on the project. The coding of NNCs shall be based on this information. NNCs that do not have a specific location will be given a special code.

Where relevant, NNCs shall differentiate between two types of required actions: immediate action and corrective action. Immediate action may be a work stoppage request or an emergency clean-up. Corrective action in some cases may be the submission of a Corrective Action Plan. However, it is anticipated that most NNCs will not require the preparation of a Corrective Action Plan, with the necessary corrective actions defined at the time of the action. As a general rule, the NNC should target problems rather than solutions, as the responsibility for the effectiveness of the corrective action rests entirely with the Contractors. The NNC shall also record the timelines for implementing the requested corrective actions.

Corrective Action Plans will be submitted by Contractors when the NNC indicates the need for them. As stated above, the Corrective Action Plan is requested on a selective basis and shall include a detailed description of any proposed corrective action and the timeline for implementation consistent with the overall deadline set forth in the NNC. This shall also include a description of the documentation to be submitted to demonstrate compliance. Corrective Action Plans will be approved by the ATOME Monitoring Team, which may request modifications or further details as appropriate.

NNC closure forms will be prepared by the Monitoring Team to formalise acceptance of the corrective action taken by the Contractors (or subcontractors) to remedy the NNC. These will be based on inspection of the implemented corrective actions, which will be triggered when the Contractors notify that the NNC has been resolved. If closure is confirmed, the date of the Contractor's notification of completion will be recorded on the NNC closure form.

5.4. Coordination of environmental and social programmes of the ESMP

To ensure the correct implementation of the environmental and social programmes proposed in the ESMP, with technical quality, the HSE Management Team of ATOME must develop a wide range of activities.

The team will manage the implementation of this Environmental and Social Management Programme (P.02) and all other ESMP programmes and measures under the responsibility of ATOME, including the following:

- Stakeholder Engagement Programme (P.03);
- Biodiversity Action Plan - BAP (P.07);
- Environmental Quality Monitoring Measures (Section 5.7 of P.02).

ATOME's HSE Management team will also oversee the implementation of the ESMP Programmes and measures that are the responsibility of the Contractors, including:

- Environmental Construction Control Programme (P.01);
- Occupational Health and Safety Programme in the Construction and Operation Phases (P.04);
- Labour Management and Working Conditions Programme (P.05);
- Programme for the Prevention of Impacts on Flora and Fauna (P.08);
- Emergency Response Programmes for the Construction and Operation Phases (P.06 and P.10);
- Solid waste and hazardous product management measures, monitoring of treated effluent, environmental and social training of the O&M team, odour control and maintenance of the easement strip of the Operation Phase Environmental and Social Management Programme (P.09);
- ADA Archaeological and Cultural Heritage Conservation Programme (P.11);
- Operation Phase Transport Management Programme (P.12).

The coordination activities of the ESMP Programmes will be implemented during the planning, construction and operation phases of the Project.

For implementation of the ESMP Programmes and measures that are the responsibility of the Contractors, each Contractor will have to form its own HSE team, which will be responsible for implementation of the measures, monitoring and reporting of compliance and performance to ATOME.

For the Programmes and measures of the ESMP that are the responsibility of ATOME, its HSE Management team will be responsible for the implementation, monitoring, supervision of works and activities of the Contractors, evaluation of reports and preparation of audit and compliance and performance reports to the authorities and funding bodies.

To implement some measures, such as water quality, air quality, environmental noise, and wildlife monitoring, it may be necessary to hire expert companies or teams. These teams must meet the human and material resource requirements specified for each environmental and social programme included in each contract and will be maintained during the implementation schedule of the respective programme/measure. The contractors' expert teams will be technically responsible for carrying out field activities and also for analysing the results.

The expert teams will rely on the local infrastructure provided by ATOME, which will provide the necessary logistical support for the monitoring campaigns and other planned activities.

Overseeing the implementation of the ESAP

On an ongoing basis during the implementation schedule of the ESMP Programmes, the ATOME HSE Management Team will systematically monitor the implementation of the Programmes

under the responsibility of the Contractors and the work contracted with expert teams. This activity will require:

- Quality control ("assurance") of each social and environmental programme, managing deadlines and deliverables, verifying the allocation of human and material resources as planned, requesting corrective actions and monitoring their implementation;
- Technical engagement with those responsible for each programme, promoting adjustments where necessary;
- Detailed review of all reports generated by the EPC Contractor for each programme under his responsibility;
- Systematic evaluation of the compliance and results of each programme according to the contents of this ESMP and/or the contract of the responsible implementer;
- Identification, based on the analysis of programme results, of unforeseen impacts and risks and/or of different intensity than expected, and discussion of management/mitigation strategies;
- Organisation of all documentation related to the implementation process of the ESMP Programmes.

Analysis of the results of the ESMP Programmes

As mentioned above, all results of the activities carried out within the Environmental and Social Programmes of the ESMP will be subject to systematic evaluation by the HSE Management Team of ATOME, together with the responsible specialist teams.

This will include reviewing and assessing deviations from performance standards set by law or as foreseen in the programme. For example, any water quality measurements that exceeded the limit, among others.

Systematic (periodic) monitoring-based programmes will also include the identification of changes from the baseline developed in the ESIA, and based on the evolution of construction activities during each monitoring period under review, seeking to establish causal relationships.

In systematic monitoring programmes, the analysis will take into account previous collection data, seeking to understand the observed changes in the cumulative and seasonal context, and to identify their causes more precisely.

Based on the evaluation of the results, possible improvements in programme implementation will be identified. Evaluations may also identify the irrelevance of actions included in any of the environmental and social programmes, and recommend their exclusion by informing MADES accordingly.

Through coordination meetings the HSE Management Team of ATOME will ensure the exchange of information between Programme implementers that have synergistic relationships.

Based on the evaluation of the results, the HSE Management Team may, where appropriate, propose adjustments to improve the ESMP Programmes. These adjustments may include:

- Adequacy of the sampling grid, if any of the sampling sites are inadequate or additional sites should be considered;
- Adequacy of the measurement parameters, according to the observed variations;
- Change of target audience;
- Changes to other specific aspects of the proposed methodologies.

Management of corrective actions

When problems are detected in construction activities that are being reflected in the results of any of the ESMP plans or programmes, the ATOME HSE Management Team will promote the necessary interaction with the Contractors and subcontractors and prepare a Corrective Action Plan when necessary due to the complexity of the action required.

Closure of social and environmental programmes

Once completed, according to the deadlines established for the Programmes, they will be subject to a closure procedure to be stipulated in the contracts to be signed with the companies contracted for their implementation. This will include:

- Issuance of the Final Report of the programme and its approval by the HSE Management Team of ATOME;
- Other programme-specific closing activities;
- Submission of a copy of the Final Programme Report to MADES, other authorities, and financial/lender institutions.

5.5. Management of greenhouse gas emissions

In order to avoid or minimise greenhouse gas (GHG) emissions related to the Project, GHG emissions estimates will be carried out for the construction and operation phases, using internationally recognised methodologies.

ATOME's HSE Management Team will be responsible for these calculations, relying on information from the Contractors to estimate the GHGs related to the construction phase.

The GHG Protocol tool, available on the Greenhouse Gas Protocol website[1] , can be used for calculations.

In the event that the estimate for any of the Project phases results in an amount greater than 25,000 tonnes of CO_2 equivalent per year, the HSE Management Team will conduct the annual inventory of GHG emissions and establish measures to reduce emissions.

5.6. Procedures for negotiating and acquiring land and establishing easements s

The land on which the plant will be built is regularly titled and has been purchased from the company Monteclaro S.A. in an amicable negotiation between the parties ("willing buyer -

[1] https://ghgprotocol.org/ghg-emissions-calculation-tool.

willing seller"). The seller (Monteclaro S.A.) is a qualified company with full capacity to defend its interests in the negotiation process.

Regarding the establishment of easements, ND5 recognises the right to expropriation. It also understands expropriations as restrictions on land use that result in physical or economic displacement and that must be carried out through symmetrical negotiations between the parties to reduce social and socio-economic impacts.
The Paraguayan Civil Code (Law No. 1183/85) establishes that easements may be constituted with compensation for the value of the use of the necessary land and any other prejudice. According to Articles 2208 to 2214 of the Law, a "servidumbre de tránsito" may be constituted when a property is deprived of access to a public road or if the access is not sufficient for its rural or industrial exploitation. In the case of "servidumbre de acueducto" (Articles 2215 to 2229), these may be constituted when they are necessary to allow the entry of water from other properties to one's own property.

For the Project, ATOME needs to establish an easement for the electric TL, affecting the property of El Arreglo S.A., and an aqueduct easement for the pipelines, which would cross the property of the company Omega Green and [redacted]. In this regard, ATOME will negotiate the easements on amicable terms and in accordance with the conditions set out in the ND5 and the national Civil Code.

In the case of the transit easement for the LT, the landowner must be compensated for the temporary and permanent loss of rice cultivation areas, as well as for the restriction of future use of the easement strip, taking into account the above-mentioned non-permitted uses in the strip.

In the case of an aqueduct easement to be established for water and effluent pipes, the owner of the servient estate is obliged to "permit" the use of the easement in the manner that is "least detrimental" to his interests. The parties can and should contractually regulate which buildings may or may not be built in the area of the easement.

As mentioned in Impact 6.04 (**Section 6.1.3.3**), the exercise of dominion in the easement area must be defined via contract, taking into account the needs of use and maintenance of the pipelines and the TL. For example, in the case of underground pipelines, such as those of the Project, it is possible to build over them, but a mechanism must be foreseen to allow for the maintenance and repair of the aqueduct. In practice, it is preferable to leave the easement area free. For the LT, the restriction on the easement is partial and allows agricultural and pasture uses. Only the cultivation of large trees (eucalyptus, pine, among others) is prohibited in the strip, as well as species whose management puts the TL at risk, such as sugar cane, for example, a crop that is generally cleared by burning.

As mentioned in Impact 6.04, ATOME's use of the LT and pipeline easement areas is secured through a TRANSIT SERVITAGE CONSTITUTION document established with the landowners. This contract sets out the amount that ATOME will pay as compensation as a lump sum, but makes clear the commitment to pay for any damage caused to the property during maintenance activities. It also sets out the exclusive obligations of the owner and ATOME and the obligations to be fulfilled by both parties.

5.7. Environmental quality monitoring measures

Air quality

During construction, air quality monitoring will be carried out in order to track air pollutants for which reference standards are available. A specialised company will be contracted for this purpose.

Measurements shall be made at the same point used for the baseline (see **Figure 5.2.8.2.a** in **Section 5.2.8.2**), and shall be carried out annually, preferably during the dry season.

The parameters Inhalable Particulate Matter (PM_{10} , $PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO) and Ozone (O_3) will be measured here. The results will be compared with the air quality standards of national and WHO legislation included in the IFC MASS General Guidelines.

The campaign will be carried out using international reference sampling techniques, such as the Large Volume Sampler (AGV/Hi-Vol) and the Trigas sampler. The air quality monitoring equipment will be defined by the plant operator in coordination with ATOME. They shall be properly calibrated and their certificates shall be presented in the reports.

River and groundwater water quality

Water quality monitoring of the river and groundwater will be carried out by specialised companies to be contracted.

Monitoring will be carried out semi-annually during the construction phase in order to extend the baseline prior to project operation, and to collect dry and rainy season data.

For river water monitoring, the sampling points will be the same as those at which the baseline analyses were carried out, i.e. 3 (three) points.

For groundwater monitoring, measurements will be made in existing wells within the Project site.

In both cases, the parameters to be monitored will be those established for Class 2 waters in Art. 3 of Resolution SEAM Nº 222/02.

Sample collection and preservation methods shall be carried out in accordance with the Paraguayan Standard Nº 186-Toma de Muestras para el Análisis Físico, Químico y Bacteriológico de las Aguas and the *Standard Methods For the Examination of Water and Wastewater (24th Edition), Section 1060 - Collection and Preservation of* Samples.

Laboratory determinations shall be performed in a laboratory accredited by the National Accreditation Body (ONA) according to the NP-ISO/IEC 17025:2018 standard equivalent to ISO/IEC 17025:2017 "GENERAL REQUIREMENTS FOR THE COMPETENCE OF TESTING AND CALIBRATION LABORATORIES".

6. Effectiveness Indicators

To monitor the implementation of this Programme, the following indicators will be considered:

- Effectiveness of the Project's works schedule;
- Number of ESMP Programme reports issued within the implementation schedule;
- Number of non-conformities (NNC) recorded;
- Number of non-conformities (NNC) corrected within the deadline;
- Frequency of coordination meetings between Programmes;
- Unexpected interference;
- Execution of GHG emission calculations at the required periodicity;
- Consolidation of evidence and progress information for all ESMP Programmes;
- Evidence of monitoring and % of parameters in compliance with legislation.

7. Reports

The recording and monitoring of ESMP Programmes and respective measures will be done through standardised and systematic records and reports, which will be produced with defined function and frequency. Based on existing details, the production of the following documents can be predicted:

Programme monitoring reports: the contractors' EHS Management Teams will produce monthly reports, with records of the execution of the ESMP Programmes, with a description of activities carried out in the period, comparison of planned and executed activities, critical analysis of the results; deviations and non-conformities recorded by plan and programme, with a deadline for adaptation/correction. These reports will highlight the environmental and social performance of the Contractors, according to the results presented in the reports of the Construction Environmental Control Programme.

Monthly site supervision reports: these will be prepared on a monthly basis by the contractors' HSE Management Team professionals. They will include all documentation generated during the period, recorded in the Construction Supervision, such as the following:

- Inspection report, with relevant measures for each work front;
- Recommendation for corrective action and request for adjustment of the executive procedure;
- Notification of non-conformity (NNC), recording serious misconduct and stipulating guidelines for correction;
- Observations on environmental, social and health and safety issues, recording minor problems;
- Record of effective and correctly implemented preventive actions;
- Monitoring of implemented corrective actions;
- Record of deactivation of work fronts, for effective verification of the completion of all deactivation and/or environmental remediation procedures applicable in each case.

Environmental and Social Management Plan Audit Reports: these include the ESMP compliance audit reports in compliance with Resolution No. 201/2015. ATOME will conduct frequent audits

in order to gather the necessary information for the submission of the annual audit report as required in the Project's environmental licence.

8. Implementation Schedule

This Programme will be carried out during the construction , assembly and deactivation phases of the works.

Action 5.6 started at the planning stage, with contact with landowners and establishment of CONSTITUTION OF TRANSIT AND WATER SUPPLY documents.

As part of the LT easement will affect rice crops, when clearing the service strip it should be verified whether it is possible to wait for the harvesting phase, in order to avoid a substantial loss of production.

The periodicities of environmental quality monitoring are specified in **Section 5.7.**

P.03 - Stakeholder Engagement Programme

1. Justification of the Programme

This Stakeholder Engagement Programme describes the main stages of the process of identification of affected or interested project stakeholders, ATOME's engagement with the population, and the activities that will be carried out during the planning, construction and operation phases of the Project.

The Plan includes mechanisms to ensure that all stakeholders are properly informed and consulted about the Project, that their interests are considered in a balanced manner, and that a continuous channel of information exchange is established. The Plan should ensure that any disputes related to the impacts of the project are properly managed.

In all cases where the ESMP Programmes include stakeholder engagement and communication activities, there will be close interaction between the team responsible for the implementation of the Stakeholder Engagement Programme, and the teams responsible for the implementation of the other Programmes. In some cases, the Stakeholder Engagement Programme implementation team will also be responsible for the other social programmes under the responsibility of ATOME.

2. Main Objectives

The main objectives of the Stakeholder Engagement Programme are:

- Mapping and analysing the stakeholders affected by the project;
- Conduct the public hearing in accordance with international best practice and consultations required by funders to ensure public participation in the Environmental and Social Impact Assessment (ESIA) process;
- Inform the population, companies and other stakeholders in the Project's area of influence about ATOME's commitments and responsibilities with respect to environmental, social and health and safety issues;
- Systematically identify the perceptions of affected parties or stakeholders in relation to the Project and its impacts, as well as prevention, mitigation and compensation measures and control plans, so that, where possible, they can be adapted and revised to adequately respond to local demands;
- Establish a mechanism to receive enquiries and complaints from stakeholders, as well as develop specific review procedures and a formal response mechanism;
- Monitor, evaluate and report on communication and stakeholder relations activities.

3. Applicable Legislation

- Law Nº 294/1993, on Environmental Impact Assessment, as amended by Law Nº 345/1994 and regulated by Decree Nº 453/2013;
- SEAM Resolution Nº 2127/2005, which establishes deadlines for the submission of studies contemplated in the framework of Law Nº 294/1993 "on Environmental Impact Assessment";
- Decree Nº 453/2013, which regulates Law Nº 294/1993 "on Environmental Impact Assessment" and its amendment, Law Nº 345/1994, and repeals Decree Nº 14281/1996;
- Decree No. 954/2013, amending and extending articles 2°, 3°, 5°, 5°, 6° clause E), 9°, 10, 14 and the annex of Decree No.º 453/2013;
- Resolution N° 640/2014, which establishes the General Regulations for public hearings within the framework of Law Nº 294/1993 on Environmental Impact Assessment, and its regulatory decree Nº 453/2013 and modifying and extending Nº 954/2013;

4. Responsibilities

ATOME is responsible for the implementation of this Stakeholder Engagement Programme. The Programme team will be composed of qualified professionals who will be responsible for visits, consultations and other communication activities with interested and affected parties. These professionals will be from ATOME's own staff or from a company to be contracted. The number of people in the team will depend on the demands during the various phases of the project.

As part of this team, one professional will be dedicated to managing the community's complaint and enquiry response mechanism. This professional will be responsible for formalising the receipt and handling of enquiries and complaints during construction, as well as regularly monitoring, tracking, documenting and assisting in the resolution of complaints.

ATOME will take the lead in the communication and stakeholder relations activities foreseen in

this Plan, with the support of the Contractors, as appropriate.

5. Implementation Methodology

The measures that form part of this plan are detailed below.

5.1. Stakeholder identification and analysis

The objectives of Project stakeholder identification and analysis are to identify the individuals, groups or organisations that may affect or be affected by the Project; and to analyse the interests and expectations of stakeholders, how and to what extent they will be affected by the Project and their potential impact or influence on the Project, in order to develop appropriate management strategies to effectively involve stakeholders in Project decisions and implementation.

Stakeholder identification and analysis is an iterative, dynamic and continuous process, which is updated periodically throughout the Project life cycle, especially in cases where changes are introduced in any component of the Project, extensions of operations, initiation of new phases of the Project cycle, among others. The minimum frequency of review and updating will be annual in the construction phase, but it may be carried out at any time the need is observed; this may also be considered for the O&M phase.

The identification of Project stakeholders started in the Project preparation phase, during the preparation of the Environmental and Social Impact Assessment (ESIA, March 2023) and a first update and extension of this identification and analysis was carried out during the preparation of the Public Consultation on the ESIA (November 2023).

The extended version of the stakeholder mapping is presented in **Annex 11**.

5.2. Public consultation

As mentioned in Section 4.1 Environmental Licensing of the ESIA, Decree N° 453/2013, on the process of Environmental Impact Assessment of projects and activities in Paraguay, establishes that the Ministry of Environment and Sustainable Development (MADES) may decide whether or not to convene a Public Hearing for the Project. This decision is taken within a period of 10 (ten) days during which the Environmental Impact Report (RIMA) of the Project is published on the MADES website. If the Public Hearing is convened, it is held in accordance with the General Regulations for Public Hearings established by Resolution SEAM N° 640/2014.

ATOME has submitted an Environmental and Social Impact Assessment (ESIA) and its corresponding RIMA to MADES on 08 May 2023, by which it has obtained the Environmental Impact Statement (EIS or Environmental License) of the Project on 06 September 2023 for the production of hydrogen and green ammonia. In this Environmental Impact Assessment process, MADES did not request ATOME to hold a Public Hearing.

Notwithstanding the above, ATOME decided to hold a Public Consultation to comply with the international requirements demanded by the entities that will finance the Project with respect to the due participation that must be given to the interested parties potentially affected by the

Project in the process of its planning and development. This consultation was held on 13 December 2023 at 18.00 hs in the municipality of Villeta.

The objective of the public consultation was to present information to stakeholders affected by the Project and to open a channel of dialogue with the population to express their concerns and suggestions about the project. The information presented focused on:

- Description of the Plant, LT and water catchment system and the water and effluent pipes;
- Overview of the baseline physical, biological and socio-economic environment and culture;
- Identified social and environmental impacts and risks;
- Environmental and Social Management Plan;
- Communication channel with ATOME (email and WhatsApp number) for queries, comments, suggestions and any other comments that interested parties may wish to make regarding the Project.

The dissemination and call for the public consultation was based on a previously elaborated Consultation Plan, which foresaw the identification of the place to hold the event, the dissemination of the event through local media (Villeta radio, vehicles with loudspeakers, delivery of invitations, etc.), free transport for communities further away from the municipal centre and the direct transmission of the event through Facebook.

During the consultation, information on the Project was presented in simple and easy to understand language.

The entire public consultation was duly documented in written, photographic and audiovisual format (live transmission with the possibility of subsequent reproduction of the video).

A question and answer session was held. In general, the main questions and comments from participants related to:

- Impacts of the Project on the quantity and quality of water in the Paraguay River.
- Impacts of the Project on the fishing activity of the Ypeka'e community.
- Cumulative impacts of the Project, considering other industries installed and planned in the area of influence.
- Risks to the population related to hydrogen and ammonia.

The comments and suggestions of the participants in the consultation were taken into account in the final version of this ESIA and will also be considered in the process of detailing the design of the Project components.

The Report of the Public Consultation is presented in **Annex 13**.

5.3. Communication Subprogramme

The overall objective of the disclosure of relevant information about the Project is for stakeholders to understand the risks, impacts and opportunities involved in the Project.

The planning of the ongoing dissemination of information on the Project foresees, in the first instance, a periodic review/update of the stakeholder identification and analysis. This is in order to identify the different audiences and the corresponding types and frequency of information to be disseminated, which will be consolidated in the Communication Sub-Programme. Dissemination planning should consider as possible allies for this task contacts with local authorities, existing structures for working with the population (e.g. Directorate of Neighbourhood Commissions of the Municipality of Villeta) and social organisations, who can help to ensure that information is disseminated to the local population.

As implementation of the Project begins, ATOME and the Contractors will work closely to develop channels of communication with local people and ensure that information is provided on key issues such as hiring practices, training of local workers, construction camp, Code of Conduct, planned processes and mechanisms for participation and raising queries or complaints, and future construction activities.

ATOME will lead the stakeholder communication and engagement process during construction. However, EPC Contractors shall have qualified environmental and health and safety professionals designated to contribute to stakeholder engagement activities when dealing with site aspects.

In general, strategies and mechanisms for information delivery such as newsletter distribution, visits and/or ad hoc meetings will be used. These routine actions will be at least quarterly, as urgent needs will be addressed in advance. In particular, additional strategies and mechanisms will be used on an as-needed basis.

The main materials, modes and content of information dissemination foreseen for the construction phase of the Project are described below.

Information materials

The dissemination of information materials will be an important part of the relationship process during construction. During construction, outreach will focus on the public who are considered to be the most susceptible to impacts and disturbance caused by construction activities, these are:

- Owner and residents of the estate neighbouring the Project site;
- Owners affected by rights of way and aqueduct easements;
- Residents near the aqueduct easement;
- Residents, passers-by and vehicular drivers on Route PY19 in the access/egress area.

However, communication will also focus on the population of Villeta as a whole, as job opportunities and the provision of inputs and services for the population and local businesses will be announced.

The main informative material to be produced during the works consists of a Newsletter, prepared by the Contractors and approved by ATOME, which will serve to disseminate their activities. On the other hand, ATOME will also prepare a Bulletin with information on environmental and social issues of specific interest to the population. This will be disseminated on a quarterly basis or as needed, in digital and printed format.

The bulletins will be distributed to the above-mentioned public. The topics covered will consist of:

- Recruitment policies and employment opportunities;
- Opportunities for suppliers of goods and services for the works;
- Construction activities planned for the period;
- Planned noise-emitting activities, timetable and duration;
- Transport and traffic in the project area, including access restrictions, transport of oversize loads, etc;
- Risks to the health and safety of the population living along the access roads for the works;
- Health and safety measures to avoid affecting the population living nearby and/or passing through the area;
- Information on measures implemented to prevent, mitigate, control and monitor impacts;
- Training of local workers;
- Code of Conduct for workers, with measures to ensure good relations between the surrounding population and Project workers;
- Mechanism for managing queries and complaints about the Project;
- Results of monitoring of the environmental quality of the Project's area of influence;

These bulletins will be sent via email, WhatsApp, by post to those residents with a viable address, or through appropriately advertised high-traffic points (municipality, commercial establishments, schools/colleges, health posts, other locations).

The social communication officer of the ATOME team will maintain a comprehensive database of communication materials prepared and disseminated by the Project.

Visits and/or one-off meetings

Visits and/or ad hoc meetings will be held to provide specific information to stakeholders as appropriate and/or necessary.

These visits and/or meetings will take place at least quarterly, as urgent needs will be addressed in advance.

The information to be provided to these stakeholders in these visits and/or meetings will be previously prepared and approved by the HSE Management Team of ATOME, and will be recorded in order to ensure that the information provided is relevant. During these visits and/or meetings, the other information materials described in this Programme may also be handed out.

Any visit and/or meeting activity must first be approved by the Environmental, Social and Health and Safety Management Team.

Any visit and/or meeting activity must first be approved by the Environmental, Social and Health and Safety Management Team.

5.4. Mechanism for handling complaints, queries and suggestions

ATOME will implement a complaints, queries and suggestions management mechanism aimed at the community, its own workers, Contractors, subcontractors and suppliers, starting from the planning phase and extending through to the operation phase of the Project.

The EPC Contractor will also be contractually required to have a complaints handling and management mechanism, the general guidelines of which are detailed in P.02 Environmental Control Programme. This will be part of the programmes and plans that will make up its MASS management system.

ATOME will inform Project stakeholders and affected parties about the grievance mechanism throughout its communication and community engagement process. The channels for responding to complaints, queries and suggestions were communicated in the Public Consultation and shall be continuously disseminated. These channels will include:

- Address of the ATOME office;
- E-mail;
- ATOME website;
- ATOME telephone, enabled for calls and WhatsApp;
- Worksite, direct communication with EPC Contractors.

At the start of construction, a sign will be erected in front of the Project site with the following information:

- Contractors' telephone number for queries and complaints;
- ATOME telephone number for queries and complaints;
- ATOME website;
- ATOME e-mail address;
- Name of the person responsible for the construction (Contractors' engineers);

All complaints and requests received will be classified immediately, separated according to issues and directed to the responsible professionals for processing in accordance with the applicable procedure.

All complaints received through the channels of the mechanism or verbally by ATOME's communication professionals or by the Contractors will be recorded in writing.

The complaint registration system shall contain at least the following information:

- The date of receipt;
- The category of the query or complaint;
- The channel by which the query or complaint was received;
- The name of the person who registered the enquiry or complaint or if you wish to make it anonymously;

- Those responsible for the preparation of the response;
- The date on which the response was sent;
- The person or address to whom the query or complaint was referred;
- Record of compliance with the resolution of the complaint, once the response is issued;
- The final result.

Complaints and queries will be classified and recorded according to categories, which include:

- Requests for information;
- Complaints related to construction activities;
- Complaints related to the operation of the Project;
- Complaints from Contractors' and subcontractors' workers;
- ATOME complaints;
- Suggestions for improvement;
- Others.

Applications for employment shall not be considered as enquiries or complaints and shall be sent directly to the human resources department of the Contractors or operators, in the operation phase.

All enquiries shall be responded to within ten (10) days, except where there is a just reason for a longer response time. Refusal to provide information shall only be considered in cases where confidentiality is required and such refusal is legally justified.

After being answered by the person responsible for each area, responses to queries and complaints will be reviewed by the ATOME professional responsible for the complaints mechanism. When the response is not favourable (in whole or in part), it must contain an adequate justification. In this case, the complainant will be informed of his/her right to insist on the query or complaint. The complainant will be informed of the possibility to take his/her complaint to court if he/she wishes to do so.

As contacts for submitting complaints and queries will include the possibility of sending them directly to the Contractors, the companies' community relations professional will receive specific training on the Project's grievance mechanism. They will be required to provide an initial response to any complaints directed to the Contractors.

The Contractors' community relations professional will maintain a consolidated log book of complaints received at the construction camp, and this consolidated log will be sent weekly to ATOME for consolidation into the Project's single complaints register.
The Contractors shall inform ATOME's social officer as quickly as possible of any complaint relating to aspects not directly related to the works under their responsibility and also of those which, although they concern aspects of the Contractor's responsibility, are considered to be of greater seriousness according to criteria to be established by ATOME at the start of the works and periodically updated during construction. Any hostile attitude of the parties concerned will also be reported, even if there is no formalised complaint.

All construction related complaints shall be evaluated and responded to by the Contractors. Subcontractors receiving complaints shall, by contract, pass them on to the Contractors within

24 hours. Complaints against subcontractors shall also be recorded in the complaints register. Complaints received by the Contractors but addressed to ATOME shall be forwarded to ATOME within 24 hours.

In all cases, Contractors shall respond to complaints within 10 (ten) days, with longer periods provided there is justification.

ATOME's social officer will hold regular meetings with the Contractors to verify the complaints and queries received and their responses. ATOME will review and pre-approve the Contractors' response only in the following cases:

- Complaints received from local authorities;
- Complaints filed by NGOs, civil society organisations, or similar;
- Complaints on issues of collective interest to the community;
- Complaints involving any type of legal non-compliance by Contractors;
- Complaints about damage to third party property;
- Complaints against the conduct of any Contractor's employees;
- Complaints with which the Contractors do not agree and intends to refuse to take the remedial action requested by the complainant.

For the operation phase, ATOME will adapt the grievance handling mechanism based on experience during the construction phase.

Figure 5.4.a of P.03 illustrates the process of ATOME's Complaints, Grievance and Conflict Management Mechanism for all Project stakeholders.

Figure 5.4.a of P.03
ATOME's complaint, grievance and dispute management mechanism



6. Effectiveness Indicators

The following indicators are proposed for the Programme:

Public Consultation

- Number of invitees to the Public Consultation in relation to the total number of contacts in the stakeholder mapping;
- Number of participants in the Public Consultation in relation to the number of invitees;

Communication Sub-Programme

- Number of newsletters prepared and distributed to stakeholders affected by the project at the planned periodicity;
- Number of visits and/or meetings held to provide information to stakeholders;

Complaints, Grievances and Disputes Management Mechanism

- Number of complaints, claims, denunciations, queries or suggestions (separately) received in the month;
- Rate of handling of complaints, claims, allegations, enquiries, suggestions and disputes (separately) and their responses within the specified timeframe, by month;
- Number of cases of complaints, claims, complaints, enquiries, suggestions and disputes (separately) satisfactorily resolved per month;
- Conflict escalation rate of a complaint, grievance or report received per month.

7. Reports

A report on the results of the Public Consultation was prepared and is presented in **Annex 13.**

Records and responses to Contractors' complaints and queries will be communicated to ATOME in its monthly reports to be prepared under P.01.

On a quarterly basis during construction and annually during operation, ATOME will consolidate the results of the Plan in a Social Communication Report that includes at least the following:

- A list of activities carried out during the quarter (construction) or year (operation);
- Results;
- Statistics related to the Complaints Handling Mechanism (response rate to complaints and responses within the agreed timeframe, according to the complexity of the complaint);
- Identify, based on the incidence of similar questions, the degree of information of the population in the area of influence regarding the project;
- Programme of activities for the next quarter (construction) or semester (operation).

8. Implementation Schedule

Dissemination about the Project has started with the execution of a field campaign for the ESIA in which authorities and other stakeholders in Villeta were interviewed.

Prior to the start of the works, a Public Consultation convened by ATOME was carried out in the framework of compliance with international regulations.

During the implementation of the Project, social communication will be constant. Newsletters will be distributed on a quarterly basis or at shorter intervals to be established.

The consultation and complaints handling mechanism will be carried out during the construction phase and will be extended to the operation phase of the project.

P.04 - Occupational Health and Safety Programme l

1. Justification of the Programme

The construction works and the operation and maintenance of the Project will involve activities and operation of facilities with health and safety risks for workers, including earthworks, handling of loads, transport, operation of machinery and equipment, handling of hazardous products, work at heights, work in confined spaces, electrical installation, maintenance, explosion of the H_2 tanks, leaks of NH_3 , HNO_3 and NH_4 NO_3 , exposure to excessive noise, among others.

Therefore, the EPC Contractors hired for the works and the companies subsequently hired for the operation and maintenance of the Plant will prepare and implement health and safety plans and procedures in accordance with international good practice, Paraguayan requirements and the requirements of the performance standards, the General Environmental, Health and Safety Guidelines (MASS) and the IFC's MASS Guidelines for Nitrogen Fertilizer Production. This will be

a contractual obligation. These Plans and procedures will be reviewed and approved by the ATOME HSE Management team.

2. Main Objectives

The main objective of the Occupational Health and Safety Programme during construction and in the operation and maintenance of the Project is to establish minimum standards of compliance with occupational health and safety control legislation, with application to the employees and service providers of the Contractors, subcontractors, suppliers and other contracted companies, and ATOME itself, land and river transport companies and maintenance companies in operation, in order to anticipate, recognise, evaluate and control the environmental risks that exist or may exist in the operation, suppliers and other contracted companies, and ATOME itself, land and river transport companies and maintenance companies in the operation, in order to anticipate, recognise, evaluate and control the environmental risks that exist or may exist in the workplace, taking into account the protection of workers, the environment and natural resources.

The Programme also aims to:

- Preventing the occurrence of occupational accidents and health problems due to occupational issues during construction, operation and maintenance, and mitigating their consequences if they occur;
- Establish contractually binding occupational health and safety guidelines to be adopted systematically by Contractors and other contracted companies throughout the duration of the project;
- Ensure compliance with all health and safety requirements;
- Stipulate minimum health and safety requirements to be met by all contractors, standardising some Safe Work Procedures (SWP) and facilitating the management of occupational safety for the whole Project;
- Implement systematic self-monitoring so that all executed services are routinely inspected and evaluated;
- Implement an efficient procedure for responding to corrective action requests and/or notifications of non-compliance with respect to the TSPs;
- Train workers to comply with the PTS and relevant legal requirements;
- Assess and monitor the health of contracted workers through intake and periodic screening for viral, bacterial, and parasitic diseases, among others, as well as hearing, vision and other physical capacity tests relevant to the activities the workers will perform;
- Collaborate to maintain favourable sanitary conditions for staff;
- Educate and orient staff regarding sexually transmitted diseases and communicable infectious diseases in general;
- Providing emergency medical assistance to staff in case of accidents;
- Transporting cases requiring hospital care to contracted health services;
- Notify the competent authorities in case of notifiable diseases.

3. Applicable Legislation

All legislation set out in **Section 4.6** of the ESIA applies, in addition to applicable international occupational health and safety requirements, including IFC GL 2, IFC General MASS Guidelines and IFC MASS Guidelines for Nitrogen Fertiliser Production and applicable ILO Conventions.

4. Responsibilities

Health and safety management incorporates two components: management and supervision. Contractors will be responsible for the implementation of health and safety procedures during construction. ATOME will be responsible for supervision, checking compliance with the minimum health and safety requirements to be met by Contractors, subcontractors and suppliers, including compliance with the PTS. Contractors will be responsible for ensuring compliance of subcontractors.

The Contractors must structure an occupational health and safety team, which has a Health and Safety Manager and a doctor responsible for occupational health. ATOME will have an occupational safety technician to verify compliance with the PTS at the work fronts.

In the operation phase, ATOME will contract companies with proven experience in the operation of similar facilities and will be responsible for monitoring the compliance of these contracted companies with health and safety procedures.

5. Implementation Methodology

5.1. Preparation of the Integrated Health and Safety Plan (IHSP)

The Contractors shall document the Health and Safety procedures by means of a Comprehensive Health and Safety Plan (HSSP) for the construction phase, which shall have the following components:

- *Procedures manual*, detailing the specific procedures to be adopted for all health and safety management tasks, including forms, record-keeping systems and procedures, communication flow and other aspects;
- *Responsibilities,* distributing responsibilities among key health and safety personnel.
- *Health and safety training programme,* presenting the contents, frequency and context of application of each health and safety training module;
- *Occupational health management,* which will include worker health monitoring and medical assistance, as well as emergency response;
- *Safe work procedures* for the main high-risk activities in the Project.

The PISS will be prepared prior to the start of works and submitted for analysis and approval by the ATOME Team. This will include all aspects listed in the objectives and will ensure compliance with all applicable legal regulations and contractual terms. It will contain the details of all sections of the PTS document and their minimum requirements.

The Contractors shall conduct self-monitoring through routine health and safety inspections.

The ATOME team's health and safety professional will, in turn, establish monitoring procedures including tools for non-conformance reporting (NNC) and corrective action requests from Contractors and subcontractors.

Health and safety requirements shall be included in contracts with Contractors.

The primary activities to be carried out by the Contractors' occupational health and safety officers shall be as follows:

- Preparation of the Integrated Health and Safety Plan (PISS);
- Recruitment of staff and training of the Health and Safety Management team;
- Health and safety inspections (self-monitoring);
- Inspections/supervision of subcontractors;
- Ensuring worker participation in health and safety management through an Accident Prevention Committee.

The contracted operator will prepare the ISSP for the operation and maintenance (O&M) phase according to the activities, risks, equipment and companies involved in this new stage of the project. This will be part of its MASS management system to be approved by ATOME.

5.2. Personnel for health and safety management

The Contractors' organisational structure for the management of health and safety issues shall include, as a minimum, a Health and Safety Manager and a doctor responsible for occupational health. The number of health and safety personnel will depend on local regulations and laws, based on the number of workers and the type of service being performed.

The functions of the Contractors' Health and Safety Manager are:

- Ensure that all machinery, equipment, facilities and construction activities are routinely inspected for health and safety aspects;
- Inform workers of any risks involved;
- Instruct workers in the PTS to avoid injury;
- Provide the necessary and appropriate personal and collective protective equipment (PPE and CPE) for each type of activity;
- Ensure that adequate working conditions are provided for all workers;
- Coordinate health and safety training;
- Ensure that first aid and medical assistance for workers is available;
- Having appropriate resources to respond to emergencies;
- Coordinate the investigation of accidents.

5.3. Requirements legal requirements and international best practices for Safe Work Procedures (SWP)

The items listed below must necessarily be incorporated into the TSPs, which will be detailed by the Contractors in the ISSP, and will be complied with by all subcontractors.

1. Transport, handling and storage of materials;

2. Transport of hazardous materials;
3. Transport of persons;
4. Storage and handling of fuels and flammable materials;
5. Operation of machinery and equipment;
6. Excavations;
7. Concrete works;
8. Work at height;
9. Tree felling;
10. Work with electrical risk;
11. Work in confined spaces.

The ISSP for the O&M phase should minimally incorporate these same STPs and add others, such as the following:

12. On-board work (on inland waterway transport of fertiliser), carried out by the companies contracted for transport or the port;
13. Work in explosion hazardous areas;
14. Work in areas with risk of NH leakage$_3$, HNO_3 and NH_4 NO_3;

A first aid kit shall be provided at the construction camp and work fronts at all times.

When any part of the body may be exposed to toxic or corrosive materials, showers and eyewashes shall be provided in the work area for immediate emergency use. When persons are exposed to epoxy resins, solvents, hydrocarbons, cement, quicklime, and other dermatitis-producing substances, ointments recommended by the manufacturer for the specific exposure shall be available and used.

5.4. Occupational Safety Training

Training related to compliance with the PTS will be the ongoing responsibility of the Contractors throughout the construction period and of the operating companies during the O&M phase.

Therefore, Contractors shall have health and safety inspectors in numbers compatible with the size of the construction workforce.

During the intake process, all workers will receive health and safety training on PTS and other health and safety requirements.

During construction, all workers on the work fronts will receive weekly briefings of at least 15 minutes duration. In addition, daily safety talks are planned.

If accidents occur or health and safety compliance observations are deemed too frequent, the ATOME supervisory team may require Contractors to intensify training.

The health and safety training to be provided by the Contractors shall be detailed in the ISSP, which shall specify the contents, target groups, frequency and forms of evaluation for each type of training to be applied. It shall include at least the following modules:

- Induction training
- First aid
- Poisonous animals
- Use of PPE and EPCs
- Safe Working Procedures
- Daily security talks

5.5. Monitoring of health and safety conditions

Compliance with the ISSP measures will be subject to two types of supervision: (i) supervision through health and safety inspections by the Contractors (self-monitoring), and (ii) supervision by ATOME.

Contractors shall carry out Safety Inspections on a continuous basis at the work sites (self-monitoring) to verify compliance with the provisions of the STPs. Safety inspections, mainly of a preventive nature, aim to detect unsafe conditions and/or behaviours which, in turn, could indicate the necessary steps to control and reduce the observed risks and to reinforce training.

The Contractors' health and safety team will also supervise the activities of the subcontractors, assessing compliance with the PTS and also with the other commitments, such as training, worker participation, use of PPE, among others. Subcontractors will not need their own medical service as the health of the subcontractor's employees will be monitored by the Contractor's medical service.

Contractors' and subcontractors' health and safety teams shall produce evidence of compliance with all applicable commitments.

Health and safety supervision by ATOME, in turn, in both construction and operation (self-monitoring and supervision of transport and maintenance companies) will include the following activities:

- Handling of non-conformities
- Accident investigation
- Accident statistics

Handling of non-conformities

A procedure shall be implemented to respond to all Notifications of non-conformity issued by the ATOME OSH supervisor in relation to non-compliance with any aspect of the ISSP. This procedure shall be detailed in the ISSP and shall include as a minimum the following:

- Corrective Action Plan, which shall detail the actions/measures to be taken to correct the problems, identify the persons responsible for each action, specify the evidence to be presented to demonstrate compliance and the time period for each action;
- Notification of compliance, which is the document to be sent to the ATOME team informing of the completion of the Corrective Action Plan and attaching the corresponding evidence.

The non-conformity handling procedure shall also apply in the case of non-conformities due to the activities of subcontractors and suppliers.

In the O&M phase, the ATOME supervision team will adopt the procedure for handling non-conformities in the self-monitoring and inspection of the activities of contracted companies and third parties.

Accident investigations

All accidents will be methodically investigated and the investigations will be coordinated by the OSH officer responsible for the construction/O&M front where the accident occurred, under the supervision of the Health and Safety Manager. The doctor responsible for occupational health and the construction engineer responsible for the work front will also be involved. The doctor will also be responsible for issuing the Accident Report.

Reports of industrial accidents or fatalities shall be reported to the Ministry of Labour, in the latter case also to the Public Prosecutor's Office. All accidents shall be investigated and documented, with the following information as a minimum:

- Personal injury
- Name of person involved
- Name of injury
- Injury site
- Description of the accident
- Type of accident
- Reason for the accident
- Corrective action (as warranted)

The results of the accident investigation shall be recorded in formats defined in the ISSP. The results will conclude the cause of the accident and corrective actions will be planned according to this conclusion.

Accident statistics

Project accident statistics will be updated on an ongoing basis by the Contractors' Health and Safety Manager. In the O&M phase, the responsibility for producing these statistics rests with the OSH coordinator of the operating company.

5.6. Worker health management

Worker health management includes:

- Provide health insurance from the Instituto de Previsión Social (IPS);
- Undertake medical examinations required by law or otherwise upon admission, periodically, after returning to work (absence of more than 15 days), upon change of duties and upon dismissal;
- Monitor groups of workers subject to specific health risks;
- To prepare and keep the health records of workers;

- Request relocation or dismissal of workers when necessary for medical reasons and issue notifications of accidents at work;
- Maintain equipment, materials and personnel capable of administering first aid;
- Establish agreements with hospitals and other medical institutions that can provide care for workers requiring additional assistance.

In addition, during both construction (Contractors) and operation of the Project, periodic measurements of occupational noise levels shall be taken for 8 hours at a time to ensure compliance with the noise limits in the working environment and the hearing protection measures established by the IFC General Guidelines:

Table 5.6.a of P.04
Noise limits for different working environments

Place/activity	Equivalent level LAeq,8h	Maximum LAmax, fast
Heavy industry (no need for oral communication)	85 dB(A)	110 dB(A)
Light industry (decreasing need for oral communication)	50-65 dB(A)	110 dB(A)
Open-plan offices, control rooms, workbenches or similar places	45-50 dB(A)	-
Individual offices (no noise disturbance)	40-45 dB(A)	-
Academic classes, conference rooms	35-40 dB(A)	-
Hospitals	30-35 dB(A)	40 dB(A)

Source: IFC General EHS Guidelines.

Occupational noise measurement campaigns during construction will be carried out in accordance with the characteristics of the work fronts to determine hearing protection measures. During operation, the campaigns will be carried out every six months, after verification of the noise levels in each unit of the plant. In both the construction and operation phases, further campaigns will be carried out whenever there is a change in processes, procedures or exposure time that may lead to an increase in noise exposure of employees.
Specifically for construction sites, OSHA establishes the following limits. Contractors and operating companies shall have a hearing protection program for workers exposed to high noise levels.

Table 5.6.b of P.04
Noise limits at construction sites

Duration per day, in hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

Source: Occupational Safety and Health Administration (OSHA).

5.7. Committee for the prevention of accidents

The following activities are within the scope of the Committee foreseen as part of the ISSP:

- Specific training for those elected by the committee;
- Identification of risks in work processes and proposals for adjusting the PTS;
- Requests to shut down machinery or sectors that pose serious and imminent risks to the health and safety of workers;
- Communication and compliance with the PTS, as well as the clauses of collective labour agreements and conventions related to occupational safety;
- Analysis of the causes of illness and accidents at work, and proposals for measures to solve the problems identified;
- Accident investigation;
- Accident statistics.

6. Effectiveness Indicators

This Programme will use the following indicators:

- Number of accidents with medical leave;
- Number of accidents without medical leave;
- Number of accidents with simple outpatient care;
- Number of major accidents;
- Number of fatal accidents;
- Number of cases of work-related diseases;
- Number of cases of infectious diseases among workers;
- Number of notifications of non-conformities resulting from non-compliance with any of the PTS.

7. Reports

The Contractors shall prepare monthly occupational health and safety reports for submission to ATOME's supervisory team during construction.

The reports shall list all subcontracting companies operating on the construction sites and in the camp, specifying the respective number of workers and the activities carried out or under their responsibility.

Information/evidence on the effectiveness indicators listed in the previous section will be presented for the period.

In the O&M phase, the ATOME health and safety coordinator will prepare regular internal reports with information/evidence of effectiveness indicators.

8. Implementation Schedule

The Programme must be maintained throughout the construction period and afterwards in the O&M phase, in order to avoid or minimise the risk of accidents and to ensure the occupational health of people.

P.05 - Management of Labour and Working Conditions Programme

1. Justification of the Programme

The construction and operation of the Project components will involve activities that will involve several companies, including Contractors, sub-contractors and suppliers, all of which have a contracted workforce.

Therefore, the Project must have measures in place to ensure that the recruitment of these workers and their relationship with employers is in accordance with Paraguayan labour legislation and applicable international requirements. The objective is to guarantee compliance with the fundamental rights of workers, ensuring fair treatment; non-discrimination; equal opportunities for workers; the right to form organisations; respect for minorities and people in vulnerable conditions; and the non-employment of child and forced labour. In addition, safe and healthy working conditions must be ensured and the health of workers must be promoted.

2. Main Objectives

The main objective of the Labour Management and Working Conditions Programme is to ensure that labour management policies and procedures are implemented in accordance with Paraguay's labour laws and International Labour Organisation (ILO) conventions, which are the basis for IFC Performance Standard 2 requirements. To this end, it will have the following specific objectives:

- Prepare and implement a Human Resources Policy aligned with Paraguayan legislation, ILO Conventions and other applicable international requirements, including procedures for recruitment, training and reduction of the workforce;
- To benefit the population of Villeta, through the use of local labour in construction and operational activities;
- Prevent impacts that may occur as a result of migration of people from other regions;
- Establish working and employment conditions;
- Implement a mechanism for handling queries, complaints and suggestions for workers;
- Detail a Code of Conduct for workers.

3. Applicable Legislation

All legislation set out in **Section 4.7** of the ESIA applies, in addition to the main applicable international requirements on labour and employment conditions that are aligned with Paraguayan labour laws, including IFC GL 2 and applicable ILO Conventions.

4. Responsibilities

ATOME has a Human Resources Policy aligned with the applicable legislation mentioned in the previous item. The Contractors of the construction phases and the Companies contracted for

the operation and maintenance will have to prepare a Human Resources Policy that is in line with the ATOME Policy and includes detailed procedures for hiring, training and reduction of workers, aligned with Paraguayan legislation, ILO Conventions and other applicable international requirements. These procedures must be complied with during the construction works of the Project and in the operation and maintenance, and compliance by subcontractors and suppliers must be ensured.

ATOME will review the HR Policy procedures of EPC Contractors and operation and maintenance companies. ATOME's monitoring team will be responsible for evidencing the adoption of the Policy's procedures by Contractors, subcontractors and suppliers during construction and in operation and maintenance.

5. Implementation Methodology

The Management of Labour and Working Conditions Programme will be implemented through the following measures:

5.1. Preparing a Human Resources Policy

A Human Resources Policy (or equivalent instrument) is required to formalise the Project's commitment to Paraguayan labour management legislation, ILO Conventions and other applicable international requirements, and to establish procedures to ensure compliance. It applies to workers hired directly by ATOME, by Contractors, subcontractors, maintenance companies, land and river transport companies, and suppliers (supply chain workers) in the construction and operation phases of the Project.

Each company's HR policy and procedures should detail at least the following processes and activities:

(i) Recruitment and qualification of staff;
(ii) Wages and benefits practices;
(iii) Disciplinary measures;
(iv) Conflict prevention (consultation and complaint mechanisms);
(v) Admission and dismissal process;
(vi) Training;
(vii) Reduction/demobilisation.

Recruitment procedures and other aspects of the employment relationship (remuneration, working conditions and terms of employment, access to training, job assignment, promotion, dismissal or retirement and disciplinary practices) should ensure that there is no discrimination, exclusion or preference based on sex, age, race, colour, national extraction, social origin, political opinion, trade union membership or religious belief, sexual orientation, gender identity and disability; prohibition of child or forced labour; respect for minorities and persons in vulnerable conditions.

The policy should make clear the prohibition of work by minors under 18 years of age, as established in the Paraguayan Labour Code for industrial settings. It should also guarantee

respect for the right to form labour organisations; safe and healthy working conditions; and workers' health.

5.2. Recruitment and job training

The Project will make every effort to recruit local skilled and unskilled labour from within its area of influence (Villeta), where necessary and where the requirements for the type of work offered are met. When recruiting, efforts will also be made to ensure that women and men have equal opportunities.

Local communities will be informed about the profiles required for skilled and unskilled labour, according to the needs of the Project.

Recruitment requirements will be publicised by the Project, explaining the qualifications and documents to be submitted.

Receipt of CVs will be handled by each Contractor's HSE team leader. A location for receipt of these CVs will be designated in the construction support areas and/or other convenient location. In any case, resumes eventually received through the grievance handling mechanism or the **P.03 - Stakeholder Engagement Programme** communication team will be forwarded to this Contractor's professional responsible for handling resumes.

Seeking to comply with the maximum hiring of local workers, the Contractors will seek data on available labour in the region through contact with the municipality of Villeta and/or other institutions, and will advertise the positions on platforms such as the Public Employment Service - Paraguay, on Facebook.

Also to maximise local recruitment, a training and apprenticeship programme for local residents will be developed to enhance the supply of local labour and to promote and reward motivated individuals who successfully graduate from training programmes.

The training of contracted employees will cover the basics of the techniques necessary for work performance, such as the purpose of the work, safe use of tools, interpersonal relations, teamwork, safety at work and care for the environment, among others.

The Contractors shall submit to ATOME a monthly Labour Composition Report, indicating the total number of workers, their functions/grades of qualification and place of origin.

5.3. Working and employment conditions

The minimum working conditions in the construction camp and work fronts set out in Decree N° 14390/1992 and amendments, and in international requirements such as the IFC/EBRD document *Workers Accommodation: Process and Standards* will be complied with. The conditions will be met in the camp facilities including canteens, bathrooms, changing rooms, toilets, rest areas, and in the accommodation of workers from outside the region in hotels and flats in Asunción or Villeta.

The requirements to be met relate to minimum space; water supply; adequate sanitation and

waste disposal system; adequate number and distance of toilets, separating men's and women's toilets; adequate protection from heat, cold, damp, noise, fire and disease-carrying animals; adequate sanitary and washing facilities; ventilation; lighting; cleanliness; and basic medical facilities and fire-fighting system. In addition, facilities and physical distancing conditions that comply with WHO recommended international good practice for the prevention of COVID-19 in the work environment shall be met.

The minimum standards and conditions shall also apply to employees of third parties during the construction phase.

EPC Contractor teams will submit inspection reports to ensure compliance with standards at the construction camp, worker accommodation facilities including hotel accommodation and flats in Asuncion or Villeta.

5.4. Mechanism for handling workers' complaints

Contractors should implement a complaints mechanism for workers (own and third party), which should be accessible and allow them to raise any complaints or concerns regarding the workplace, labour disputes, lack of safety in the performance of the function, and to make complaints of any nature, confidentially and without reprisal of any kind.

Channels for the submission of queries, suggestions, complaints and allegations should be widely disseminated to the worker already in induction training and in all environmental and social trainings for workers (see **Section 5.6**). ATOME and its EPC contractors will maintain an "open door" policy, providing confidential and fair treatment to all workers, who will be informed of viable channels to voice their grievances without having to discuss them directly with their immediate supervisor.

The system should involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides timely information to workers.

It should also be made clear to the worker that the mechanism will not preclude access to other judicial or administrative remedies that may be available under existing legislation or arbitration procedures, or replace grievance mechanisms provided by collective agreements.

The internal grievance mechanism should be extended to subcontractor and supplier workers as necessary to ensure that all companies manage their labour relations diligently and responsibly.

According to **P.03 - Stakeholder Engagement Programme**, channels for receiving complaints and suggestions from workers may also include suggestion boxes to be distributed in the construction camp, which should be sealed and guarantee the confidentiality of the complainant, in addition to the other means already mentioned.

The worker-specific grievance mechanism should indicate a timeframe for responding to complaints, allowing for an extension of the timeframe if justified.

In informing workers about the grievance mechanism, it will be made clear that they can send their complaints and suggestions directly to ATOME, through a specific contact that will be

created as part of the grievance mechanism managed by ATOME as part of P.03. The opening of this direct channel does not imply that ATOME will assume responsibility for established labour or contractual relations. This will simply have the function of allowing ATOME to also receive employee grievances from Contractors and subcontractors and to request that corrective actions be considered when such management is deemed to be inappropriate or may imply a risk to the Project.

5.5. Code of Conduct for employees

The Contractors shall develop a Code of Conduct which shall include policies and standards to be adhered to by employees and employers involved in the Project works, including the Plant, the LT and the water supply infrastructure and water and effluent pipelines. These guidelines establish a framework for appropriate behaviour and interaction, the objectives of which are:

- Ensure the quality of relations between site personnel (including employers, suppliers, etc.), site personnel and civil society (including the neighbouring farm, population close to site access, civil society in general, etc.);
- Protect the environment;
- Ensure health and hygiene conditions for workers;
- Protect public or private property;
- Comply with environmental and labour legislation and ensure discipline.

To adequately disseminate the Code of Conduct, Contractors shall include it in the content of induction training and environmental training for workers provided for in this Programme (see **Section 5.6**), and it shall be posted at strategic locations in the construction camp.

The Code of Conduct must be adopted by all employees of Contractors, subcontractors and suppliers. It is normally based on the values of the Contractors and the mission statement of each company, however, the following are the minimum requirements that a Code of Conduct should contain:

<u>General aspects</u>

- The conduct of employees before, during and after working hours shall be exemplary and in strict accordance with the law. In particular, a polite and respectful relationship shall be maintained with everyone; hostile behaviour towards the local community shall not be accepted, but respect for local values, customs and culture shall be shown at all times.
- Any form of discrimination based on sex, age, race, colour, national extraction, social origin, political opinion, trade union membership or religious belief, sexual orientation, gender identity and disability is strictly prohibited.
- All workers shall wear badges that allow easy identification of their names, position and company for which they work.
- Carrying weapons, consuming alcoholic beverages or drugs, as well as possessing pornographic materials (images, videos, magazines, etc.) is strictly prohibited in all areas of the Project.
- The sale of goods within or near the boundaries of the construction camp will be controlled. This will be done by registering traders and limiting the number of people who can carry out this service.

- Any damage to camp facilities and/or third party property will be reported in a timely manner to the direct supervisor.
- Graffiti on the construction camp premises, as well as any form of vandalism affecting the property of the Contractors, ATOME or third parties is prohibited.
- No Contractor's employees may make any statements related to the Project to the press or any other media, as only ATOME or the Stakeholder Engagement Programme team are allowed to do so.
- All employees must report any conduct that violates the Code of Conduct in general to their supervisor immediately.

Gender-based violence and sexual harassment

- Gender-based violence is strictly prohibited. To this end, the content to be provided to workers in environmental and social education will include awareness and familiarisation with the actions that constitute such violence, so that they can identify when it manifests itself.
- Gender-based violence targets not only women and girls, but also people of diverse sexual orientation or identity (gays, lesbians, transgender people, among others).
- Any action that may constitute physical, emotional, sexual and/or (financial) control and/or use of power against women workers, women and LGBTQI+ people in the area of influence of the works is strictly prohibited.
- Each worker will be penalised for any action that constitutes sexual harassment, rape or any form of physical or verbal aggression against workers and against women and LGBTQI+ people in the community in the area of influence of the works.
- Workers will be informed about the risks of contracting or transmitting sexually transmitted diseases in contact with the population of the communities surrounding the construction site.
- It is prohibited to deny opportunities to women, and to prevent them from competing for jobs recognised as male jobs, participating in job training, among other opportunities.
- All actions relating to issues of gender-based violence and sexual harassment will be dealt with in an appropriate manner, through mechanisms that maintain the safety of the victims and will be subject to the strictest sanctions (such as dismissal for serious cause, among others), without prejudice to the criminal consequences of such acts.

Hygiene and safety

- All employees must strictly comply with occupational safety standards. Any failure to comply with these standards will be considered a serious misconduct by the Contractors' Occupational Safety Coordinator.
- All workers must comply with the rules for the prevention of Covid-19 and other communicable diseases.
- Any employee shall report to the immediate Safety Supervisor any conduct which is unsafe or which does not conform to health and safety standards.
- Medical examinations must be carried out for admission, dismissal and for any change of job function.
- Any employee showing symptoms of illness shall report it immediately.
- All workers must agree to take vaccinations if necessary.

- All employees must have good personal hygiene habits. Disposal of rubbish outside the designated rubbish containers will not be permitted. Toilets must be used on the premises.
- Drivers of heavy machinery and equipment operators working off-site shall strictly follow road signs and traffic regulations and respect the prohibition of littering on the roads while travelling.
- The transport of third parties in work vehicles during construction related activities is strictly prohibited. Transport of third parties is only permitted with the express authorisation and under the direct responsibility of the Contract Manager and/or Contractors' Engineer.
- The use of construction service roads, speed limits and any instructions contained in signage must be complied with at all times.

Environmental and cultural heritage

- Fishing, hunting and physical harm of any kind to wildlife, as well as unauthorised cutting of vegetation and keeping of wild animals is strictly prohibited. Any worker found doing such actions will be dismissed immediately.
- Any visual contact with local terrestrial fauna within the Project areas must be reported without delay to the immediate supervisor for appropriate action to be taken by the environmental monitoring team.
- Feeding of local wildlife is prohibited.
- It is prohibited to keep, capture or affect in any way (mistreatment, running over, etc.) any type of domestic animal in the Project areas.
- Wandering in sensitive environmental areas outside the Project areas is prohibited.
- Lighting small bonfires or starting open fires is strictly prohibited.
- Any archaeological, palaeontological or historical remains or vestiges found during construction shall be preserved and reported to the immediate supervisor without delay.

General safeguard

- Some situations or aspects not foreseen above may arise during the process of execution of the works. In all these situations, diligent conduct is expected from workers, following the same ethical standard that guided the preliminary elaboration of this Code of Conduct.

5.6. Environmental and social education of workers

The Contractors' and subcontractors' employees will receive environmental and social education in standard 1 (one) hour modules, every 6 (six) months (or when necessary according to the activities executed) , administered at the construction camp, in which participation will be compulsory, with registration of all participants.

The environmental and social education modules will cover the following content:

- Summary of relevant environmental and social legislation, with emphasis on prohibitions on unauthorised logging of vegetation, fishing, hunting of wild animals, plant collection, damage to historical, cultural, archaeological and palaeontological heritage, noise emission;
- Prohibition of collection and hunting of wildlife, guidelines to avoid accidents with wildlife and guidelines not to attract domestic animals to work fronts and construction camps;
- Forest fire prevention;

- Importance of preventing and controlling erosion and environmental pollution;
- Solid waste disposal;
- Recognition of poisonous animals and procedures in case of bites;
- Archaeological, historical, cultural and palaeontological heritage - awareness-raising on the need for preservation, notions for identification and actions to be taken in case of chance finds;
- Explanation of how to act in case of emergencies such as accidents at work, accidental fires, among others;
- Possession and use of weapons in general - firearms and edged weapons, except when required by the function performed;
- Defensive driving training;
- Speed limits on service fronts, internal and external accesses;
- Presentation of the Code of Conduct for workers and rules on relations with the community in the area of influence;
- Sex education and communicable diseases.
- Respectful coexistence with the people living and/or working on the neighbouring farm, as the number may vary, and with the communities in the area of influence;
- Mitigation measures for negative impacts and environmental control instructions contained in this Plan, explained in simple and direct language, with the help of illustrations, to inform about good practices to be used and supervised in the works;
- Description of the environmental supervision/monitoring procedures for the works, focusing on the non-conformity management system;
- Use of personal and collective protective equipment (PPE and CPE);
- personal protective equipment (PPE);
- Among other issues.

6. Effectiveness Indicators

Programme indicators should manage/monitor the following key aspects:

- Detailed and approved Human Resources Policy procedures;
- Number of workers participating in job training events in relation to the total number of workers employed;
- Number of workers hired locally in relation to the total number of workers hired;
- Number of non-conformities (NC) recorded through the Environmental and Social Management Programme related to Labour and Employment conditions;
- Number of complaints/suggestions received through the suggestion boxes installed in the construction camp and response time;
- Number of employees participating in Environmental and Social Education events in relation to the total number of employees;
- Number of workers trained in the content of the Code of Conduct in relation to the total number of workers hired.

7. Reports

ATOME and Contractors shall detail the procedures of their Human Resources Policies.

Contractors' compliance with the procedures shall be evidenced by periodic reports during construction, which should include data on hiring, training and reduction in force for the period, and the results of the grievance handling mechanism.
Compliance will also be evidenced through periodic inspections and verification of labour documentation by contractors EPC and ATOME.

8. Implementation Schedule

The Human Resources Policy and Code of Conduct procedures shall be developed and approved prior to the start of construction. The implementation of the measures shall last throughout the construction phase.

Environmental and social education of workers shall commence after the training of the Contractors' teams and every six months during construction, or when necessary according to the activities executed, in a standard module of one (1) hour duration.

Worker recruitment measures will start at the planning stage and may extend to much of the construction phase while civil works and plant assembly are still in progress.

ATOME's Human Resources Policy will continue to apply in the operation phase of the Project, and standards of recruitment, training, working conditions and conduct will be required of subcontracted companies in this phase, such as road and river transport and maintenance companies.

P.06 - Emergency Response Programme for the Construction Phase

1. Justification of the Plan

The Construction Environmental Control Programme (P.01) provides procedures to prevent or mitigate impacts during project construction. However, emergency situations may arise in which Contractors must be prepared to act quickly. The Emergency Response Programme for the Construction Phase will minimise the environmental consequences of any accidental scenarios through rapid and effective emergency action.

2. Main Objectives

The objective of the Emergency Response Programme for the Construction Phase is the establishment of technical and administrative procedures for immediate, disciplined and efficient actions, through the use of trained manpower and appropriate equipment and materials to be applied in any emergency situation during the works phase of the Plant, LT and water supply and effluent discharge infrastructures. The main objective is, in the event of an accident, to obtain a quick and effective action aimed at preserving lives, preventing or minimising the destruction of the Project, protecting workers and the community and the environment of the region.

The objective of this Plan is also to communicate to all stakeholders about emergency situations, accidental release of contaminants, and occurrences that may endanger the population and the environment.

3. Applicable Legislation

The legislation set out in **Section 4.8** of the ESIA applies, in addition to the main applicable international requirements, including IFC GNs 1 and 4 and the IFC's General Environmental, Health and Safety (EHS) Guidelines.

4. Responsibilities

The Contractors are responsible for the execution of the Emergency Response Programme for the Construction Phase, under the supervision of ATOME. For this purpose, the Contractors will designate professionals who will perform the role of Emergency Coordinator.

5. Implementation Methodology

This Plan includes:

- Description of the emergency or disaster scenarios considered;
- The bodies to be involved according to the type of situation and collaboration agreements;
- The logical sequence of actions to be implemented in each case;
- The equipment and material and technical resources that Contractors, subcontractors and ATOME must rely on to support emergency actions;
- The delimitation of responsibilities.

The accident scenarios considered in construction are:

- Spillage of hazardous products;
- Fires / explosions;
- Extreme events, such as tropical storms and droughts.

Emergency Action Plans were developed for each situation and are presented below, covering the different scenarios envisaged for each type of accident/emergency and the minimum procedures to combat each hypothesis considered, including the following steps in all cases:

- Pre-assessment;
- Accident/emergency severity analysis;
- Selection of the procedure to be adopted;
- Activation sequence: forms of communication;
- Stabilisation and accident/emergency control measures;
- Corrective action as appropriate;
- Recovery/stabilisation monitoring.

The bodies to be activated vary according to the scenario considered. However, depending on the accidental hypotheses considered, the following entities, bodies or intervening elements will be included:

- ATOME;
- Contractors and subcontractors;

- National Emergency Secretariat - SEN;
- Departmental and local emergency organisations;
- Fire Brigade;
- MADES;
- Directorate of Watershed Management;
- Hospital and first aid;
- Traffic police;
- Sanitation Board.

5.1. Emergency Action Plan in case of spillage of hazardous products

The present Emergency Action Plan aims to define actions to respond to accidental events involving the leakage of hazardous products with contamination of watercourses and/or soil during construction activities.

Resources required to address the accidental scenario envisaged

- Containment barriers;
- Industrial absorbents;
- Fuel/oil collection swabs;
- Casks to receive collected fuel/oil or contaminated soil;
- Absorbent foam for fuel and/or lubricant leaks in sufficient quantity.

Organs to be activated

- ATOME;
- Contractors and subcontractors;
- MADES;
- Directorate of Watershed Management;
- Junta de Saneamiento de Villeta (in case of contamination of watercourse used for water catchment);
- Fire Brigade, if necessary.

Emergency response procedures

This Emergency Action Plan will be implemented with the support of existing communications systems at the construction sites and camp. All leaks of fuels and/or hazardous products will be reported immediately to the person responsible for the camp or construction site, who will activate the Emergency Coordinator.

The procedures to be adopted in the event of spillage of hazardous products into watercourses and onto the ground are as follows:

1. Immediately stop the activities that led to the leak, as appropriate (pumping, discharging, other);
2. Eliminate all nearby ignition sources (turn off vehicles and equipment);
3. Identify the point of leakage and stop where possible (broken hoses, tanks, others);

4. After the above initial actions, the person responsible for the work front will isolate the area and prohibit access;
5. Identify the spilled product;
6. Communicate with the Emergency Coordinator, describing the size and severity of the situation;
7. Activate protocol and communicate to MADES and the Fire Brigade if necessary;
8. Communicate to the ATOME Environmental Monitoring team;
9. Activate the trained service and fire brigade team;
10. Identify the points reached by the leak/spill;
11. After assessing the situation, the trained team, equipped with the necessary PPE, will carry out the appropriate measures;
12. Implement containment measures followed by absorption and placement of spilled products in drums or other devices;
13. Implement containment measures with floating barriers, followed by absorption (or pump suction) procedures;
14. When the leakage reaches the margins of the water body, identify the sensitivity index, the type of margin affected and the possible consequences of the pollution;
15. Carry out the rescue of fauna possibly affected by the spill;
16. Implement remediation procedures, including scraping and stockpiling of contaminated soils and clean-up of spills by application of industrial absorbents and other measures as may be indicated by the manufacturer of the spilled product;
17. In case of leakage/spillage on the ground, apply industrial absorbents;
18. Pack all absorbents and contaminated soil in appropriate drums and then send to treatment, recycling or disposal companies.

5.2. Emergency Action Plan for fires/explosions

This Emergency Action Plan aims to define sequential actions to respond to accidental events involving fires in the Project areas, followed by explosion or reaching the surrounding vegetation.

Resources required to address the accidental scenario envisaged

- Fire extinguishers in sufficient number and type for initial fire fighting;
- Tanker truck or towable water tank;
- Tractor to make emergency firebreaks.
- Fire warning sirens;
- Specific PPE: gloves, helmet, respirator, chemical safety goggles.

Organs to be activated

- ATOME;
- Contractors and subcontractors;
- National Emergency Secretariat - SEN;
- Departmental and local emergency organisations;
- Fire Brigade;
- MADES;
- Hospital and first aid;
- Traffic police.

Emergency response procedures

This Emergency Action Plan will be implemented with the support of the existing communications systems at the construction sites and camp. All fires will be reported immediately to the person responsible for the camp or construction site, which will activate the Emergency Coordinator.

The procedures to be adopted in the event of fire/explosion are as follows:

1. Keep fire prevention and extinguishing systems in perfect working order, as well as emergency exits unobstructed and signposted;
2. On identifying the fire, report to the Emergency Coordinator with a description of the size and severity of the situation;
3. Activate the Contractors' fire brigade and fire brigade;
4. Remove the victims;
5. Isolate the area to a radius of at least 300 (metres) if there is an explosion, with only members of the service teams remaining near the site;
6. Activate emergency medical care according to the nature of the injuries;
7. Move the water truck and tractor to the site for firebreak implementation;
8. Initially combat with water and use of manual buffers;
9. Cool (laterally with water) equipment exposed to flames, even after the fire has been extinguished;
10. Execute the emergency firebreak around the burnt area using the tractor;
11. Monitor situations of reactivation of braziers;
12. Remove nearby flammable materials that could be affected by fire;
13. In case of fire affecting forest areas, inform MADES;
14. Activate traffic police if fire reaches roadside vegetation.

5.3. Emergency Action Plan for extreme events, such as severe storms and droughts

This Emergency Action Plan aims to define sequential actions to respond to emergency situations due to storms or droughts, extreme events considered of high or medium risk in the Project area (see **Section 5.2.1.4**).
The following emergency situations are considered in these events:

- Physical damage to structures on the construction site and in the construction camp;
- Affected water supply for human consumption and outbreak of communicable diseases and other aggravations related to the consumption of poor quality water due to drought (e.g. outbreaks of diarrhoea, dengue fever, gastrointestinal infections, trachoma, dehydration).

Resources required to address the accidental scenario envisaged

- Meteorological Station Silvio Pettirossi Airport (Luque);
- Communicator radios;
- Vans and other 4x4 vehicles for local service;
- Crane truck;
- Specific PPE: gloves, helmet, respirator, chemical safety goggles;

- Emergency alarm and communication system;
- Medicines, supplies and equipment;
- Drinking water.

Organs to be activated

- ATOME;
- Contractors and subcontractors;
- National Emergency Secretariat - SEN;
- Directorate of Meteorology and Hydrology (DMH);
- Departmental and local emergency organisations;
- Fire Brigade;
- MADES;
- Hospital and first aid;
- Rural patrols;
- Traffic police.

Emergency response procedures

The procedures to be adopted in the case of physical damage to structures on the construction site and in the construction camp are as follows:

1. Notify the Emergency Coordinator, giving a description of the size and severity of the situation;
2. Disconnect all equipment immediately;
3. Evacuate areas at risk of structural collapse due to wind;
4. Activate the fire brigade;
5. Allow access to the affected area only to Fire, Police, Rural Patrols, Ambulance and support agencies;
6. On arrival at the site, conduct a reconnaissance to verify the occurrence of casualties;
7. Activate emergency medical care according to the nature of the injuries;
8. Remove the victims;
9. Allow access to areas only after removal of debris and unstable parts of structures.

The procedures to be adopted in the event of disruption of drinking water supply and outbreaks of communicable diseases and other aggravations related to the consumption of poor quality water due to drought (e.g. outbreaks of diarrhoea, dengue fever, gastrointestinal infections, trachoma, dehydration) are as follows:

1. Constantly monitor the risks of severe drought through climatological data from the region;
2. Maintain updated protocols and operational procedures necessary for the implementation of alert and response management actions;
3. Maintain a stock of drinking water;
4. Maintain a stock of medicines and strategic inputs to respond to diseases and grievances arising from drought conditions;
5. Keep the first aid room and ambulance at the construction camp operational;
6. To have an occupational physician as part of the permanent resources;

7. Establish an agreement with a hospital;
8. Train workers on water consumption and hygiene in situations of water scarcity;
9. Activate emergency medical care according to the severity of the illnesses;
10. Remove the victims;
11. Providing support to the four residents of the neighbouring farm in case of illness or injury, through assistance in the camp's first aid room and transport to the hospital.

6. Effectiveness Indicators

The indicators of this programme are:

- Number of trainings conducted per year;
- Number of workers trained in emergency response activities;
- Number of emergencies controlled, considering the following aspects: extent of damage, applicability of procedures, response time and efficiency of the workers involved in the action;
- Evidence of the preparation of the Environmental Emergency Report - EER for each emergency/accidental event that has occurred.

7. Reports

For each emergency/accident event, an Environmental Emergency Report - EER shall be prepared, which shall include at least the following information:

- Identification of the emergency/accident;
- Date and time of the emergency/accident;
- Location of the emergency/accident;
- Description of third party involvement;
- Victims, including names and place of assistance;
- Affected areas, discriminating water bodies, adjacent forests, etc..;
- Structures affected;
- Equipment used in assistance;
- Investigations/Cause(s), discriminating between:
  - Natural / induced;
  - Equipment failure;
  - Human failure;
  - Failure of retaining structures;
  - Failure of facilities;
  - Other (specify).
- Staff involved in assistance:
  - Internal: members of the fire brigade, engineer and occupational safety technician, and others;
  - External: Fire brigade, SEN technicians, DGCH, MADES, etc.
- Additional information from the report:
  - Description of the emergency/accident;
  - Provisions / consequences, briefly reporting the actions taken to neutralise the damage to safety and the environment;

- Information on the disclosure of the emergency/accident (if it was public knowledge);
- Preventive measures necessary to prevent similar emergencies/accidents.

- Information on the person responsible for the report.

The IEA will be prepared by the Contractors' Environmental Management and sent to the ATOME HSE Management Team.

8. Implementation Schedule

The Emergency Response Programme for the Construction Phase shall commence prior to the commencement of the Project works, with the preparation of the Emergency Action Plans by the Contractors, and shall apply throughout the construction period, including the period of deactivation of the work fronts.

Emergency response team trainings will be conducted semi-annually.

P.07 - Biodiversity Action Plan (BAP)

1. Justification of the Plan

The Project's construction activities will result in direct and indirect negative impacts on the biota and habitats of the AID.

The land where the project will be implemented has natural habitats in a good state of conservation, with endangered species of flora and fauna. The expected impact of the project is expected to be small, with an initial impact of 25.51 ha (including 24.75 ha of native vegetation existing in zones A and B of the land where the plant will be installed - see **Figure 6.1.3.2.a**, 0.07 ha corresponding to the existing savannahs in the service strip of the TL and 0.69 ha in the pipeline easement). Of these 25.51 ha, 2.9 ha are sub-humid forest and 22.61 ha are savannahs. At a later stage of Plant expansion, it may be necessary to remove vegetation from zone C shown in **Figure 6.1.3.2.a**, with a total area of 5.1 ha, 3.38 ha of sub-humid forest and 1.72 ha of savannahs. As a result, the total removal for the Plant and LT easements and pipelines would amount to 30.61 ha, of which 6.28 ha are sub-humid forest and 24.32 ha are savannahs.

Despite the small impact, it should be noted that the sub-humid forest is considered a natural habitat of great importance for biodiversity that is protected by national laws and has a high degree of degradation.

Project construction activities will result in direct and indirect negative impacts on the biota and habitats of the DIA. In accordance with IFC Performance Standard (PS) 6, mitigation measures will be designed to achieve no net loss of biodiversity in natural habitats.

These measures will be detailed in a Biodiversity Action Plan (BAP), which should be developed based on the recommendations of the IFC's Guidance Notes (GN) to IFC's PS6 (version 27 June 2019), and also on IDB Invest's Environmental and Social Sustainability Policy, which alludes to IFC's PS6.

2. Main Objectives

The main objectives of the Plan are as follows:

- Structure the project's mitigation strategy according to the mitigation hierarchy stages set out in IDB Invest's Environmental and Social Sustainability Policy and in IFC's PS6 NO16;
- Detail the measures needed to achieve zero net loss of natural habitats;
- Use data from wildlife monitoring to support the development of the BAP.

3. Applicable Legislation

The legislation related to the protection of flora and fauna mentioned in **Section 4.1, 4.2** and **4.3** of the ESIA applies. In addition, IFC Performance Standard 6 and respective Guidance Notes (version 27 June 2019) and the IDB Invest Environmental and Social Sustainability Policy also apply.

4. Responsibilities

ATOME is responsible for the Biodiversity Action Plan, allocating the necessary physical, human, administrative and financial resources for its elaboration and implementation. For the monitoring, ATOME will hire teams of biologists specialised in flora and in each fauna group.

The BAP should be developed in accordance with international best practice, with the support of experts and in consultation with stakeholders.

5. General guidelines for the elaboration of the BAP

The BAP should be developed in accordance with international best practice, with the support of experts and in consultation with stakeholders, and should consider IFC's PS6, specifically Guidance Note (NO) 91 and the IDB Invest Environmental and Social Sustainability Policy which refers to IFC's PS6. The BAP should include time-bound implementable actions with adequate budget allocations, which should be detailed in the Biodiversity Conservation Programme (the Biodiversity Monitoring and Assessment Programme).

The BAP should contain the following structure:

- Presentation and justification;
- Objectives;
- General description of the project;
- Description of applicable laws and regulations related to biodiversity, including applicable international laws;
- Overview of the baseline biodiversity and critical habitat assessment, which is presented in more detail in the ESIA;
- General description of the project alternatives analysis, which is presented in more detail in the ESIA;
- General description of the impacts of the project on biodiversity, which is presented in more detail in the ESIA;

- Proposed actions to achieve zero net loss for natural habitats. This section should include an assessment of ecological/technical, social and political feasibility, as well as address assumptions, uncertainties and risks. In addition, the calculation of zero loss should be clearly demonstrated;
- Monitoring and Evaluation Programme (detailed below);
- Relationship with the other programmes of the ESMP;
- Timeline, budgets and organisational requirements.

Biodiversity Conservation Programme

Fauna and Flora Monitoring

The monitoring of fauna and flora at specific sampling points aims to verify the impacts of the project on endangered species of flora and fauna, to contribute with information for the preparation of the BAP to achieve zero loss, and also to assess the effectiveness of the project's mitigation measures.

Monitoring should be carried out in areas of remaining natural vegetation. This measure is important to verify the permanence and use of local fauna in the areas to be preserved, the identification of the health of relocated flora individuals and the identification and control of anthropogenic agents, such as the presence of invasive alien species.

Monitoring should follow the same methodology and target groups as the environmental assessment, using non-invasive methods and including birds, bats, large mammals, reptiles and amphibians.

The implementation team shall be composed of a flora specialist, an ornithologist, a mammal specialist and a herpetologist (reptiles and amphibians).

Flora sampling should aim to assess the health of relocated individuals, evaluate the conservation status of the native habitat and assess the presence of invasive alien species and, if necessary, develop control measures.

As most species of medium and large terrestrial mammals can be identified in the field, sampling should be by direct and indirect observation methods with time-limited camera traps and binoculars. Indirect methods such as finding tracks, faeces, burrows, etc. should also be used and recorded.

For the group of aerial insectivorous bats, ultrasonic recorders must be used and identification must be carried out manually in specific programmes.

For reptiles and amphibians, time-limited searches should be conducted in different strata/environments and at different times to cover the different activity schedules of the species. Recorders should be used to record amphibian vocalisations.

For the bird group, observations should be made in the early hours of the day and in the late afternoon for direct and auditory observation, through binoculars and recorders.

In addition to the specific equipment for each group, all professionals must carry cameras to record the species in the field.

- Effectiveness Indicators

The following indicators are suggested for the evaluation of the effectiveness of monitoring:
  - Number of species recorded in fauna monitoring;
  - Number of species recorded in flora monitoring;
  - Number of invasive alien species recorded in conservation forests.

- Reports and Documentation

For the monitoring of flora and fauna species, quarterly progress reports will be prepared on the selection of sampling areas and installation of markers. Partial reports will be prepared after the completion of each monitoring campaign, with the results collected in the field.

- Implementation Schedule

Fauna and flora monitoring should cover the entire seasonal period (dry and rainy) for at least one year after project installation.

Compensation Measures to be proposed in the BAP

Environmental compensation through forest conservation

The implementation of the Project will result in negative impacts to biota, such as conversion of forest habitats and the impact on populations of endangered species of flora and fauna. Although the project region is highly anthropised, the remaining natural habitats are of regional importance for the maintenance and dispersal of biota.

Law No. 422/1973 declares the rational use and management of the country's forests and forest lands to be in the public interest, as well as the protection, conservation, improvement and enhancement of forest resources to be in the public interest and compulsory.

IFC PS6 also establishes conservation as a mitigation measure for natural habitats. According to paragraph 15 of PS6, appropriate mitigation measures to achieve no loss of biodiversity in natural habitat areas include the prevention of impacts on biodiversity through the identification and protection of reserve areas.

Thus, in order to compensate for these negative impacts, conservation actions are proposed for the forest fragments on the Project site. These conservation fragments will be subject to relocation measures for rescued flora individuals, as well as monitoring of flora and fauna to assess their conservation status and the possible presence of exotic species or other anthropogenic agents.

In this respect, the following actions are proposed:

- Adjust the areas of future expansion of the Project, so as to enable the conservation of as

much native vegetation as possible on the site, especially forests. In this regard, as already mentioned, it is initially foreseen to remove vegetation only in Zones A and B of the Plant site (see **Figure 6.1.3.2.a**), keeping Zone C, where most of the existing sub-humid forests in the area are located, preserved;
- Implement informative signage indicating that these are conservation forests;
- Develop flora and fauna monitoring.

Forest conservation shall be carried out during the operation of the Project.

Environmental compensation through the purchase of Environmental Services Certificates (ESCs)

The Law N° 3.001/2006 ("On Valuation and Retribution of Environmental Services") determines in its Chapter V the obligation to invest in environmental services:

Art 11. - Projects of works or activities defined as having a high environmental impact, such as construction and maintenance of roads, hydraulic works, power plants, transmission lines, pipelines, port works, industries with high levels of gas emissions, discharge of industrial, urban or other effluents, shall include within their investment plans compensation for environmental services, by means of the acquisition of environmental services certificates, not less than 1% of the cost of the work or of the annual operating budget of the activity.
Resolution Nº 81/2019 ("Article 8 of Decree 11.202/13, which partially regulates article 11 of Law Nº 3001/2006) establishes in its article 1 as *projects of works and activities of high environmental impact "those resulting from physical or human actions, of significant effect both in the area of influence as well as in the severity of the action considered practically irreversible, i.e. with the impossibility of the environment to return to the initial situation".*

Annex I of Resolution No. 81/2019 lists the works of high environmental impact, including the following:

- Item d: Construction and installation of overhead transmission lines and electrical substations from 220 kV.
- Item e: Construction of industrial establishments with investments of USD 50 million or more.

Annex II of the Resolution lists the activities with high environmental impact, highlighting "item f: operation of chemical industries: all basic industrial chemical factories".

However, as shown in the risk and impact analysis (**Sections 6.1.3 and 6.1.4**), with the application of the mitigation measures detailed in the various ESMP Programmes, the Project does not constitute a high impact activity in its operational phase, taking into account the design and characteristics of the plant's equipment, which considers the best technologies available on the market, the activities inherent to the operation and the environmental and social management measures to be implemented, as well as the quantities of waste generation (see quantities in **Section 2.4.1.5), effluents (77.30 m /h) and atmospheric emissions (see Table 2.4.1.6.a in Section 2.4.1.6).4.1.5**), effluents (77.30 m^3 /h) and atmospheric emissions (see **Table 2.4.1.6.a** in **Section 2.4.1.6**).

In view of the above, the compensation for environmental services of the Project applies to

items d and e of Annex I of Resolution No. 81/2019, referring to the works of the transmission line (item d) and the ATOME Plant (item e). For the latter, the items of high environmental impact are composed of earthmoving services that include land clearing, excavations, embankments and disposal of the resulting material.

The total cost of the high environmental impact items for the works to be executed is shown below. It should be noted that these costs are still preliminary and will be refined during the detailed design of the project.

The final quantification of the environmental compensation, as well as the process of acquiring environmental services certificates, will be executed by the Environmental Management Programme team.

Activity	Cost (U$)
Item d: Construction and installation of high-voltage transmission lines and transformer substations	
Plant substation (SE)	**1,063,197**
220 kV equipment civil works	202,644
Civil works for gantries	254,869
Civil works of electrical house (switchgear room and control room of dimension 62 x 15 m).	602,997
Electrical and electromechanical installation, commissioning and start-up	2,687
220 kV power transmission line (LT)	**63,667.24**
TOTAL (SE+LT)	**1,126,864.24**
Environmental compensation (1%) item d	**11,268.64**
Item e: Construction of industrial establishments	
Earthmoving Services	
Clearing and clearing of land	252,618.06
Removal of trees	6,699.90
Excavations	224,108.56
Supply and embankment	1,728,304.56
Transport to landfill	342,606.07
Total	**2,554,337.15**
Environmental compensation (1%) item e	**25,543.37**
Total Project Environmental Compensation	**35,812.01**

Environmental compensation for felled trees

Although ATOME's property is located in an area surrounded by industries and agricultural activities, not constituting an urban area, the company intends to use as a reference Law 4928/2013 "De Protección al Arbolado Urbano" and Ordinance No 07/2022 that regulates this law in the municipality to define the compensation measures.

As compensation for the affected trees, ATOME will work with the Environment Directorate of the municipality to define the actions to be implemented, these will consider: i) perimeter tree planting on ATOME's land, ii) delivery of small trees (seedlings) or native tree seedlings of 1 meter high with their respective protectors to the Municipality to be destined to the Municipal Nursery, iii) planting of seedlings or seedlings in places approved by the Municipal Arborisation Plan of Villeta.

Article 4 line "a" defines a tree as "an *evergreen plant with a woody, tall trunk, branching at a certain height above ground level*".

The coordination and communication with the authorisations for the definition of the above-mentioned compensation measures will be carried out by the ATOME environmental management team responsible for the Environmental and Social Management Programme.

- Effectiveness Indicators

The following indicators are suggested for the evaluation of the effectiveness of compensation measures:

- Area of protected native vegetation, especially forests;
- Progress in acquiring environmental certificates;
- Evidence of payment of the amount of compensation through purchase of environmental services;
- Number of seedlings/saplings planted by ATOME on its property, in relation to the number of trees felled;
- Number of seedlings/ saplings and respective protectors planted in locations designated by the Municipality, in relation to the number of trees felled;
- Number of seedlings/saplings and respective protectors effectively delivered to the Environmental Directorate of Villeta, in relation to the number of trees felled.

- Reports and Documentation

For the compensation measure by means of forest conservation, progress reports of activities will be bimonthly, which should contain the actions carried out to formalise the conservation and marking of the area, with partial results reports every six months.

For all measures in the plan, annual reports will be prepared with consolidated results, including information on the effectiveness indicators listed in the previous section for the period.

For compensation measures through the acquisition of certificates for environmental services and felled trees, progress reports on the activities will be bimonthly, and must contain the actions carried out to formalise the process of acquiring certificates and the destination of the compensation to the Municipality of Villeta.

- Implementation Schedule

Compensation measures must be completed before the operation phase of the Project.

P.08 - Programme for the Prevention of Impacts on Flora and Fauna

1. Justification of the Programme

The land where the project will be implemented has natural habitats in a good state of conservation, with endangered species of flora and fauna. The expected impact of the project is expected to be small, however, it should be noted that the existing ecosystem, the sub-humid

forest, is considered a natural habitat of great importance for biodiversity that is protected by national laws and presents a high degree of degradation.

The construction activities of the Project will result in direct and indirect negative impacts on the biota and habitats of the AID and, for mitigation and compensation, this Biodiversity Conservation Programme is proposed.

2. Main Objectives

The main objectives of the Programme are as follows:

- To reduce the loss of floristic diversity in the areas cleared for the implementation of the project by rescuing and relocating plant germplasm;
- Reduce the impact on wildlife during clearing activities, with the implementation of wildlife scaring for adjacent areas that will not be affected.

3. Applicable Legislation

The following legislation related to the protection of flora and fauna mentioned in **Section 4.3** of the ESIA applies, in addition to the requirements of IFC PS 6 and the IDB Invest Environmental and Social Sustainability Policy which refers to PS 6 mentioned above.

4. Responsibilities

ATOME will allocate the necessary physical, human, administrative and financial resources for the elaboration of a protocol for germplasm rescue and wildlife rescue and repelling. This protocol will include all the necessary details to ensure that the implementation is carried out in accordance with the aforementioned applicable legislation and the recommendations of MADES.

The protocol will be handed over to the EPC Contractor for implementation, a contractual requirement being the hiring of a team of biologists and a veterinary doctor specialised in wild animals for its implementation.

ATOME will monitor the implementation of the protocol through its HSE Management Team.

5. Implementation Methodology

5.1. Rescue of germplasm

The clearing of vegetation for the implementation of the project will result in the disturbance of natural habitats, however, it will allow access to biological material, especially tree propagules and specimens of epiphytes and hemiepiphytes, which, in principle, would be lost with the removal of vegetation. Such material is of great value for increasing scientific knowledge on the local flora and also contains important information on the genetic diversity of the populations. It is therefore proposed to rescue germplasm prior to clearing activities in order to mitigate and compensate for some of the impact generated by the loss of native vegetation. This activity will start before the BAP is developed (P.07). However, it is an important part of the mitigation hierarchy of the project, in the impact minimisation phase, and will be carried out

simultaneously with the BAP development process.

It is important to rescue germplasm of all flora species. However, it is important to pay special attention to the rescue of species threatened with extinction such as those categorised as endangered in MADES Resolution 470/2019, as well as non-timber forest species such as orchids, kangorosa, easily moved shrubs and adaptability resistance will also be considered.

For the elaboration of a list of priority species for this measure, the lists of species of the region where the project will be located, presented in the section on the diagnosis of flora and vegetation, should be considered.

Plant germplasm can be collected in the form of fruits and seeds and also from individuals of epiphytes and hemiepiphytes. Collection of botanical samples for herborisation is recommended, with proper recording of location data. The rescued germplasm will be relocated in the remaining forests within the land destined for conservation, and also in the surrounding forests and/or donated to nurseries, *ex situ* botanical collections and herbariums of regional research institutions, and may also be used in revegetation and landscape recovery actions, and in the areas intervened by the work.

Germplasm rescue must comply with the following:

- Identify/mark in situ the areas/individuals where endangered species are found.
- Preferably cover different fruiting periods;
- Identify rescued species to the lowest possible taxonomic level;
- Preferably, collect botanical samples for the preservation of core material, to be deposited in herbaria or *ex situ* botanical collections;
- Collect information on the quantity (weight or number of individuals) of materials collected;
- Collect data on the location and type of environment of rescue and relocation areas.

Germplasm rescue must be carried out in all areas where project implementation requires the clearing of native vegetation.

5.2. Pre-scaring and rescue of fauna during the construction phase

Pre-scaring and rescue of wildlife in areas where vegetation will be removed is an important measure to minimise the negative effects of the project on wildlife present in the Directly Affected Area. This activity will start before the BAP (P.07) is prepared. However, it is an important part of the project's mitigation hierarchy, in the impact minimisation phase, and will be carried out simultaneously with the BAP development process.

Wildlife rescue is aimed at species with low mobility, such as amphibians, snakes, small mammals with fossorial and semi-fossorial habits. In the case of fauna repelling, the focus will be on animals with a greater capacity for locomotion, mainly medium and large mammals, such as deer, felines, primates, etc., as well as birds and large lizards. These animals will be passively driven away to adjacent areas without the need for trapping.

The execution of the procedures for pre-scaring and rescue of wildlife will be the responsibility of a team made up of wildlife biologists and a veterinary doctor with experience in wildlife

management, who will carry out this activity with the support of the clearing teams, who will be properly oriented and trained to carry out the pre-scaring, as they will receive orientation as part of the training in clearing procedures established as part of the Construction Environmental Control Plan. A wildlife pre-scaring team will be assigned to each suppression front.

The rescue procedure for low mobility fauna, especially amphibians, snakes, small mammals is designed to rescue them and subsequently release them in previously delimited areas that have not been subject to any intervention.

Pre-clearing procedures are passive measures targeting some groups of fauna, mainly medium and large mammals and birds. A prior analysis of the areas to be cleared is necessary in order to optimise the direction of the removal, thus increasing the efficiency of the method. Through synchronised and targeted procedures, fauna with greater mobility capacity will be displaced to other fragments of vegetation or nearby areas that will not be affected by the clearing.

Members of the scaring team will use instruments and materials that emit a high-pitched sound (e.g. horns, metal objects, whistles, etc.). Rockets can also be used to scare away large wild vertebrates such as primates, felines, hawks, etc. All members shall work with appropriate protective clothing such as boots, gloves, leggings and thick trousers to avoid accidents.

Teams should proceed as follows:

- In each clearing section, the team of biologists will guide the field assistants on the direction to take to make synchronised noises;
- The team will start this activity 60 minutes prior to clearing activities in the area with vegetation removal activities;
- Any sighting of wildlife specimens in the inspected section shall be reported to the responsible coordinator, with subsequent rescue if necessary;
- If active nests or burrows are found in the area, they will be marked with marking tape, geo-referenced and then rescued;
- If the wildlife team finds specimens of terrestrial vertebrate fauna in the affected area, they will be captured and placed in a containment box for later release;
- Injured animals will be captured by the wildlife and veterinary team and sent to the nearest veterinary clinic.

Animals shall preferably be chased away. Rescue shall only be carried out with animals that are not very mobile or have been found injured.

The transport crates of rescued animals shall be ventilated and humidified until the animal can be released elsewhere or sent to a veterinary clinic in case of injury.

Animals that are considered healthy and suitable for release will be released in areas close to the capture sites. It is important that the release areas are located in areas with similar vegetation to the capture areas, located close to the register and which will not be impacted by the works. Fragments of vegetation suitable for receiving the animals will be evaluated in the field by the wildlife team, choosing as a priority those closest to the capture site.

During the process of vegetation removal and after clearing, accidents with resident fauna may

occur, which may somewhat impede the passive dispersal of specimens to unaffected areas. All animals found injured or possibly injured due to construction activities will be rescued and sent to veterinary clinics in the IIA municipalities to assess their health status. Subsequently, all animals will receive the necessary care before being sent to the release areas and/or to repository institutions in case of death.

The veterinary clinic shall be identified prior to the commencement of work and shall have experience with wild animals.

The rescued animals will undergo biometric procedures, taxonomic identification and classification for their fate.

A database of all rescued and/or collected animals shall be created, containing the following information: place of capture (with coordinates), taxonomic identification (as small as possible), final destination (including coordinates in case of release), as well as their physical and clinical conditions at the time of rescue and other information considered relevant.

The general measures mentioned in items 5.1 and 5.2 will constitute guidelines for the elaboration of the protocol for germplasm rescue and wildlife rescue and relocation and removal. The protocol will include further details about the methodology, materials and/or tools needed, as well as human resources required for the formation of the team of biologists that will lead the actions.

6. Effectiveness Indicators

The following indicators are suggested for the evaluation of the Programme's effectiveness:

- Rate of clearing fronts where plant germplasm rescue was carried out;
- Number of species rescued, with emphasis on priority (threatened) species;
- Number of individuals or quantity of fruits or seeds rescued;
- Ratio of individuals relocated or materials donated to total rescued;
- Rate of clearing fronts where wildlife repelling was carried out;
- Number of species and individuals of fauna rescued.

7. Reporting and Documentation

The teams implementing the actions foreseen in the Programme will prepare progress reports of the activities, partial results reports and consolidated reports, destined for the ATOME environmental management team.

For the rescue of germplasm and the scaring and rescue of fauna, monthly progress reports will be drawn up, reporting the activities carried out and the difficulties encountered, with evidence of the execution of the work. Partial results will be presented in six-monthly reports.

8. Implementation Schedule

The rescue of germplasm and the scaring and rescue of fauna will be carried out concomitantly with the clearing activities during the construction phase.

P.09 - Environmental and Social Management Programme of the Operation Phase

1. Justification of the Programme

This programme focuses on the need to manage the potential environmental and social impacts associated with the operation phase of the Project.

2. Main Objectives

The main objective of this Programme is to manage the potentially impacting actions arising from the operation phase of the Project in environmental and social components.

The specific objectives are:

- Standardise the criteria and methodological procedures to be applied in the process of controlling the environmental and social aspects of the Project's operation;
- Monitor and manage environmental and social impacts and/or risks and control their actions or activities;
- Hire and train workers in the operation and maintenance (O&M) phase, seeking to include people from the region among those hired;
- Manage the waste generated in the operation phase of the Project;
- Control odour, noise and atmospheric emissions to avoid nuisance to the local population;
- Monitor treated effluent and water quality in the receiving body;
- Maintain operational channels of the Complaints Handling Mechanism and communication with P.03 stakeholders.

3. Applicable Legislation

- Law N° 294/93, on Environmental Impact Assessment, regulated by Decree N° 453/13.

They establish that the actions related to obtaining the Environmental Impact Statement extend to the operation phase of the projects.

- Law No. 6681/2020, amending Article 1 of Law No. 976/1982, extending Law No. 966/1964;

Article 1 of Law No. 6681/2020 determines, as a safety and service zone for 220,000 volt transmission lines, a distance of 50 m, 25 m measured on each side of the axis. According to Art. 2 of Law No. 976/1982, ANDE shall proceed, without any compensation, to demolish any work or construction carried out in the aforementioned area with easement already established and to remove the materials, as well as to adopt all necessary measures to ensure the permanent and effective operation of the service.

4. Responsibilities

ATOME will contract companies with proven experience in the operation and maintenance of similar facilities. These companies will be responsible for implementing some of the measures of this Programme, such as solid waste and hazardous product management, monitoring of

treated effluent, environmental and social training of the O&M team, odour control and maintenance of the easement strip. To this end, they will be contractually obliged to have a sufficient team to fulfil these measures and those of other operation phase programmes under their responsibility, such as the Operation Phase Occupational Health and Safety Programme, the Labour and Working Conditions Management Programme, the Operation Phase Emergency Response Programme, and the Operation Phase Transport Management Programme.

ATOME will monitor the compliance of the measures by the contracted O&M companies and will carry out the measures of this Programme under its responsibility, including the social programmes and the implementation of the BAP during operation.

5. Implementation Methodology

5.1. Supervision of compliance with environmental and social measures in the operation phase

The ATOME HSE Management Team will be responsible for:

- Oversee the social, environmental and health and safety performance of the operation phase programmes to be implemented by the operating companies;
- Analyse and evaluate the results of each plan and programme, including verification of their adequacy and/or relevance and the need to adjust their scope or technical specifications;
- Manage together with ANDE the maintenance activities of the TL and systematically monitor the conditions of the easement strip;
- Produce annual Operation Phase Environmental Programme Reports in accordance with standardised procedures and documentation standards defined in the construction phase;
- Conduct annual audits of environmental, social and health and safety performance, including that required by Resolution N° 201/2015, reviewing in more detail the related documentation, monitoring the results obtained in the implementation of the Programmes of the operation phase.

5.2. Environmental and social training of the operation and maintenance (O&M) team .

In addition to the environmental integration training, the companies contracted for operation and maintenance of the Plant, the LT and the water catchment system and water and effluent pipelines, shall provide technical guidance to O&M personnel to adapt their routine procedures to environmental and social impact minimisation guidelines, and shall be informed of the possible environmental consequences of performing services without appropriate precautions.

Topics to be addressed in the environmental and social training for the O&M phase include:

- Fundamentals of environmental, social and health and safety legislation;
- Care for flora, fauna and water resources;
- Fire prevention;
- Importance of environmental pollution prevention and control;
- Reuse, recycling, segregation, control and disposal of waste;
- Traffic management measures;
- Procedures for action in the event of environmental accidents;

- Contact and relationship with neighbouring communities.

Environmental and social training events will also be extended to vehicle drivers and other workers of companies subcontracted for NH_3 land transport or will require the presentation of a certificate of training on environmental and social issues conducted by the companies themselves with their workers.

Initially, training events are expected to be implemented annually. However, the frequency should be defined according to need, verified according to the number of cases related to non-compliance with the technical guidelines transmitted.

5.3. Solid waste management

The solid waste and hazardous product management process is the instrument through which the companies contracted to operate and maintain the Plant, the TL and the water collection system and water and effluent pipelines will manage all solid waste flows generated in the Project's O&M activities.

The solid waste management process is structured in the following main stages:

- Identification and classification of solid waste;
- Packaging, sorting and collection;
- Temporary storage;
- Transport;
- Treatment and final disposal.

Types of waste to be generated

During the operation of the Plant, common waste will be generated from offices, toilets, canteen; organic waste such as food waste; used PPE and EPCs; waste from sweeping and pruning of green areas; contaminated waste resulting from maintenance activities, such as dirty oil rags, empty lubricating oil containers, chemical product containers; expired chemical products; parts and components; remains of pipes; sludge from water treatment plants; sludge from wastewater treatment plants; used batteries; used light bulbs; among others.

It also includes rubbish eventually disposed of in the LT easement strip by the population; waste from vegetation clearing and easement strip maintenance activities (cleaning and pruning operations); scrap metal and defective parts (replacements), which may include conductors, insulators, metal structure components; and miscellaneous waste contaminated with oils, lubricants, grease, etc., resulting from LT maintenance.

Packaging, sorting and storage

The waste generated in treatment will be collected in different containers that will be kept in a waste storage area at the Plant, until its collection and final disposal in the sanitary landfill or collection by a company duly authorised for the final destination of each type of waste.

The waste storage area shall be properly identified, covered, ventilated and with an impermeable surface. Oily and other hazardous waste shall be placed in containers marked with the symbol "hazardous waste", which shall be leak-proof.

Mixing of waste of different classifications, such as hazardous waste with non-hazardous waste, shall be mainly avoided. In case of mixing, all waste will be treated as hazardous waste. Therefore, ATOME will ensure the availability in all areas of the Plant, as appropriate, of separate and identified containers for the following types of waste: recyclable, non-recyclable and hazardous.

Transport of waste

Transport from the waste storage area should only take place if appropriate conditions for waste conditioning are ensured.

The external transport of waste will be carried out by a supplier duly authorised by the environmental authority, which will guarantee the conditions of the waste to the final destination, preventing environmental impacts and risks to health and safety at work and to the community during the journey.

All external transport of waste shall take place through the issuing of waste transport manifests, which shall contain, as a minimum, the following data:

- Name and identification number of the material(s) making up the waste;
- Physical state (i.e. solid, liquid, gaseous or a combination of one or more of these);
- Quantity (e.g. kilograms or litres, number of containers);
- Waste shipment tracking documentation with date of shipment, date of transport and date of receipt, record of sender, receiver and carrier;
- Method and date of storage, repackaging, treatment or disposal at the facility, cross-referenced to the specific manifest document numbers applicable to the waste.

Treatment and final disposal

Preference shall be given to the hierarchy of techniques associated with recovery, reuse, re-purposing or recycling, where technically/economically feasible, in relation to the alternatives of treatment and final disposal in landfill or incineration.

Among the set of technical alternatives available for the treatment/disposal of solid waste, the companies contracted for O&M will analyse and select the recommendations considered most appropriate taking into account the following parameters:

- Applicable legal and regulatory requirements;
- Classification of solid waste;
- Volumes of waste involved;
- Frequency of generation;
- Associated liability risks;
- Costs involved.

As in the construction phase, the solution identified in the region for the disposal of organic and common non-hazardous waste is disposal by the company EMAASA at the Villa Hayes landfill.

5.4 Hazardous waste management

Hazardous waste is waste that, due to its physical or chemical characteristics, poses a risk to human health, property or the environment. Hazardous waste includes waste from medicine cabinets (e.g. expired medicines), waste contaminated with oil, empty containers of hazardous products and other types of waste that cannot be disposed of in landfill.

For the handling of these materials EPC Contractors shall prepare more detailed specifications appropriate to the type of hazardous materials they anticipate handling, these shall constitute part of a hazardous materials handling programme of their MASS Management System.

Initially, the aim should be to avoid the generation of hazardous waste, if this is not possible, hazardous waste should be separated from non-hazardous waste and its management should consider the following:

<u>Storage of hazardous waste</u>

- They shall be stored in a manner that prevents or controls accidental releases to air, soil or water resources, taking into account the following:
    - Storage in a manner that prevents mixing or contact between incompatible wastes and in a manner that allows for inspections between containers and tracking of leaks or spills. Examples include sufficient space between incompatible materials or physical separation by containment walls or curbs;
    - Storage in closed containers protected from direct sunlight, wind and rain;
    - Secondary containment systems with materials appropriate to the waste to be contained and adequate to prevent emissions to the environment;
    - Secondary containment systems whenever liquid waste is stored in volumes greater than 220 litres. The available volume of secondary containment shall be at least 110 per cent of the largest storage container or 25 per cent of the total storage capacity (whichever is higher), at the particular site.
    - Where volatile wastes are stored, appropriate ventilation systems must be provided.
    - Storage activities shall be managed by employees properly trained in the handling and storage of hazardous waste. They shall: i) provide available chemical compatibility information including labelling of each container, ii) limit access to appropriately trained employees, iii) label and delineate the area, including documentation of its location on a map of the facility, iv) conduct periodic inspections of storage areas and document findings, v) develop and implement emergency and spill response plans to address accidental releases, vi) avoid underground storage tanks for hazardous waste.

<u>Transport of hazardous waste</u>

Internal and external transport should be carried out in a manner that avoids or minimises spillage, emissions and risks to employees and others. All containers should be securely sealed and appropriately labelled with the contents and associated hazards, properly loaded onto

transport vehicles before leaving the site and accompanied by a shipping document (i.e. a declaration) describing the cargo and the hazards associated with it.

Considering that the treatment and final disposal of hazardous waste will be carried out by outsourced companies specialised in the area, duly authorised by MADES, it is expected that they will have the necessary procedures and elements to carry out this activity in compliance with the above. However, the Contractor shall ensure that the contracted companies comply with these provisions.

Follow-up

Monitoring activities associated with the management of hazardous and non-hazardous waste shall consider:

- Regular visual inspections of all waste storage or collection areas to check that there are no signs of accidental releases and to verify that the waste is properly labelled and stored. Where significant quantities of hazardous waste are generated and stored on site, monitoring activities will include:
  - Inspection of containers for leaks, drips or other indicators of leakage;
  - Identification of cracks, corrosion or damage to storage containers, protective equipment or floors;
  - Checking of shut-offs, emergency valves and other safety devices for proper operation;
  - Checking the operability of emergency systems;
  - Document the results of integrity tests, emissions or monitoring stations (air, soil vapour or groundwater);
  - Document changes to storage facilities, and significant changes in the quantity of materials stored.
- Regular audits of waste segregation and collection practices;
- Monitoring of waste generation trends by type and quantity of waste generated, preferably by department;
- Waste characterisation at the beginning of the generation of a new waste stream, and periodically documenting the characteristics and appropriate management of the waste, especially if it is hazardous waste;
- Keep the declarations and other documents justifying the quantity of waste generated and its destination;
- Regular audits of treatment operations and disposal services carried out by third parties, including recycling and reuse facilities where third parties are responsible for handling significant quantities of hazardous waste. Wherever possible, audits shall include visits to storage and disposal areas at individual sites;
- The records of the tracking of hazardous waste received, stored or shipped shall include the following:
  - Name and identification number of the materials composing the hazardous waste;
  - Physical state (solid, liquid, gaseous or a combination of one or more of the above);
  - Quantity (e.g. kilograms or litres, number of containers);
  - Documentation of waste shipment tracking, including type and quantity, date of delivery, date of transport and date of receipt, details of origin, consignee and carrier;
  - Method and date of storage, repackaging, treatment or disposal at the facility, with reference to the specific hazardous waste declaration numbers;

- Location of hazardous waste within the facility and the quantity deposited in each area.

5.5. Handling of hazardous materials

The company in charge of O&M should prepare a Hazardous Materials Management Plan that will be part of its MASS Management System, to be approved by ATOME. The following are general guidelines set out in the IFC General MASS Guidelines to be considered for the preparation of the Plan, however, the company will need to have more specific information based on its competence in the operation of Plants and similar operations.

Hazard assessment

A continuous assessment of the level of risk posed by the management of hazardous materials used at the site or plant shall be carried out. The assessment shall consider: i) Name and description of the material, ii) Classification, iii) Maximum allowable quantity, iv) Quantity used per month, v) Characteristics that make the material hazardous, vi) Study of possible spill and release scenarios using available industry statistics, vii) Study of the possibility of uncontrolled reactions such as fires and explosions, viii) Study of the possible consequences depending on the physical and geographical characteristics of the project site. The assessment will be carried out through accepted methodologies such as HAZOP and HAZID, which are studies to be carried out for the Project.

Management actions

The Management Plan shall include management actions in accordance with the results of the above assessment. This Plan shall be tailored to the hazards associated with the Project and shall include the following:

- **Planning, control and prevention of leaks**

  - Operator training on leak prevention, including specific practices with hazardous materials as part of emergency preparedness and response training;
  - Inspection programmes for pressure vessels, tanks, piping systems, vent and discharge valves, containment infrastructure, automatic emergency shutdown systems, controls and associated process pumps and equipment;
  - Preparation of written standard operating procedures;
  - Identification of hazardous material locations and associated activities on an emergency plan situation map;
  - Documentation of the availability of specific personal protective equipment and the training required to respond to an emergency;
  - Documentation of the availability of spill response equipment sufficient to handle, as a minimum, the initial stages of a spill and a listing of external resources of equipment and personnel, if needed, to supplement internal resources
  - Description of measures to be taken in case of spills, leaks or other chemical emergencies.

- **Occupational health and safety**

The Plan should address the following essential elements on occupational health and safety:

- An occupational safety analysis to identify specific potential hazards that may be present and industrial hygiene surveys, where appropriate, to monitor and check levels of exposure to chemical hazards and compare them with applicable occupational exposure standards;
- Hazard information and training programmes to prepare workers to recognise and respond to occupational chemical hazards;
- Definition and implementation of permitted maintenance activities, such as work at elevated temperatures or access to confined spaces;
- Provision of appropriate personal protective equipment (PPE) (footwear, masks, protective clothing and goggles in appropriate areas), body showers and eye showers in emergency situations, ventilation systems and sanitary facilities;
- Monitoring and record-keeping activities, including procedures designed to verify and record the effectiveness of prevention and control of exposure to occupational hazards;
- Accident and incident investigation reports to be kept on file for at least five years.

- **Documentation and process knowledge**

The Plan shall be incorporated and aligned with the other elements of the Facility Management System for environmental safety and occupational health and safety, and shall consider:

- Written description of process safety parameters (chemical hazards, safety equipment specifications, safe operating ranges for pressure, temperature or other applicable parameters);
- Written operating procedures;
- Written transport procedures;
- Written procedures for storage of materials;
- Compliance audit procedures;
- Written description of the preventive measures incorporated in the Plant design such as containment measures, alarm and leak detection systems, etc.

5.6. Monitoring of treated effluent

As part of this measure, the effluent treated at the plant's Wastewater Treatment Plant (WWTP) will be monitored. This WWTP will treat effluents from the purification and demineralisation pre-treatment, the oil separator, the non-oily network and the cooling tower.

During the commissioning tests, start-up and maintenance of the plant, chemical cleaning of the pipes for certain circuits is also foreseen, which will generate yet another effluent that will have to be managed. However, it is expected that this service will be carried out by an authorised company in a closed circuit, so that the chemicals will be recovered and removed by the same company specialising in these services for reuse.

For the effluent treated at the WWTP the following controls shall be carried out:

-Flow , pH, temperature, conductivity and free chlorine residual - continuous measurement;
-BOD5, COD and ammonia analysis - daily;

-Analysis of suspended solids, settleable solids, fats, oils and grease, floating materials, sulphates, total nitrogen, total phosphorus, faecal coliforms and ammonium nitrate - weekly;
-Analysis of remaining parameters shown in **Table 5.6.a of P.09** - half yearly.

The values resulting from the analysis must be compared with the limits established by Art. 7 of Resolution SEAM Nº 222/2002, which establishes the conditions and criteria for the discharge of effluents from any polluting source, directly and indirectly, into the receiving body, and by the General EHS Guidelines and the IFC EHS Guidelines for the production of nitrogen fertilisers, adopting the most restrictive ones. These values are shown in **Table 5.6.a of P.09** below.

Table 5.6.a of P.09
Limits for effluent discharge to the receiving body

Substances, Conditions and Criteria	SEAM Resolution Nº 222/2002	General MASS Guides	MASS guidelines for nitrogen fertiliser production
pH	5 a 9	6 a 9	6 a 9
BOD 5d 20° C	50 mg/L	30 mg/L	
COD	150 mg/L	125 mg/L	
Temperature	< 40º C		
Receiving Body Temperature Elevation	3RD C		<3º C
Settleable matter (1 h test as Immhoff)	< 1 mg/L		
Launch Regime	with maximum flow rate < 1.5 times the average rate of the critical period		
Mineral Oils	< 20 mg/L		
Vegetable Oils and Animal Fats	50 mg/L	10 mg/L	
Total Suspended Solids	-	50 mg/L	30 mg/L
Floating Matters	0		
Ammonium (N)	5.0 mg/L		
Arsenic (As)	0.5 mg/L		
Barium (Ba)	5.0 mg/L		
Boron (Bo)	5.0 mg/L		
Cadmium (Cd)	0.2 mg/L		
Cyanates (CN)	0.2 mg/L		
Lead (Pb)	0.5 mg/L		
Copper (Cu)	1.0 mg/L		
Hexavalent Chromium (Cr)	0.5 mg/L		
Trivalent Chromium (Cr)	2.0 mg/L		
Tin (Sn)	4.0 mg/L		
Phenol Index (C6H5OH)	0.5 mg/L		
Soluble Iron (Fe)	15 mg/L		
Soluble manganese (Mn)	1.0 mg/L		
Total mercury (Hg)	0.01 mg/L		
Nickel (Ni)	2.0 mg/L		
Silver (Ag)	0.1 mg/L		
Selenium (S)	0.05 mg/L		

Substances, Conditions and Criteria	SEAM Resolution Nº 222/2002	General MASS Guides	MASS guidelines for nitrogen fertiliser production
Sulphates (Se)	0.05 mg/L		
Zinc (Zn)	5.0 mg/L		
Total Nitrogen (N)	40 mg/L	10 mg/L	15 mg/L
Total Phosphorus (P)	4 mg/L	2 mg/L	
Ammonium nitrate (mg/L)			100 mg/L
NH_3 (mg/L)			5 mg/L
Faecal Coliforms	4000 NMP/100 mL		
Total coliforms		400 NMP/100 mL	

Samples for analysis shall be collected at the treated effluent tank of the WWTP.

5.7. Water quality monitoring

The discharge of treated effluent from the WWTP has the potential to cause changes in the water quality of the Paraguay River. Although monitoring of the effluent emission limits required by legislation is foreseen (see previous measure, **Section 5.4**), water quality monitoring will also be carried out to demonstrate that the standards set by the applicable legislation are being met.

The points at which samples will be collected for water quality monitoring in the operation phase are the same as those at which the analyses were carried out for the baseline of this ESIA, i.e. the water intake point for the Project and the points upstream and downstream of the effluent discharge (see **Figure 5.2.2.2.3.a** in **Section 5.2.2.3.a**).

The collection and preservation of samples shall be carried out in accordance with the Paraguayan Standard Nº 186 - Sample Collection for the Physical, Chemical and Bacteriological Analysis of Water and the *Standard Methods For the Examination of Water and Wastewater (24th Edition), Section 1060 - Collection and Preservation of Samples*.

Laboratory determinations shall be performed in a laboratory accredited by the National Accreditation Body (ONA) according to the NP-ISO/IEC 17025:2018 standard equivalent to ISO/IEC 17025:2017 "GENERAL REQUIREMENTS FOR THE COMPETENCE OF TESTING AND CALIBRATION LABORATORIES".

The preservation techniques to be used for the preservation of the samples should be as recommended by the contracted laboratory.

Collection work must be carried out under safe conditions and all necessary personal and collective protective equipment must be used.

For each sampling point, a field sheet must be completed as a means of recording all information necessary for the adequacy of the procedures. As a minimum, the field sheet should contain the following information:

- Name(s) of the technician(s) and coordinator of the works
- Sample identification number

- Georeferenced identification of the sampling point
- Date and time
- Nature of the sample
- Type of sample (single, composite or integrated)
- Field measurements
- Weather conditions
- Model of equipment used
- Photographic record

After sample collection, identification and recording, samples shall be carefully packed and stored according to the instructions of the responsible laboratory. Samples should be taken to the laboratory in the shortest possible time, taking into account the time necessary to preserve each parameter.

After laboratory analysis, the results must be compared with the permitted concentrations for Class 2 waters, established in Art. 3 of Resolution SEAM N° 222/2002 (see **Table 5.7.a of P.09**).

Table 5.7.a of P.09
Limits and/or conditions to be verified in the water quality analysis

Parameter	Unit	Art. 3º Resolution SEAM Nº 222/2002
Fluctuating matter, including non-natural foams		virtually absent
Fats and Oils		virtually absent
Artificial colours		virtually absent
Faecal coliforms	UFC	1,000 / 100 mL
Colour	Pt/Co	75
Turbidity	UTN	100
BOD_5	mgO2/L	≤ 5
O.D.	mg/L	≥ 5
Total Phosphorus	mg/L	0.05
Total Nitrogen	mg/L	0.6 N
pH	UpH	6.0 - 9.0
Inorganic		
Aluminium	mg/L	0.2 Al
Non-ionisable ammonium	mg/L	0,02 NH3
Chlorates	mg/L	250 CL
Dissolved Iron (Fe+2)	mg/L	0.3 Fe
Total dissolved solids	mg/L	0,025 P
Sulphates	mg/L	250 S04
Nitrate (as N-NO3)	mg/L	10 N
Nitrite	mg/L	1.0 N
Sodium	mg/L	200 Na
Total calcium hardness	mg/L	300 Ca
Selenium	mg/L	0.01 Se
Manganese	mg/L	0.1 Mn
Barium	mg/L	2.0 Ba
Arsenic	mg/L	0.01 As
Cyanates (as free cyanate)	mg/L	0,2 NC
Lead	mg/L	0.01 Pb
Cadmium	mg/L	0.001 Cd
Copper	mg/L	1.0 Cu
Trivalent chromium	mg/L	0,5 Cr
Hexavalent chromium	mg/L	0.05 Cr

Table 5.7.a of P.09
Limits and/or conditions to be verified in the water quality analysis

Parameter	Unit	Art. 3º Resolution SEAM Nº 222/2002
Tin	mg/L	2.0 Sn
Inorganic mercury	mg/L	0,002 Hg
Organic mercury	mg/L	zero
Nickel	mg/L	0.025 Ni
Zinc	mg/L	3.0 Zi
Organics		
Endosulfan	mg/L	0,056
Diazion	mg/L	0,005
DDT	mg/L	0,002
Endrin	mg/L	0,002
PCBs (polychlorinated biphenyls)	mg/L	zero

The analysis shall be carried out on a six-monthly basis.

In the event that the use of well water is chosen (for the secondary reserve of the fire fighting system), groundwater monitoring will also be carried out by collecting samples in the wells to be drilled, in order to obtain information on water quality and aquifer dynamics. The periodicity will be the same as that established for monitoring surface water quality. The parameters to be analysed are also the same and must comply with the limits of Resolution Nº 222/02.

5.8. Noise monitoring

Noise levels shall be checked at the time of testing and commissioning to ensure that the noise levels are those included in the guarantee for the noisiest equipment.

Periodic monitoring will then be carried out to confirm compliance at the fences and outside the nearest residence. In addition, as neighbouring properties change, such as the possible future construction of Omega Green, new noise monitoring points may be added.

Measurements shall last 20 or 24 hours and shall be made using a sound level meter with statistical data analysis, set to Logging mode, which allows measurement histograms to be obtained. The equipment must have a Calibration Certificate from an accredited laboratory.

Noise measurement campaigns should be carried out under full operational conditions (with all equipment running at the same time). Once the project is operational, levels are found to be within expected levels and no significant changes are detected in the monthly measurements, additional campaigns will only be conducted if complaints are filed through the P.03 Complaint Handling Mechanism.

5.9. Monitoring of air emissions

As in the case of noise, during testing and commissioning it shall be verified that the levels of atmospheric emissions from the stacks are in accordance with those included in the guarantee for the identified emission sources.

Additionally, during operation, emissions from stationary sources must be monitored to confirm compliance with the limits established in the IFC's MASS Guidelines for nitrogen fertiliser production. The regulated pollutants to be monitored are: i) **Ammonia Plant**: NH_3 , NOx, PM, ii) **AN Plant**: NOx, N_2 O, NH_3 , PM, iii) **CAN Plant**: PM and NH_3 .

Monitoring methodologies and equipment will consist of stack sampling points for periodic checks by the operator or appropriate body. These will be installed at strategic points such as stacks of the NH3 Synthesis Unit, AN Plant and GRAN Plant, or storage and handling areas for raw materials and products. The final definition will be made in the final engineering design phase.

Considering that there are no emission limits at the national level, only the limits set out in the IFC Guidelines mentioned above are considered (**Table 5.9.a of P.09**).

Table 5.9.a of P.09
Limits and/or conditions to be verified in the monitoring of atmospheric emissions

Pollutants	Units	Indicative value
NH3 plant		
NH3	mg/Nm^3	50
NOx	mg/Nm^3	300
MP	mg/Nm^3	50
AN Plant		
NOx	mg/Nm^3	200
N2O	mg/Nm^3	800
NH3	mg/Nm^3	10
MP	mg/Nm^3	50
CAN Plant		
MP	mg/Nm^3	50
NH3	mg/Nm^3	50

5.10 Air quality monitoring

During operation, air quality monitoring will be carried out by a specialised company to be contracted. Measurements will be at the same point used for the baseline (see **Figure 5.2.8.2.2.a** in **Section 5.2.8.2**).

At these points the parameters Total Suspended Particulate Matter (TSP), Inhalable Particulate Matter (PM_{10} , $PM_{2.5}$), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO) and Ozone (O_3) will be measured.

The campaign will preferably be carried out in the dry season.

The campaign can be carried out using international reference sampling techniques, such as the Large Volume Sampler (AGV/Hi-Vol) and the Trigas sampler. The air quality monitoring equipment will be defined by the plant operator in coordination with ATOME.

Campaign reports shall contain the following information:

- Description of sampling equipment;

- Spreadsheet with the data obtained during sampling;
- Spreadsheet with calculations of concentration and emission rate;
- Spreadsheet with modelling results for comparison with Paraguayan air quality standards (Resolution N° 259/2015) and other applicable standards;
- Table with the main results;
- For the collection of meteorological data and information accompanying the collection and sampling periods, the network of stations of the Directorate of Meteorology and Hydrology will be used.

The calibration certificates of the equipment used shall be attached to the reports of each campaign.

The values measured in the campaigns must comply with the air quality parameters established by Resolution SEAM N° 259/2015 and by the IFC's General Environmental, Health and Safety Guidelines (MASS) , the most restrictive ones being adopted (see **Table 5.4.b of P.01**).

5.11. Odour control

As mentioned in impact 8.03, during operation of the Plant there may be odours that disturb neighbouring residents, caused by ammonia gas leaking from the NH_3 plant and the main NH_3 tank , from the truck loading area, or from the operation of the WWTP.

Some odour control measures can be applied to avoid these nuisances, such as the following:

- Control gases and odours in the areas identified and previously mentioned;
- Neutralise odours and substances in the environment;
- Absorb pollutant gases by sucking in the polluted air;
- Use a scrubber with a neutralising chemical solution;
- Increase the efficiency of the installed scrubber by using water and aggressive chemicals in an attempt to condense noxious and odorous gases;
- Install a biofilter to filter contaminated air.

The effectiveness of these or other measures taken for odour control will be monitored through the complaint records of the P.03 Complaints Handling Mechanism.

5.12. Supervision of contracted companies

The strategy for contracting companies for land and river transport of CAN and for other services and supply of inputs in the operation phase of the Project, which will include waste management, certifications, laboratory, after-sales service of machinery, consulting, and secondary maintenance (IT, gardening, etc.), will take into account environmental, social and health and safety (EHS) criteria in the specification of the conditions and services to be contracted, including the specification of the responsibilities of these companies in the response to emergencies during the operation.

ATOME will have criteria for the selection of companies and will require them to have the necessary procedures and resources, which should form part of their environmental, health and safety management system.

The inclusion of the criteria to be met in the Terms of Reference for Procurement should ensure, on the one hand, that contractors incorporate the costs of EHS management measures in the prices of their services, and on the other hand, that all EHS instructions and requirements have contractual force.

Likewise, ATOME will contractually establish that the companies contracted for the operation phase comply with labour laws and environmental, health and safety requirements. ATOME will verify that the companies are duly qualified for their contracting.

5.13. Maintenance of the easement strip

Maintenance and erosion control

Erosion control in the easement strip should be a continuous activity during the operation phase.

The LT and pipeline operator's maintenance team will conduct annual inspections of the easement. During these inspections, all incipient erosion processes will be identified and immediately stabilised temporarily. Such interventions may include the execution of small works such as diversion of water flow over destabilised areas, placement of stone in the preferred watercourse, stabilisation works.

Vegetation management in the easement strip

The TL operator must carry out periodic selective pruning in the easement strip, maintaining the safety distance between the cables and the tree crown, so that the vegetation does not endanger the TL and its components (maintain the safety distance recommended in the National Electricity Code - CNE - Supply, approved by the legal regulation R.M Nº 214-2011-MEM/DM, in Section 23).

Shrub vegetation will be cut periodically by the maintenance teams, only when necessary, maintaining the herbaceous vegetation. In the scheduling of these works, the risks of fire propagation shall be considered, ensuring extensive mowing before the dry seasons of the year.

During mowing, maintenance crews will be able to collect and dispose of waste discarded by third parties on the easement.

Easement strip protection

Permitted activities within the easement strip are limited to the planting of some temporary crops, and some low-lying permanent crops. Large crops, such as the planting of eucalyptus trees; fire management, such as sugar cane; as well as any physical installations (construction or equipment) are not allowed.

All inspections of the easement strip will be carried out annually and will include verification of any irregular activity or use within the strip. Procedures for notifying the responsible person (landowner or others) will be defined on a case-by-case basis.

6. Effectiveness Indicators

The indicators of this programme are:

- Compliance with the frequency of reports and audits required by Resolution N° 201/2015;
- Frequency of O&M team training events and number of participants;
- Periodic inventories of waste generated in O&M activities and waste transport manifests;
- Amount of solid waste destined in relation to total waste generated;
- Periodicity of effluent monitoring and % of results that comply with applicable legislation;
- Periodicity of water quality monitoring and % of results that comply with applicable legislation;
- Periodicity of noise monitoring and % of results that comply with applicable legislation;
- Frequency of air quality monitoring and % of results complying with applicable legislation;
- Periodicity of stack emissions monitoring and % of results that comply with applicable legislation;
- Number of enquiries and complaints related to excessive noise received by the Complaints Handling Mechanism of the operation phase, under P.03;
- Number of odour related queries and complaints received by the Complaints Handling Mechanism of the operation phase, under P.03;
- Number of non-conformities (NC) recorded by the ATOME HSE Management Team in relation to the activities of the contracted companies.

7. Reports

For each monitoring campaign a partial report will be submitted. A P.09 Semi-Annual Report will be prepared, with the results of implementation of all measures, including:

- Photographic records and attendance lists of training events applied to O&M staff;
- Inventory of solid waste in the period and evidence of final destination;
- Critical analysis of the results of effluent, water quality, noise, air emissions and air quality monitoring, and description of any mitigation and mitigation measures taken;
- Records of queries, suggestions and complaints received by ATOME related to the operation;
- Drills;
- Training;
- Claims;
- Accidents;
- Others.

Environmental Audit Reports on compliance with the Environmental Management Programme of the Operation Phase will be prepared and sent to MADES and other interested parties such as investors.

8. Implementation Schedule

All measures described in this Programme will be carried out on an ongoing basis throughout the life of the Project, including environmental training of the O&M team, solid waste management, odour and noise control, and effluent and water quality monitoring, each at the

frequency set out in the respective sections of this Plan. Noise monitoring will be conducted periodically in full operation (with all equipment running simultaneously) and whenever necessary due to recurring complaints related to the issue.

P.10 - Operational Phase Emergency Response Programme

1. Justification of the Programme

This Emergency Response Programme for the Operation Phase provides procedures for companies involved in the operation and maintenance activities of the Plant to deal quickly and effectively with emergency situations. The Emergency Action Plans to be developed as part of this Programme will minimise the environmental consequences of any accidental scenarios related to the operation of the Project through rapid and effective emergency action.

The accidental scenarios to be considered in the operation phase and which will be the subject of the Emergency Action Plans are:

- Explosion of the H_2 and NH tanks$_3$;
- NH leakage$_3$;
- Extreme events, such as tropical storms and droughts.

In case of accidents related to the transport of CAN by land or inland waterway, the company contracted for this purpose shall have an Emergency Response Programme as part of its MASS Management System.

2. Main Objectives

The objective of the Emergency Response Programme for the Operation Phase is to establish technical and administrative procedures for immediate, disciplined and efficient actions, using trained manpower and appropriate equipment and materials to be applied in any emergency situation during the operation phase of the Project. The main objective is, in the event of an accident, to obtain rapid and effective action aimed at preserving lives, preventing or minimising the destruction of the Project, protecting the community and the environment of the region.

The objective of this Plan is also to communicate to all stakeholders about emergency situations, accidental release of contaminants, and occurrences that may endanger the population and the environment.

3. Applicable Legislation

The legislation set out in **Section 4.8** of the ESIA applies.

4. Responsibilities

The responsibility for the elaboration and execution of the Emergency Action Plans lies with the team of specialised companies contracted for the operation and maintenance (O&M) of the Plant. These plans must be submitted to ATOME's HSE Management Team for approval. The O&M companies may be supported by independent specialist consultants, if required. The

ATOME HSE Management Team will be responsible for ensuring that such Emergency Action Plans are adequate for the operation of the plant.

5. Implementation Methodology

The Emergency Action Plans that make up this Emergency Response Programme for the Operational Phase, to be prepared by the O&M companies and reviewed and approved by ATOME, should include:

- Description of the emergency scenarios considered;
- The organs to be involved depending on the type of situation;
- The logical sequence of actions to be implemented in each case;
- Equipment and material and technical resources to support emergency actions;
- The delimitation of responsibilities.

The Emergency Action Plans to be developed should include minimum procedures to combat each emergency scenario, considering the following steps in all cases:

- Pre-assessment;
- Accident/emergency severity analysis;
- Selection of the procedure to be adopted;
- Activation sequence: forms of communication;
- Stabilisation and accident/emergency control measures;
- Corrective action as appropriate;
- Recovery/stabilisation monitoring.

The bodies to be activated vary according to the hypothesis considered and the severity of the emergency. The following is a list of the entities, bodies or intervening elements that may be activated:

- ATOME;
- National Emergency Secretariat - SEN;
- Agencies that regulate the use of the Paraguay-Paraná Waterway in each country;
- Departmental and local emergency organisations;
- Fire Brigade;
- ANDE - National Electricity Administration;
- MADES;
- Toxicology Service of the Emergency Medical Centre;
- Directorate of Watershed Management;
- Hospital and first aid;
- Traffic police;
- Sanitation Board.

5.1. Emergency Action Plan in case of physical explosion in structures of the NH_3 Synthesis Unit, Electrolysis Plant, H_2 and NH tanks$_3$ and synthesis gas compressors.

This Emergency Action Plan aims to define sequential actions to respond to accidental events related to physical explosion in different areas of the Plant where this risk has been identified (see risk 13.02 in **Section 6.1.4.3**), more specifically in structures in the NH Synthesis Unit$_3$, in the Electrolysis Building, in the H_2 and NH_3 tanks and in the synthesis gas compressors, which may represent hazardous situations for the health and safety of workers, the community or the environment.

Resources needed to address the accidental scenario envisaged

- Fire extinguishers of appropriate types for each category of fire and in sufficient number for initial firefighting;
- Hose station;
- Hydrant and pump system fed by main water tank;
- Gas and flame detectors;
- Tractor to make emergency firebreaks.
- Fire warning sirens;
- Specific PPE: gloves, helmet, respirator, chemical safety goggles.

Organs to be activated

- ATOME;
- National Emergency Secretariat - SEN;
- Departmental and local emergency organisations;
- Fire Brigade;
- ANDE;
- MADES;
- Hospital and first aid;
- Traffic police.

Emergency response procedures

This Emergency Action Plan will be implemented with the support of the Plant's existing communications systems. The procedures to be adopted in the event of an explosion in the H_2 and NH_3 tanks are:

1. Routinely implement control of the factors that can cause the explosion;
2. Conduct regular training of workers;
3. Keep fire prevention and extinguishing systems in perfect working order, as well as emergency exits unobstructed and signposted;
4. In case of risk of a possible explosion, activate the warning system and notify the Emergency Coordinator;
5. In case of explosion, immediately activate the warning system and the Emergency Coordinator;
6. Conduct an initial assessment to determine the severity of the situation;
7. Verify the existence of victims;

8. Remove the victims;
9. Activate emergency medical care according to the nature of the injuries;
10. Activate the Fire Brigade;
11. Signpost and isolate the area within the emergency radius (see respective figure for each area in **Annex 14**), ensuring access for response teams;
12. Remove tanks not damaged by the explosion from the site;
13. In case of fire, carry out initial fire fighting with water and use of manual dampers;
14. Execute the emergency firebreak around the burnt area using the tractor;
15. Monitor situations of reactivation of braziers;
16. Remove nearby flammable materials that could be affected by fire;
17. Verify the occurrence of damage to structures, such as cracks, collapsed roofs, broken pipes, damaged doors and windows, among others;
18. Check for the occurrence of landslides or serious damage that could render the site unusable;
19. In case of fire affecting forest areas, inform MADES;
20. Activate ANDE if the fire reaches the power grid or the Buey Rodeo substation;
21. Activate traffic police if fire reaches roadside vegetation.

5.2. Emergency Action Plan in case of fires in structures in the NH Synthesis Unit$_3$, in the Electrolysis Building, in the H_2 and NH_3 tanks, in the synthesis gas compressors, in the Nitric Acid (NA) Plant and in the Ammonium Nitrate Solution (AN) Plant.

This Emergency Action Plan aims to define sequential actions to respond to accidental events involving fires initiated by *pool fire*, *jet fire* or *flash fire* during the operation of the Plant, in structures of the NH Synthesis Unit$_3$, of the Electrolysis Building, in the H_2 and NH_3 tanks, in the synthesis gas compressors, in the Nitric Acid (NA) Plant and in the Ammonium Nitrate Solution (AN) Plant, which may represent hazardous situations for the health and safety of workers, the community or the environment.

<u>Resources needed to address the accidental scenario envisaged</u>

- Fire extinguishers of appropriate types for each category of fire and in sufficient number for initial firefighting;
- Hose station;
- Hydrant and pump system fed by main water tank;
- Gas and flame detectors;
- Tractor to make emergency firebreaks.
- Fire warning sirens;
- Specific PPE: gloves, helmet, respirator, chemical safety goggles.

<u>Institutions to be activated</u>

- ATOME;
- National Emergency Secretariat - SEN;
- Departmental and local emergency organisations;
- Fire Brigade;
- ANDE;
- MADES;

- Hospital and first aid;
- Traffic police.

Emergency response procedures

This Emergency Action Plan will be implemented with the support of the Plant's existing communications systems. The procedures to be adopted in the event of fire are:

1. Keep fire prevention and extinguishing systems in perfect working order, as well as emergency exits unobstructed and signposted;
2. Conduct regular training of O&M employees;
3. When identifying a hazard that could cause a fire, notify the Emergency Coordinator with a description of the size and severity of the situation;
4. Conduct an initial assessment to determine the severity of the situation;
5. Activate the plant's fire brigade and fire brigade;
6. Isolate the area within the emergency radius (see **Annex 14** for the respective figure for each area), with only members of the service teams remaining near the site;
7. Remove the victims;
8. Activate emergency medical care according to the nature of the injuries;
9. Move the water truck and tractor to the site for firebreak implementation;
10. Initially combat with water and use of manual buffers;
11. Cool (laterally with water) equipment exposed to flames, even after the fire has been extinguished;
12. Execute the emergency firebreak around the burnt area using the tractor;
13. Monitor situations of reactivation of braziers;
14. Remove nearby flammable materials that may be affected by fire;
15. In case of fire affecting forest areas, inform MADES;
16. Activate ANDE if the fire reaches the power grid or substations;
17. Activate traffic police if fire reaches roadside vegetation.

5.3. Emergency Action Plan for NH_3 , HNO_3 or $NH_4 NO_3$

The purpose of this Emergency Action Plan is to define sequential actions to respond to accidental events related to NH3, HNO_3 or $NH_4 NO_3$ leaks in the Plant and storage areas of these products, which may represent dangerous situations for the health and safety of workers.

Resources required to address the accidental scenario envisaged

- Resources needed for the isolation of the area, including ropes, marker cones and isolation bands, among others;
- Shower and eyewash;
- Positive pressure respiratory protective equipment and chemical protective clothing for emergency personnel;
- Self-contained breathing apparatus for victim care;
- Oxygen tank for victim care;
- Leakage warning sirens;
- Specific PPE: gloves, helmet, respirator, chemical safety goggles.

Institutions to be activated

- ATOME;
- National Emergency Secretariat - SEN;
- Departmental and local emergency organisations;
- Fire Brigade;
- MADES;
- Toxicology Service of the Emergency Medical Centre;
- Hospital and first aid.

Emergency response procedures

This Emergency Action Plan will be implemented with the support of the Plant's existing communications systems. The procedures to be adopted in the event of NH_3 , HNO_3 or $NH_4 NO_3$ leaks are:

1. Ensure adequate ventilation to keep the ambient gas concentration at the lowest possible levels in case of leakage;
2. Use mechanisms for early detection of leaks at critical points, together with an alarm system;
3. Conduct regular training with workers;
4. Inform the Emergency Coordinator as soon as a leak of NH_3 , HNO_3 or $NH_4 NO_3$ is detected;
5. Stop the leak, if it can be done safely;
6. Ensure that all persons involved in emergency response and victim care wear appropriate protective equipment;
7. Evacuate the area, depending on the severity of the leak;
8. Eliminate all sources of ignition to avoid explosions that may occur due to the presence of the substance in the environment;
9. Keep fire prevention and extinguishing systems in perfect working order, as well as emergency exits unobstructed and signposted;
10. Verify the existence of victims;
11. Activate emergency medical care and the Toxicology Service;
12. Activate the Fire Brigade;
13. Remove victim to a ventilated area and keep in a position that does not interfere with breathing;
14. Wash parts that have been in contact with the toxic substance;
15. Use self-contained breathing apparatus to rescue victim. If the victim is not breathing, apply artificial respiration and, if breathing is difficult, provide oxygen;
16. Dispose of contaminated clothing;
17. Prevent the product from entering drains, pits or any other place where a hazardous atmosphere may accumulate;
18. Clean the area. Do not allow water to enter tanks. Release contents slowly to atmosphere, keeping downwind. Keep area evacuated and free of ignition sources until spilled liquid has completely evaporated. Ventilate the area. Flush tanks and contaminated area with plenty of water.

5.4. Emergency Action Plan for extreme events, such as severe storms and droughts

This Emergency Action Plan aims to define sequential actions to respond to emergency situations due to storms or droughts, extreme events considered of high or medium risk in the Project area (see **Section 5.2.1.4**).

The following emergency situations are considered in these events:

- Physical damage to Plant and LT structures;
- Affected water supply for human consumption and outbreak of communicable diseases and other aggravations related to the consumption of poor quality water due to drought (e.g. outbreaks of diarrhoea, dengue fever, gastrointestinal infections, trachoma, dehydration).

Resources needed to address the accidental scenario envisaged

- Meteorological Station Silvio Pettirossi Airport (Luque);
- Communicator radios;
- Vans and other 4x4 vehicles for local service;
- Crane truck;
- Specific PPE: gloves, helmet, respirator, chemical safety goggles;
- Emergency alarm and communication system;
- Medicines, supplies and equipment;
- Drinking water.

Institutions to be activated

- ATOME;
- National Emergency Secretariat - SEN;
- Directorate of Meteorology and Hydrology (DMH);
- Departmental and local emergency organisations;
- Agencies that regulate the use of the Paraguay-Paraná Waterway in each country;
- Fire Brigade;
- MADES;
- Hospital and first aid;
- Rural patrols;
- Traffic police.

Emergency response procedures

The procedures to be adopted in the event of physical damage to Plant and LT structures are as follows:

1. Notify the Emergency Coordinator, giving a description of the size and severity of the situation;
2. Disconnect all equipment immediately;
3. Evacuate areas at risk of structural collapse due to wind;
4. Activate the fire brigade;

5. Allow access to the affected area only to Fire, Police, Rural Patrols, Ambulance and support agencies;
6. On arrival at the site, conduct a reconnaissance to verify the occurrence of casualties;
7. Activate emergency medical care according to the nature of the injuries;
8. Remove the victims;
9. Allow access to areas only after removal of debris and unstable parts of structures;
10. If it is verified that H_2 and NH_3 tanks are affected and there is a risk of explosion, activate the corresponding Emergency Action Plan (**Section 5.1**);
11. If it is verified that structures are affected with consequent leakage of products that can start fires, activate the corresponding Emergency Action Plan (**Section 5.2**);
12. If NH_3 , HNO_3 and $NH_4 NO_3$ tanks are verified to be affected and there is a risk of leakage, activate the corresponding Emergency Action Plan (**Section 5.3**).

The procedures to be adopted in the event of disruption of drinking water supply and outbreaks of communicable diseases and other aggravations related to the consumption of poor quality water due to drought (e.g. outbreaks of diarrhoea, dengue fever, gastrointestinal infections, trachoma, dehydration) are as follows:

1. Constantly monitor the risks of severe drought through climatological data from the region;
2. Maintain updated protocols and operational procedures necessary for the implementation of alert and response management actions;
3. Maintain a stock of drinking water;
4. Maintain a stock of medicines and strategic inputs to respond to diseases and grievances arising from drought conditions;
5. A labour doctor and ambulance service as part of the permanent resources;
6. Establish an agreement with a hospital;
7. Train workers on water consumption and hygiene in situations of water scarcity;
8. Activate emergency medical care according to the severity of the illnesses;
9. Remove the victims;
10. Support residents of the neighbouring farm in case of illness or injury of family members, providing first aid and transport to hospital;
11. During low water levels in the Paraguay River, intensify the monitoring of water quality at catchment and effluent discharge points;
12. In a situation of low water levels in the Paraguay River, evaluate the possibility of using well water for the production process.

6. Effectiveness Indicators

The indicators of this programme are:

- Number of trainings conducted per year;
- Number of workers trained in emergency response activities;
- Number of emergencies controlled, considering the following aspects: extent of damage, applicability of procedures, response time and efficiency of the workers involved in the action;
- Evidence of the preparation of the Environmental Emergency Report - EER for each emergency/accidental event that has occurred.

7. Reports

For each emergency/accidental event the responsible team of the O&M companies and the contracted land and river transport companies will prepare the Environmental Emergency Report - EER, which will include at least the following information:

- Identification of the emergency/accident;
- Date and time of the emergency/accident;
- Location of the emergency/accident;
- Description of third party involvement;
- Victims, including names and place of assistance;
- Affected areas, discriminating water bodies, adjacent forests, etc..;
- Structures affected;
- Equipment used in assistance;
- Cause(s), discriminating between:
  - Natural / induced;
  - Equipment failure;
  - Human error;
  - Failure of retaining structures;
  - Failure of facilities;
  - Other (specify).
- Staff involved in assistance:
  - Internal: members of the fire brigade, engineer and occupational safety technician, and others;
  - External: Fire brigade, SEN technicians, Agencies that regulate the use of the Paraguay-Paraná Waterway, DGCH, MADES, etc.
- Additional information from the report:
  - Description of the emergency/accident;
  - Provisions / consequences, briefly reporting the actions taken to neutralise the damage to safety and the environment;
  - Information on the disclosure of the emergency/accident (if it was public knowledge);
  - Preventive measures necessary to prevent similar emergencies/accidents.
- Information on the person responsible for the report.

8. Implementation Schedule

The Emergency Programme for the Operation Phase will be prepared at the beginning of the operation phase of the Project. Its implementation should last for the life of the Project. The Plan should be reviewed annually.

Emergency response team training will be conducted annually.

P.11 - ADA Archaeological and Cultural Heritage Conservation Programme

1. Justification of the Programme

As assessed in **Section 6.1.3.3**, given that battles of the Great War took place in the region where the ATOME Project will be constructed, there is a risk of interference with possible historical finds during vegetation removal / land clearing activities and especially during earthworks.

The development of the Programme is justified by the need to act in a preventive manner, eliminating or minimising the risks of interference with the Archaeological, Historical and Cultural Heritage during the activities of clearing the land and moving earth to install the construction camp, opening accesses and laying the foundations of the Plant's structures, the towers of the TL and the water supply and effluent discharge infrastructures.

2. Main Objectives

The objectives of the programme are linked to the need to prevent or mitigate possible impacts on potentially existing archaeological, historical and cultural assets in the area directly affected by the construction of the Project components.

3. Applicable Legislation

The legislation set out in **Section 4.4** of the ESIA applies.

4. Responsibilities

As mentioned in P.02, ATOME will be responsible for the communications with the National Secretariat of Culture and the submission of the Fortuitous Findings Protocol. The implementation of the measures will be the responsibility of the Contractor and will be part of his contractual obligation. For this, it will hire a professional specialist in archaeology.

5. Implementation Methodology

5.1. Archaeological accompaniment and procedure in case of chance finds

As recommended by the specialist who carried out the diagnosis for this ESIA (see **Section 5.4.9**), during the activities of vegetation removal and land clearing and earthworks for the installation of the construction camp, opening of accesses and for the construction of the foundations of the Plant and LT structures, in addition to the implementation of the water supply and effluent discharge infrastructures, ATOME will hire a professional specialist in archaeology to prepare a Preventive Archaeology Action Protocol, which will be implemented by the Contractor as part of its contract.

As part of the Protocol, on-site accompaniment during vegetation removal and land clearing and earthworks activities will be included, to be carried out by a professional archaeologist contracted by the Contractor.

In the event that chance finds (archaeological objects or sites) occur during these activities, identified by the specialist or by workers, subject to guidance from the specialist, they will stop activities on this work front, and notify the supervisor / Contractors who will then place a danger tape around the find to prevent immediate damage while the specialist inspects the identified objects and confirms whether or not they constitute archaeological or cultural heritage.

Once the specialist confirms the chance findings, the Contractor responsible for the work shall demarcate and isolate the area, in accordance with the most appropriate demarcation measures provided by the specialist.

Once confirmed as an archaeological or cultural find, ATOME will be notified, as well as the National Secretariat of Culture (SNC).

Subsequently, additional strategies for the protection of cultural property will be evaluated, which may include:

- Changes to the Project design, if possible, such as modifications to the location of the construction camp, access route, or other changes.
- Adoption of specialised construction techniques to minimise disruption;
- Rescue of artefacts and debris.

Recovery and salvage excavations will be carried out if unavoidable and only after a formal permit has been issued by the CNS. In any case, efforts will be made to minimise artefacts collected.

Once the rescue work has been completed, the specialist will proceed with the inspection.

Once all salvage work has been completed and all necessary field investigations (excavations) have been carried out, construction will be allowed to resume in the area.

All chance find procedures will be thoroughly documented through photographs, annotations and maps. All artefacts recovered will be coded and catalogued. Daily monitoring records will be kept noting areas of recovery and artefacts found.

All artefacts, once they have been documented and catalogued, will be handed over to the institution indicated by the National Secretariat of Culture.

6. Effectiveness Indicators

The indicators of this programme are:

- Elaboration of the Protocol for Preventive Archaeology;
- Evidence of the archaeologist's accompaniment during vegetation removal, land clearing and earthworks;
- Occurrence of construction stoppages due to chance discoveries;
- Evidence of measures implemented in case of chance findings;
- Occurrence of delays in the construction schedule due to archaeological salvage (if any).

7. Reports

The archaeologist will prepare a Final Archaeological Monitoring Report at the end of the vegetation removal and site clearance and earthworks activities.

In the event that it is necessary to rescue any archaeological or historical artefacts or remains, an Archaeological Rescue Plan will be drawn up, followed by a Final Archaeological Rescue Report once the activities have been completed.

8. Implementation Schedule

The Programme will be implemented during the construction phase, while vegetation removal and site clearance and earthworks/excavation activities are being carried out.

P.12 - Transport Management Programme in the Operation Phase

1. Justification of the Programme

The increase in traffic during the operation of the Project due to the circulation of Scania tractor trucks + semi-trailers that will transport CAN fertiliser from the Plant to the Terport Port or to the cities of Cascavel and Dourados, in Brazil, if 100% land transport is chosen, in addition to the traffic of buses transporting workers, will directly impact the traffic on the corresponding roads (see impact 7.02).

The main problems that could result from this increase in traffic associated with the Project are: reduced traffic flow and road safety; increased pavement wear; gas emissions, noise and vibrations with discomfort to the nearby population; and increased risk of accidents with pedestrians and other vehicles.

As seen in **Section 6.1.3.3**, the river port from which the Paraguay-Paraná Waterway will be accessed will be Terport, located about 15 km from the Plant along National Route PY19, whose route from the Plant presupposes passing through the community of Suruby'i. In the case of the workers' buses, the route includes passing through Suruby'i and other road sections with a highly populated environment, such as the Acceso Sur and the Guarambaré - Villeta route.

2. Main Objectives

The objective of this Programme is to establish measures and ensure compliance by the companies contracted to transport CAN in the operation phase, in order to avoid or mitigate the possible consequences of this transport, such as possible traffic accidents, damage to the conditions of the roads to be used by trucks and buses of the Project, reduction of safety and traffic flow on the roads, and risk of accidents with drivers and assistants and with the population.

3. Applicable Legislation

- Decree N° 14390/1992, approving the general technical regulations on safety, hygiene and medicine at work;

- Law N° 294/93, on Environmental Impact Assessment, regulated by Decree No 453/13;
- Law N° 5016/2014, National Law on Traffic and Road Safety;
- Law N° 5804/2017, which establishes the national system for the prevention of occupational risks;
- Labour Resolution MTESS N° 785/2020, which provides for the implementation of Articles 1, 2, 3, 4, 5, 6, 7, 8, 13, 14, 17, 18, 19, 23, 24, 25, 41, 42, 43, 44, 45 and 46 of Law No. 5804/2017;
- Decree N° 5078/2021, repealing Articles 260, 262, 263, 264, 265, 266 and 270 of the general technical regulations on safety, hygiene and medicine at work, approved by Decree N° 14.390/1992.

4. Responsibilities

The companies contracted to transport CAN fertiliser and workers in the operation phase will be responsible for the Programme. ATOME will include the measures in the contract and will verify that the companies have the resources and training to comply with the legal and contractual requirements.

However, some measures will be implemented by the ATOME itself, such as regular inspection of road conditions and implementation of necessary improvements, as well as communication measures with the population along the roads and monitoring of the complaint handling mechanism, both parts of P.03 - Stakeholder Participation Programme.

5. Implementation Methodology

Only qualified companies will be selected for the transport of fertiliser and workers, ATOME will verify that they have Environmental, Social and Health and Safety Management Systems, including their own procedures governing their activities. If so, ATOME's EHS Management Team will verify the content of these procedures and ensure that they consider the necessary measures to prevent and mitigate the impacts associated with the operation's traffic.

5.1. Driver training

The contracted transport companies will train vehicle drivers and other workers involved in the transport by providing them with information on the characteristics of the communities along the roads and their dynamics of road use; the most sensitive sections of the routes; basic traffic rules; traffic signs; speed limits; and on the procedures of the Emergency Response Programme for the Operational Phase for cases of spills of hazardous products, such as fuel, into watercourses or onto the ground.

Routine maintenance

ATOME will require the companies responsible for the transport to provide evidence of the regularity of the periodic maintenance of the trucks and buses, by means of updated maintenance documentation, which must always be kept inside the vehicle. In this maintenance, especially the adjustment of the engines according to the manufacturer's specifications, the adjustment of the injection pump, nozzles, change of air and oil filters and other devices, as well

as the use of quality fuel, should be checked in order to contribute to the reduction of gas and particulate emissions (black smoke).

Transport companies must carry out a weekly black smoke check on the entire fleet. Inspection of trucks and buses for excessive black smoke emissions will be done using the Ringelmann Scale, leading to corrective maintenance of those with conspicuous black smoke emissions.

During the drier months, when it is more difficult for pollutants to disperse in the atmosphere, this inspection will be intensified.

In addition to the maintenance and black smoke monitoring records, ATOME will also receive evidence that the vehicles' companies have all the necessary safety equipment, such as seat belts on buses, valid fire extinguishers, etc.

5.3. Inspection of roads and implementation of improvements

In the operation phase, the road most used by the Project's heavy vehicles, the Villeta - Alberdi route.

Companies contracted for the land transport of inputs, products and workers must evidence in their reports to be submitted to ATOME, the maintenance and signalling conditions and the implementation of traffic management measures, including compliance with speed limits, load limits (compatible with the capacity of each vehicle), driver training, etc.

In the event that sections with deteriorating road conditions associated with Project traffic are identified, or the need to install traffic signs or speed reducers is verified, an agreement will be established with the MOPC and the municipality of Villeta to carry out the necessary improvement works.

6. Effectiveness Indicators

The following indicators are proposed for this Programme:

- Evidence of the existence of environmental, social and health and safety management procedures for transport, including hazardous cargoes, by the companies associated with the transport operation of the Project;
- Evidence of the inclusion of the measures of this Programme in the contracts with the companies associated with the transport operation of the Project;
- Number of drivers trained on P.10. measures and emergency response procedures;
- Number of inspections throughout the year on roads used for the Project's operational transport;
- Records of road damage associated with Project operation transport;
- Number of complaints registered by the P.03 Grievance Handling Mechanism related to Project operation transport.

7. Reports

The following documents / reports must be prepared / filed as part of this Programme:

- Photographic records and attendance lists of training events applied to drivers and other workers involved in transport;
- Periodic maintenance records and black smoke monitoring carried out by transport companies;
- Annual inventory of inspections and improvements implemented on roads;
- Records of complaints received by the P.03 Complaints Handling Mechanism associated with operational transport;
- Monitoring reports of the Transport Management Programme in the Operation Phase, prepared by the ATOME EHS Management Team.

8. Implementation Schedule

The Programme will be implemented during the operation phase of the Project.

8.0 Conclusions
9.0 Bibliographical References
10.0 Technical Team

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Free Trade Zone and Green Fertiliser Production Plant of ATOME Paraguay S.A.

Environmental and Social Impact Assessment (ESIA)

February 2024

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Annex 3 - Floodability and Surface Runoff Pattern Study

Annex 4 - Air Quality Modeling Report

Annex 5 - Sound Pressure Level Monitoring Report (Baseline)

Annex 6 - Noise Modelling Report

Annex 7 - Flora Sampling Data Sheets

Annex 8 - List of Flora Species

Annex 9 - Fauna Photographic Record

Annex 10 - Lists of Fauna Species

Annex 11 - Expanded Stakeholder Map

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8.0
Conclusions

The analysis of the environmental feasibility of the implementation and operation of ATOME's "Free Trade Zone and Green Fertiliser Production Plant" project was based on four main aspects:

i. the socio-environmental conditions and the degree of preservation of the Project's areas of influence;
ii. how the design is inserted in the analysis of alternatives, considering the sensitivity of the environments, the characteristics of the Project and the construction procedures envisaged;
iii. the potential impacts arising from the planning, works and operation of the Project; and
iv. the measures to be adopted to prevent, minimise, control and compensate for the risks and impacts generated by the various interferences foreseen by the Project.

As verified, this Project's main benefit is associated with the technology adopted for producing NH_3, which is based on the electrolysis of water for the production of H_2 using energy from renewable sources (hydroelectric) instead of the traditional process that uses fossil fuels mainly natural gas. This technology considerably reduces greenhouse gas (GHG) emissions and the carbon footprint of the Project, which is the most significant positive impact. In turn, this impact could potentially position the country as an agent of change in compliance with the United Nations Framework Convention and SDG 13 on taking action on climate change and its impacts.

The Project considers various environmental controls to avoid or minimise environmental impacts and the nuisances and risks associated with its operation, including controlling and monitoring atmospheric emissions and noise levels and treating and monitoring effluents and waste, among others.

The environmental studies found that the Project will be implemented on a 30-ha plot of land currently occupied almost entirely by native vegetation, mostly savannahs and some fragments of sub-humid forest, with indications of recent livestock use.

The surrounding area is almost unoccupied, with only one neighbouring property with a residence and other rural improvements that are very close to the boundary with ATOME's land. During the socio-economic baseline interviews, this residence was home to 4 people working on the farm, where ducks, morocco, goats and sheep are raised. However, as of November 2023, the number of people living on the neighbouring property has changed, with only three people living permanently, two working and one minor. According to conversations with current employees, the situation varies constantly according to the needs of work on the farm, with an estimated 4 to 5 people working and living on the site. The owner only uses the house on weekends.

The land is on the edge of the National Route PY19 (Villeta - Alberdi Route), which is paved and in good condition, with paved shoulder and road signs. The road between Villeta and the Project site is about 32 km long, and industrial and service companies mainly use its margins. Only in the passage through Surubi'y is a residential occupation on the road's edge. Other roads that will be used by the Project vehicles, mainly buses transporting workers, such as the Guarambaré - Villeta Route and especially the Southern Access, have a more densely populated environment,

especially the latter, which accesses the urban area of Asunción.

The site of the future Plant is located about 2.3 km from the Paraguay River, from which water will be extracted for the production process of H_2 and other uses. The total to be extracted is 242.70 m^3 /h, returning approximately 77.30 m^3/h to the river, with peak values of 84.20 m^3/h, the extraction balance being 165.4 m^3 /h (0.05 m^3/s) or 158.5 m^3 /h (0.04 m^3/s), respectively. If the flow of 600 m^3/s associated with the most severe drought level of the river is considered, the flow to be extracted for production represents only 0.008% (flow of 0.05 m^3/s) and 0.007% (flow of 0.04 m^3/s), respectively. In terms of average flow, the Paraguay River has a flow of approximately 2,700 m^3/s; thus, ATOME's net abstraction is 0.002% (flow of 0.05 m^3/s) and 0.001% (flow of 0.04 m^3/s) of the river's flow. In other words, obtaining water for the Project should not impact the water balance of this watercourse or its dilution capacity.

The assessment of environmental and social impacts and risks presented in **Chapter 6.0** of this ESIA demonstrates that the plant design and technologies, as well as the Programmes and respective measures proposed in the ESMP, will have the effect of preventing several potentially harmful aspects of the Project from materialising into impacts; mitigating and controlling the stated negative impacts; and maximising the benefits of the positive impacts.

As for the resulting impacts on the physical environment, mentioning the negative impact on air quality during the construction and operation phases is essential. As a positive impact, say again, the main benefit of the Project is the reduction of GHG emissions and decarbonising the fertiliser sector and the food industry. According to the figures indicated in impact 3.03 of **Section 6.1.3.1**, the green CAN fertiliser to be produced by ATOME using renewable energy has the potential to reduce up to 50% of the life cycle emissions of CAN. It is estimated that the Project will displace up to 600,000 tCO_2 -eq/year of carbon emissions in the fertiliser sector. Considering the lifetime of the Project (25 years), this impact would translate into 15,000,000 tCO_2 -eq avoided.

In terms of the resulting impacts on the biotic environment, the loss of native vegetation cover stands out, with the consequent loss of habitats for fauna. As indicated in **Section 6.1.3.2**, it is initially planned to clear Zones A and B of the site, with a vegetation area of 24.75 ha, 2.76 ha of sub-humid semi-deciduous forest and 21.99 ha of savannah. In principle, Zone C, where most of the existing sub-humid forest on the site is located (3.38 ha), will be preserved. If it is necessary to expand the plant facilities for Zone C in the future, the total area of suppression for the plant installation will be 29.85 ha, of which 6.14 ha are sub-humid forests, and 23.7 ha are savannahs.

Concerning fauna, the impact identified is associated with the reduction of habitats, as mentioned above. There are also risks of accidents with fauna related to the works and the presence of workers, including possible run-overs, accidents during construction activities (falls into trenches, accidents with chainsaws), snake deaths by workers, etc.

As preventive measures for impacts on flora and fauna, the rescue of germplasm and the scaring and rescue of fauna have been proposed, which will be carried out concomitantly with the vegetation clearing activities during the construction phase.

As compensation for vegetation removal, it is proposed to adhere to the Environmental Services Regime to comply with Law No. 3001/2006, environmental compensation through forest

conservation and environmental compensation for felled trees to comply with Villeta Ordinance No. 7/2022. These and other mitigation measures to achieve no net biodiversity loss in natural habitats should be detailed in a Biodiversity Action Plan (BAP). The BAP should define actions to mitigate the impacts of the Project, as well as actions to conserve and enhance the biodiversity values recorded in the region. Actions should be developed according to the stages of the impact mitigation hierarchy (as set out in GL25 of the SAI1) and should achieve zero loss of natural habitats. These measures should be detailed in the Biodiversity Conservation Programme, which should be an executive document, including a description of actions, objectives, methodology, implementation schedule and evaluation indicators.

The socio-economic environment identifies the most significant number of environmental and social components with potential impact. In these components, the other positive impacts of the Project are produced (the generation of jobs and the dynamisation of the economy).

The negative social impacts of the Project are mainly related to truck and bus traffic for transporting workers, both during construction and associated with overland and river fertiliser transport during the operation phase. In the operation phase, the impact of road traffic generated by the Project is considered to be highly mitigable, and therefore, the residual significance is low. The impact of river traffic is also of low residual significance, considering the number of barge trips expected.

Noise and odour emission impacts were also identified during the Plant's operation phase, with the neighbouring house's residents, as well as the workers themselves, as critical receptors. In relation to noise, noise abatement measures have already been incorporated into the engineering design of the Plant, reducing the Project's contribution. The modelling concluded that no significant negative impact on the environment will be generated, and the current (baseline) condition will continue to determine the acoustic quality. Regarding odours, control measures have been foreseen as part of the ESMP.

For the socio-economic environment, some risks have been identified that should be avoided with the effective and rigorous application of the proposed framework of preventive measures. These are risks to the health and safety of workers during construction and mainly during operation, associated with possible physical explosion in structures of the NH Synthesis Unit$_3$, of the Electrolysis Building, in the H_2 and NH_3 tanks and in the synthesis gas compressors, fires caused by *pool fire*, *jet fire* or *flash fire* in structures in the NH Synthesis Unit$_3$, in the Electrolysis Building, in the H_2 and NH_3 tanks, in the synthesis gas compressors, in the Nitric Acid Plant (AN) and in the Ammonium Nitrate Solution Plant (ANS), as well as exposure to the gases NH_3 , HNO_3 and $NH_4 NO_3$, with damage to the health of the workers. For each of these risk scenarios, it was proposed that an Emergency Action Plan be drawn up, detailing the resources required to deal with the accidental hypothesis envisaged, the bodies to be activated and the emergency response procedures.

No risks to the community associated with the operation of the Plant were identified, as there is only one neighbouring house and it is outside the radius of any explosion. However, the risk of possible accidents with Project vehicles (fertiliser transport trucks or worker transport buses) involving other vehicles or pedestrians was identified.

The risk of increased demand for health services during the works, which is directly associated with the risk of occupational accidents mentioned above, and the risk of damage to archaeological and cultural heritage during site clearance and earthmoving activities were also assessed.

All risks associated with the Project have associated preventive measures. Similarly, the impacts identified are accompanied by control, mitigation and compensation measures. Various monitoring measures are also foreseen.

These measures are consolidated into various Environmental, Social and Health and Safety Programmes to be implemented by ATOME and the EPC Contractors. These Programmes are consolidated in an Environmental and Social Management Plan (ESMP), which will be included as part of the contracts signed with the EPC contractors, ensuring that they fully comply with all the Programmes and measures under their responsibility.

The set of Environmental, Social and Health and Safety Programmes foreseen in the Project's ESMP is:

- P.01 - Environmental Building Control Programme
- P.02 - Environmental and Social Management Programme
- P.03 - Stakeholder Engagement Programme
- P.04 - Occupational Health and Safety Programme
- P.05 - Management of Labour and Working Conditions Programme
- P.06 - Emergency Response Programme for the Construction Phase
- P.07 - Biodiversity Action Plan
- P.08 - Programme for the Prevention of Impacts on Flora and Fauna
- P.09 - Environmental and Social Management Programme of the Operation Phase
- P.10 - Operational Phase Emergency Response Programme
- P.11 - ADA Archaeological and Cultural Heritage Conservation Programme
- P.12 - Transport Management Programme in the Operational Phase

The HSE Management Team of ATOME will manage the implementation of the following Programmes and measures of the ESMP:

- Stakeholder Engagement Programme (P.03);
- Biodiversity Action Plan - BAP (P.07);
- Environmental Quality Monitoring Measures (Section 5.7 of P.02).

ATOME's HSE Management team will also oversee the implementation of the following ESMP Programmes and measures that are the responsibility of the EPC Contractors:

- Environmental Construction Control Programme (P.01);
- Occupational Health and Safety Programme in the Construction and Operation Phases (P.04);
- Labour Management and Working Conditions Programme (P.05);
- Programme for the Prevention of Impacts on Flora and Fauna (P.08);
- Emergency Response Programmes for the Construction and Operation Phases (P.06 and P.10);

- Solid waste and hazardous product management measures, monitoring of treated effluent, environmental and social training of the O&M team, odour control and maintenance of the easement strip of the Operation Phase Environmental and Social Management Programme (P.09);
- ADA Archaeological and Cultural Heritage Conservation Programme (P.11);
- Operation Phase Transport Management Programme (P.12).

Due to its restricted footprint, relatively unoccupied environment and the care taken in the design of the Project and the measures to be adopted during construction and operation, it is considered that the Plant will have no potential for severe environmental and social impacts, especially if all the measures and programmes proposed in this ESIA are rigorously applied during implementation and operation.

The studies indicate that, from a technical, economic and socio-environmental point of view, no aspects have been identified that could hinder, restrict or prevent its implementation and operation, provided that the recommended preventive, mitigating and control measures are complied with, the proposed monitoring is carried out, and compensatory measures are applied when the impact of the Project cannot be mitigated.

In view of all the studies presented, it is concluded that the implementation of the ATOME project, including the Plant, the TL and the infrastructures for the collection and conduction of water and the discharge of effluents, can be considered viable from the technical-economic-environmental point of view.

9.0
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10.0
Technical Team

Name	Qualification	Function
[redacted]	Civil Engineer	Study Coordinator
[redacted]	Ecologist	Biodiversity attributes analysis coordinator and manager
[redacted]	Botany	Responsible for vegetation survey, identification of flora species and areas important for conservation.
[redacted]	Biologist	Terrestrial Biodiversity Specialist
[redacted]	Forestry Technician	Flora survey and geoprocessing support
[redacted]	Biologist and mammalogist	Field coordinator and head of mammal survey
[redacted]	Ornithologist	Responsible for bird survey, support in conservation analysis of areas of conservation importance, conservation analysis of bird species
[redacted]	Herpetological biologist	Responsible for the study of amphibians and reptiles, conservation analysis of amphibian and reptile species.
[redacted]	Sociologist	Socio-economic environment coordinator
[redacted]	Sociologist	Local Specialist - Social Aspects
[redacted]		Geoprocessing Coordinator
[redacted]	Technical Support	Formation
[redacted]	Technical Support	Formation

ANNEXES

Annex 1 – Substation General Arrangement Plant and Unifiliar Diagrams

LT 220 kV
BRO – ATOME

DESCARGADOR
198 kV

TRANSFORMADOR
DE POTENCIAL
220 kV

SECCIONADOR TRIPOLAR 220 kV c/ P.A.T.

TRANSFORMADOR
DE CORRIENTE
220 kV

INTERRUPTOR 220 kV

SECC. TRIPOLAR 220kV
s/ P.A.T.

TRANSFORMADOR
N°:1
220/MT kV
80 MVA

SECCIONADOR
MT

CELDA C1
TR ZZ

CELDA C2
SS.AA.

CELDA C3
MEDICION

CELDA C4
B.C. N°:1

CELDA C5
AL. N°:1

CELDA C6
AL. N°:2

CELDA C7
AL. N°:3

CELDA C8
AL. N°:4

CELDA C9
AL. N°:5

CELDA C10
LLEGADA TR1

CELDA C11
AL. N°:6

CELDA C12
AL. N°:7

CELDA C13
AL. N°:8

CELDA C14
AL. N°:9

2					
1					
–	08/2022	W.S.	PRELIMINAR		
REV.	FECHA	NOMBRE	DESCRIPCION	APROBO	FECHA

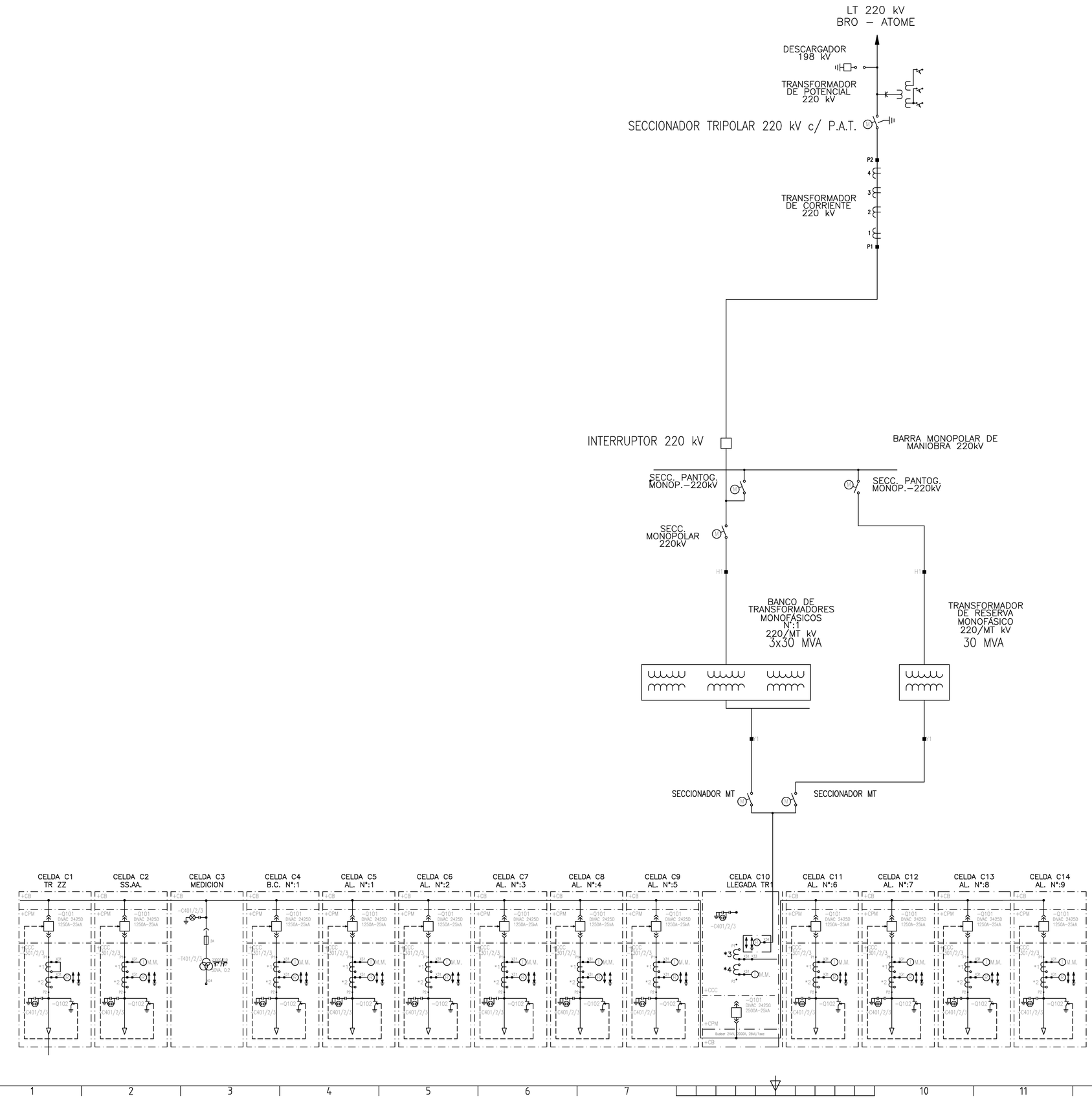
ATOME

ATOME PARAGUAY S.A.
ATOME ENERGY PLC

CONCRET MIX S.A.

"CONSTRUCCIÓN DE LA SUBESTACIÓN ATOME"

PROY.	Ing. W. Sora	SUBESTACION ATOME DIAGRAMA UNIFILAR – TRAFO TRIFÁSICO 1 x 80 MVA	
REVISO	Ing. S. Semidei		
APROBO	Ing. H. Richer	Esc.: S/E	CÓDIGO DE PLANO



2					
1					
–	08/2022	W.S.	PRELIMINAR		
REV.	FECHA	NOMBRE	DESCRIPCION	APROBO	FECHA

ATOME

ATOME PARAGUAY S.A.
ATOME ENERGY PLC

CONCRET MIX S.A.

"CONSTRUCCIÓN DE LA SUBESTACIÓN ATOME"

PROY.	Ing. W. Sora		SUBESTACION ATOME DIAGRAMA UNIFILAR BANCO DE TRAFOS 4 x 30 MVA
REVISO	Ing. S. Semidei		
APROBO	Ing. H. Richer		Esc.: S/E — CÓDIGO DE PLANO

TRANSFORMADOR N°:2

TRANSFORMADOR N°:1

LT 220kV
BRO – ATOME

DESCARGADOR
198 kV

TRANSFORMADOR
DE POTENCIAL
220 kV

TNP
TNR
TNM

SECCIONADOR TRIPOLAR 220 kV c/ P.A.T.

INTERRUPTOR 220 kV

P2
P1
C.C.TC

TRANSFORMADOR
DE CORRIENTE
220 kV

SECC. TRIPOLAR
220kV
s/ P.A.T.

BARRA N°:1 220kV

SECC. TRIPOLAR
220kV
s/ P.A.T.

TRANSFORMADOR
DE CORRIENTE
220 kV

INTERRUPTOR 220 kV

TRANSFORMADOR
DE CORRIENTE
220 kV

INTERRUPTOR 220 kV

H1,H2,H3

TRANSFORMADOR N°:2
60 MVA
220/MT kV

X1,X2,X3

SECCIONADOR MT

H1,H2,H3

TRANSFORMADOR N°:1
60 MVA
220/MT kV

X1,X2,X3

SECCIONADOR MT

CELDA C1
TR ZZ

CELDA C2
SS.AA.

CELDA C3
MEDICION

CELDA C5
AL. N°:1

CELDA C8
AL. N°:4

CELDA C9
AL. N°:5

CELDA C10
LLEGADA TR2

CELDA C15
ACO. BARRAS

CELDA C16
TRANSICION BARRAS

CELDA C10
LLEGADA TR1

CELDA C11
AL. N°:6

CELDA C12
AL. N°:7

CELDA C13
AL. N°:8

CELDA C14
AL. N°:9

REV.	FECHA	NOMBRE	DESCRIPCION	APROBO	FECHA
2					
1					
–	08/2022	W.S.	PRELIMINAR		

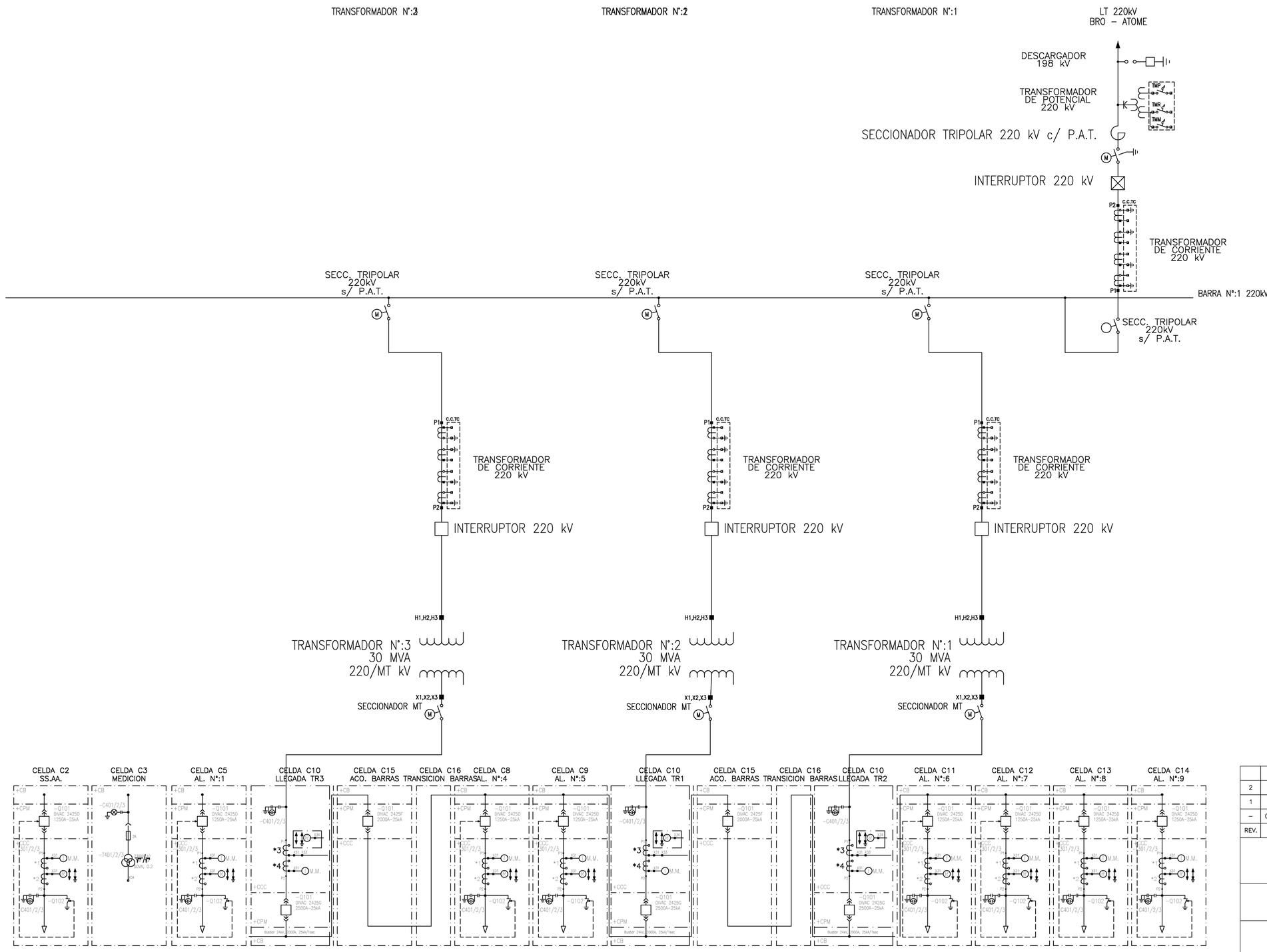
ATOME

ATOME PARAGUAY S.A.
ATOME ENERGY PLC

CONCRET MIX S.A.

"CONSTRUCCIÓN DE LA SUBESTACIÓN ATOME"

PROY.	Ing. W. Sora	SUBESTACION ATOME DIAGRAMA UNIFILAR – TRAFOS TRIFÁSICOS 2 x 60 MVA	
REVISO	Ing. S. Semidei		
APROBO	Ing. H. Richer	Esc.: S/E	CÓDIGO DE PLANO



REV.	FECHA	NOMBRE	DESCRIPCION	APROBO	FECHA
2					
1					
–	08/2022	W.S.	PRELIMINAR		

ATOME

ATOME PARAGUAY S.A.
ATOME ENERGY PLC

CONCRET MIX S.A.

"CONSTRUCCIÓN DE LA SUBESTACIÓN ATOME"

PROY.	Ing. W. Sora	SUBESTACION ATOME DIAGRAMA UNIFILAR – TRAFOS TRIFÁSICOS 3 x 30 MVA BARRA SIMPLE	
REVISO	Ing. S. Semidei		
APROBO	Ing. H. Richer	Esc.: S/E	CÓDIGO DE PLANO

ACOPLAMIENTO 220kV

TRANSFORMADOR N°:3

TRANSFORMADOR N°:2

TRANSFORMADOR N°:1

LT 220kV
BRO – ATOME

DESCARGADOR
198 kV

TRANSFORMADOR
DE POTENCIAL
220 kV

SECCIONADOR TRIPOLAR 220 kV c/ P.A.T.

INTERRUPTOR 220 kV

TRANSFORMADOR
DE CORRIENTE
220 kV

BARRA N°:1 220kV

BARRA N°:2 220kV

TRANSFORMADOR DE POTENCIAL–B1

TRANSFORMADOR DE POTENCIAL–B2

SECC. TRIPOLAR
220kV
s/ P.A.T.

TRANSFORMADOR
DE CORRIENTE
220 kV

INTERRUPTOR 220 kV

TRANSFORMADOR N°:3
30 MVA
220/MT kV

TRANSFORMADOR N°:2
30 MVA
220/MT kV

TRANSFORMADOR N°:1
30 MVA
220/MT kV

SECCIONADOR MT

CELDA C2
SS.AA.

CELDA C3
MEDICION

CELDA C5
AL. N°:1

CELDA C10
LLEGADA TR3

CELDA C15
ACO. BARRAS

CELDA C16
TRANSICION BARRAS

CELDA C8
AL. N°:4

CELDA C9
AL. N°:5

CELDA C10
LLEGADA TR1

CELDA C15
ACO. BARRAS

CELDA C16
TRANSICION BARRAS

CELDA C10
LLEGADA TR2

CELDA C11
AL. N°:6

CELDA C12
AL. N°:7

CELDA C13
AL. N°:8

CELDA C14
AL. N°:9

REV.	FECHA	NOMBRE	DESCRIPCION	APROBO	FECHA
2					
1					
–	08/2022	W.S.	PRELIMINAR		

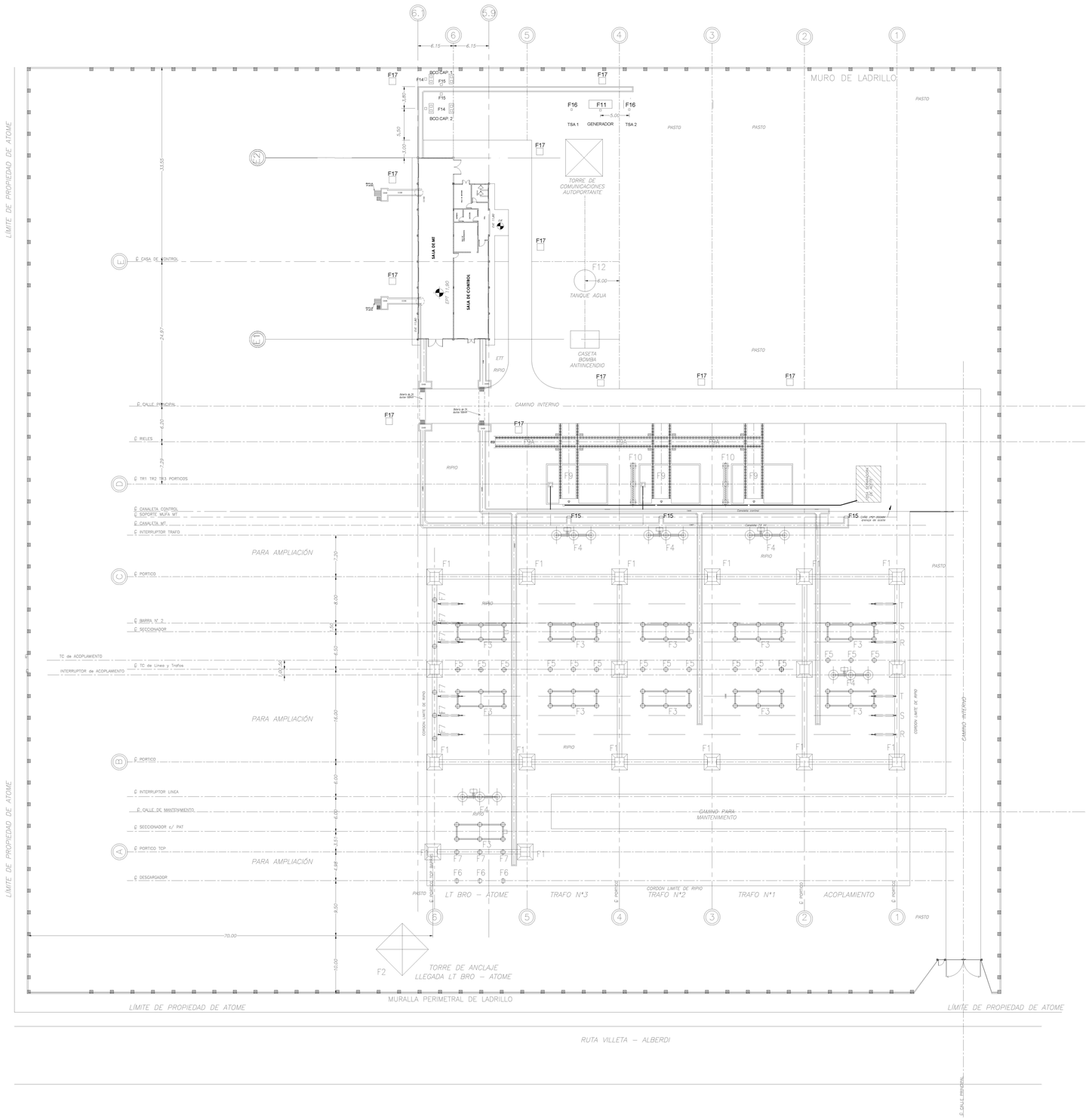
ATOME

ATOME PARAGUAY S.A.
ATOME ENERGY PLC

CONCRET MIX S.A.

"CONSTRUCCIÓN DE LA SUBESTACIÓN ATOME"

PROY.	Ing. W. Sora	SUBESTACION ATOME DIAGRAMA UNIFILAR – TRAFOS TRIFÁSICOS 3 x 30 MVA DOBLE BARRA
REVISO	Ing. S. Semidei	
APROBO	Ing. H. Richer	Esc.: S/E — CÓDIGO DE PLANO



SIMBOLOGIA

E.T.N ELEVACION TERRENO NATURAL
CC40 CANALETA DE 0,40M
CC60 CANALETA DE 0,60M
CC80 CANALETA DE 0,80M
CC100 CANALETA DE 1,0M
CA60 CAMARA 1,40 X 1,20M
CA80 CAMARA 2,0 X 1,0M
CABRESTANTE 1 EN CABECERA VIGA DE TRANSFORMADOR
CABRESTANTE 2 EN CABECERA VIGA DE RIEL AUXILIAR
CABRESTANTE 3 CABRESTANTE AISLADO EN FRENTE DE TRANSFORMADORES

H°A° HORMIGON ARMADO
H°S° HORMIGON SIMPLE.
COTA DE NIVEL

EJES PRINCIPALES DE LA ESTACION

REV.	FECHA	NOMBRE	DESCRIPCION	APROBO	FECHA
2					
1					
–	09/2022	W.S.	PRELIMINAR		

ATOME

ATOME PARAGUAY S.A.
ATOME ENERGY PLC

CONCRET MIX S.A.

"CONSTRUCCIÓN DE LA SUBESTACIÓN ATOME"

PROY.	Ing. W. Sora	SUBESTACION ATOME DISPOSICIÓN GENERAL – PROPUESTA TRAFOS TRIFÁSICOS 3 x 30 MVA DOBLE BARRA	
REVISO	Ing. S. Semidei		
APROBO	Ing. H. Richer	Esc.: 1/400	CÓDIGO DE PLANO

Annex 2 – Water Quality Analysis Reports

GRUPO MULTILAB

Mcal. Estigarribia 1349 - Asunción, Paraguay
Tel. (595 21) 230 560 R.A.
www.multilab.com.py

EcoNatura
Laboratorio de Control
de Alimentos y Medio Ambiente

Informe de Resultados No. 1-0530/23

Determinación solicitada	Matriz
Análisis fisicoquímicos **Elementos químicos**	Agua de río

*Datos del cliente**	*Datos de la muestra*
Solicitado por: Sra. Renata Moretti **Empresa**: JGP CONSULTORÍA E PARTICIPAÇÕES LTDA **Dirección:** Rua Américo Brasiliense 615, Chácara Santo Antonio – São Paulo/SP – CEP: 04715-003. Brasil **Muestra identificada como:** AGUA DE RIO PY 1 – ARRIBA	**Código interno de EcoNatura**: 1-27961 **Fecha de recolección:** 21/03/2023 **Recolectado por:** Téc. Carlos Ruiz / Téc. Genaro Cañiza – Grupo Multilab S.A. **Descripción de la muestra:** La muestra fue recolectada por personal de Grupo Multilab S.A. en 2 (dos) botellas de vidrio ámbar y 1 (una) botella de plástico conteniendo aproximadamente 1 (un) litro cada una.
Fecha de inicio del análisis: 22/03/2023 **Fecha de finalización del análisis:** 21/04/2023	

*El Laboratorio es responsable de la información suministrada en el informe, excepto cuando la misma es proporcionada por el cliente.

Resultados

Análisis	Resultados	Valores de referencia*
pH Método: Potenciométrico	6,85	6,00 a 9,00
Turbidez Método: Nefelométrico ORBECO HELLIGE	14 NTU	100 NTU
Cloruros Método Espectrofotométrico: 90 LOVIBOND	3 mg/L Cl^-	SR**
Sulfatos Método Espectrofotométrico: 360 LOVIBOND	< 2 mg/L SO_4^{-2}	250 mg/L SO_4^{-2}
Amonio no ionizable Método Espectrofotométrico: 62 LOVIBOND	0,02 mg/L NH_3	0,02 mg/L NH_3
Nitrato Método Espectrofotométrico: 8039 HACH	0,5 mg/L N	10 mg/L N

Informe de Resultados No. 1-0530/23

Nitrito Método Espectrofotométrico: 8507 HACH	0,002 mg/L N	1 mg/L N
Color Método Espectrofotométrico: 203 ORBECO HELLIGE	**90 mg/L Pt-Co**	75 mg/L Pt-Co
DBO (5 días, 20°C) Método: SM 5210 B	4,7 mg/L O_2	5 mg/L
Oxígeno disuelto Método: Medidor de oxígeno disuelto ORION STAR A223/RDO	**1,46 mg/L O_2**	No inferior a 5 mg/L O_2
Nitrógeno total Método Espectrofotométrico: 10071 HACH	**1,2 mg/L N**	0,6 mg/L N
Sólidos totales disueltos Método: APHA 2540 C	77 mg/L	500 mg/L
Cianatos Método: APHA 4500 – CN L	< 0,2 mg/L	0,2 mg/L
Cromo hexavalente Método Espectrofotométrico: 124 LOVIBOND	0,061 mg/L	0,5 mg/L
Cromo trivalente Método Espectrofotométrico: 124 LOVIBOND	< 0,005 mg/L	2 mg/L
Bifenilos Policlorados (PCB)*** Método: GC/MS	< 0,0002 mg/L	SR**
Dureza cálcica Método: Titulométrico	23 mg/L $CaCO_3$	300 mg/L $CaCO_3$

Informe de Resultados No. 1-0530/23

Materia Flotante Método: NMX-AA-006-SCFI-2000	Ausencia	Ausencia
Aceites y grasas Método: SM 5520 B	9 mg/L	Ausencia
Pesticidas		
Endosulfan I y II Método: GC/MS Límite de cuantificación: 0,010 mg/L	< 0,010 mg/L	0,056 mg/L
Diazinon Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,005 mg/L
4,4 DDT Método: GC/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,002 mg/L
Endrin Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,002 mg/L
Elementos químicos		
Aluminio (Al) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**2,60 mg/L**	0,2 mg/L
Hierro soluble (Fe) Método: ICP/MS Límite de cuantificación: 0,1 mg/L	**2,1 mg/L**	0,3 mg/L
Sodio (Na) Método: ICP/MS Límite de cuantificación: 1 mg/L	5 mg/L	200 mg/L

Informe de Resultados No. 1-0530/23

Selenio (Se) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Manganeso (Mn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,32 mg/L**	0,1 mg/L
Bario (Ba) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,07 mg/L	2 mg/L
Arsénico (As) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,003 mg/L	0,01 mg/L
Plomo (Pb) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,01 mg/L
Cadmio (Cd) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,001 mg/L
Cobre (Cu) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	1 mg/L
Estaño (Sn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	2 mg/L
Mercurio total (Hg) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	SR**
Níquel (Ni) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,025 mg/L
Zinc (Zn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	3 mg/L

Informe de Resultados No. 1-0530/23

Fósforo total (P) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,37 mg/L**	0,050 mg/L

Observaciones: Los resultados obtenidos sólo afectan a la muestra recolectada y analizada en EcoNatura, un laboratorio del Grupo Multilab S.A.

*Referencia tomada de la Resolución Nº 222/02 emitida por la Secretaria del Medio Ambiente, por la cual se establece el padrón de calidad de las aguas en el territorio nacional. Clase 2. Art. 3º.

**SR: Sin Referencia

***Bifenilos Policlorados monitoreados: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 y PCB 180.

Comentarios: No se registran.

Analizado por:	Autorizado por:
Viviana Báez Bioquímica Responsable del Laboratorio de Medio Ambiente	PA **Alicia Salgueiro** Bioquímica - Reg. Prof. No. 1898 Director Técnico

EcoNatura Laboratorio de Control de Alimentos y Medio Ambiente

Fecha y Hora del Informe: 24/04/2023; 11:26 h
Fin del informe.

Informe de Resultados No. 1-0531/23

Determinación solicitada	Matriz
Análisis fisicoquímicos **Elementos químicos**	Agua de río

*Datos del cliente**	*Datos de la muestra*
Solicitado por: Sra. Renata Moretti **Empresa**: JGP CONSULTORÍA E PARTICIPAÇÕES LTDA **Dirección:** Rua Américo Brasiliense 615, Chácara Santo Antonio – São Paulo/SP – CEP: 04715-003. Brasil **Muestra identificada como:** AGUA DE RIO PY 2 – PUNTO MEDIO	**Código interno de EcoNatura**: 1-27962 **Fecha de recolección:** 21/03/2023 **Recolectado por:** Téc. Carlos Ruiz / Téc. Genaro Cañiza – Grupo Multilab S.A. **Descripción de la muestra:** La muestra fue recolectada por personal de Grupo Multilab S.A. en 2 (dos) botellas de vidrio ámbar y 1 (una) botella de plástico conteniendo aproximadamente 1 (un) litro cada una.
Fecha de inicio del análisis: 22/03/2023 **Fecha de finalización del análisis:** 21/04/2023	

*El Laboratorio es responsable de la información suministrada en el informe, excepto cuando la misma es proporcionada por el cliente.

Resultados

Análisis	Resultados	Valores de referencia*
pH Método: Potenciométrico	6,77	6,00 a 9,00
Turbidez Método: Nefelométrico ORBECO HELLIGE	15 NTU	100 NTU
Cloruros Método Espectrofotométrico: 90 LOVIBOND	3 mg/L Cl^-	SR**
Sulfatos Método Espectrofotométrico: 360 LOVIBOND	< 2 mg/L SO_4^{-2}	250 mg/L SO_4^{-2}
Amonio no ionizable Método Espectrofotométrico: 62 LOVIBOND	0,01 mg/L NH_3	0,02 mg/L NH_3
Nitrato Método Espectrofotométrico: 8039 HACH	< 0,3 mg/L N	10 mg/L N

Informe de Resultados No. 1-0531/23

Nitrito Método Espectrofotométrico: 8507 HACH	< 0,002 mg/L N	1 mg/L N
Color Método Espectrofotométrico: 203 ORBECO HELLIGE	**93 mg/L Pt-Co**	75 mg/L Pt-Co
DBO (5 días, 20°C) Método: SM 5210 B	3,9 mg/L O_2	5 mg/L
Oxígeno disuelto Método: Medidor de oxígeno disuelto ORION STAR A223/RDO	**1,62 mg/L O_2**	No inferior a 5 mg/L O_2
Nitrógeno total Método Espectrofotométrico: 10071 HACH	**1,6 mg/L N**	0,6 mg/L N
Sólidos totales disueltos Método: APHA 2540 C	70 mg/L	500 mg/L
Cianatos Método: APHA 4500 – CN L	< 0,2 mg/L	0,2 mg/L
Cromo hexavalente Método Espectrofotométrico: 124 LOVIBOND	0,059 mg/L	0,5 mg/L
Cromo trivalente Método Espectrofotométrico: 124 LOVIBOND	< 0,005 mg/L	2 mg/L
Bifenilos Policlorados (PCB)*** Método: GC/MS	< 0,0002 mg/L	SR**
Dureza cálcica Método: Titulométrico	39 mg/L $CaCO_3$	300 mg/L $CaCO_3$

Informe de Resultados No. 1-0531/23

Materia Flotante Método: NMX-AA-006-SCFI-2000	Ausencia	Ausencia
Aceites y grasas Método: SM 5520 B	9 mg/L	Ausencia
Pesticidas		
Endosulfan I y II Método: GC/MS Límite de cuantificación: 0,010 mg/L	< 0,010 mg/L	0,056 mg/L
Diazinon Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,005 mg/L
4,4 DDT Método: GC/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,002 mg/L
Endrin Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,002 mg/L
Elementos químicos		
Aluminio (Al) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**1,92 mg/L**	0,2 mg/L
Hierro soluble (Fe) Método: ICP/MS Límite de cuantificación: 0,1 mg/L	**2,1 mg/L**	0,3 mg/L
Sodio (Na) Método: ICP/MS Límite de cuantificación: 1 mg/L	5 mg/L	200 mg/L

Informe de Resultados No. 1-0531/23

Selenio (Se) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Manganeso (Mn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,32 mg/L**	0,1 mg/L
Bario (Ba) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,07 mg/L	2 mg/L
Arsénico (As) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,003 mg/L	0,01 mg/L
Plomo (Pb) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Cadmio (Cd) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,001 mg/L
Cobre (Cu) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	1 mg/L
Estaño (Sn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	2 mg/L
Mercurio total (Hg) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	SR**
Níquel (Ni) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,025 mg/L
Zinc (Zn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	3 mg/L

Informe de Resultados No. 1-0531/23

Fósforo total (P) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,34 mg/L**	0,050 mg/L

Observaciones: Los resultados obtenidos sólo afectan a la muestra recolectada y analizada en EcoNatura, un laboratorio del Grupo Multilab S.A.

*Referencia tomada de la Resolución Nº 222/02 emitida por la Secretaria del Medio Ambiente, por la cual se establece el padrón de calidad de las aguas en el territorio nacional. Clase 2. Art. 3º.

**SR: Sin Referencia

***Bifenilos Policlorados monitoreados: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 y PCB 180.

Comentarios: No se registran.

Analizado por:	Autorizado por:
Viviana Báez Bioquímica Responsable del Laboratorio de Medio Ambiente	**Alicia Salgueiro** Bioquímica - Reg. Prof. No. 1898. Director Técnico

Fecha y Hora del Informe: 24/04/2023; 11:30 h
Fin del informe.

GRUPO MULTILAB

Mcal. Estigarribia 1349 - Asunción, Paraguay
Tel. (595 21) 230 560 R.A.
www.multilab.com.py

EcoNatura
Laboratorio de Control
de Alimentos y Medio Ambiente

Informe de Resultados No. 1-0532/23

Determinación solicitada	Matriz
Análisis fisicoquímicos **Elementos químicos**	Agua de río

*Datos del cliente**	*Datos de la muestra*
Solicitado por: Sra. Renata Moretti **Empresa**: JGP CONSULTORÍA E PARTICIPAÇÕES LTDA **Dirección:** Rua Américo Brasiliense 615, Chácara Santo Antonio – São Paulo/SP – CEP: 04715-003. Brasil **Muestra identificada como:** AGUA DE RIO PY 3 – ABAJO	**Código interno de EcoNatura**: 1-27963 **Fecha de recolección:** 21/03/2023 **Recolectado por:** Téc. Carlos Ruiz / Téc. Genaro Cañiza – Grupo Multilab S.A. **Descripción de la muestra:** La muestra fue recolectada por personal de Grupo Multilab S.A. en 2 (dos) botellas de vidrio ámbar y 1 (una) botella de plástico conteniendo aproximadamente 1 (un) litro cada una.
Fecha de inicio del análisis: 22/03/2023 **Fecha de finalización del análisis:** 21/04/2023	

*El Laboratorio es responsable de la información suministrada en el informe, excepto cuando la misma es proporcionada por el cliente.

Resultados

Análisis	Resultados	Valores de referencia*
pH Método: Potenciométrico	6,75	6,00 a 9,00
Turbidez Método: Nefelométrico ORBECO HELLIGE	13 NTU	100 NTU
Cloruros Método Espectrofotométrico: 90 LOVIBOND	3 mg/L Cl^-	SR**
Sulfatos Método Espectrofotométrico: 360 LOVIBOND	< 2 mg/L SO_4^{-2}	250 mg/L SO_4^{-2}
Amonio no ionizable Método Espectrofotométrico: 62 LOVIBOND	0,01 mg/L NH_3	0,02 mg/L NH_3
Nitrato Método Espectrofotométrico: 8039 HACH	< 0,3 mg/L N	10 mg/L N

Informe de Resultados No. 1-0532/23

Nitrito Método Espectrofotométrico: 8507 HACH	< 0,002 mg/L N	1 mg/L N
Color Método Espectrofotométrico: 203 ORBECO HELLIGE	**91 mg/L Pt-Co**	75 mg/L Pt-Co
DBO (5 días, 20°C) Método: SM 5210 B	3,9 mg/L O_2	5 mg/L
Oxígeno disuelto Método: Medidor de oxígeno disuelto ORION STAR A223/RDO	**1,33 mg/L O_2**	No inferior a 5 mg/L O_2
Nitrógeno total Método Espectrofotométrico: 10071 HACH	**1,3 mg/L N**	0,6 mg/L N
Sólidos totales disueltos Método: APHA 2540 C	73 mg/L	500 mg/L
Cianatos Método: APHA 4500 – CN L	< 0,2 mg/L	0,2 mg/L
Cromo hexavalente Método Espectrofotométrico: 124 LOVIBOND	0,058 mg/L	0,5 mg/L
Cromo trivalente Método Espectrofotométrico: 124 LOVIBOND	< 0,005 mg/L	2 mg/L
Bifenilos Policlorados (PCB)*** Método: GC/MS	< 0,0002 mg/L	SR**
Dureza cálcica Método: Titulométrico	35 mg/L $CaCO_3$	300 mg/L $CaCO_3$

Informe de Resultados No. 1-0532/23

Materia Flotante Método: NMX-AA-006-SCFI-2000	Ausencia	Ausencia
Aceites y grasas Método: SM 5520 B	8 mg/L	Ausencia
Pesticidas		
Endosulfan I y II Método: GC/MS Límite de cuantificación: 0,010 mg/L	< 0,010 mg/L	0,056 mg/L
Diazinon Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,005 mg/L
4,4 DDT Método: GC/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,002 mg/L
Endrin Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,002 mg/L
Elementos químicos		
Aluminio (Al) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**2,43 mg/L**	0,2 mg/L
Hierro soluble (Fe) Método: ICP/MS Límite de cuantificación: 0,1 mg/L	**2,1 mg/L**	0,3 mg/L
Sodio (Na) Método: ICP/MS Límite de cuantificación: 1 mg/L	5 mg/L	200 mg/L

Informe de Resultados No. 1-0532/23

Selenio (Se) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Manganeso (Mn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,30 mg/L**	0,1 mg/L
Bario (Ba) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,07 mg/L	2 mg/L
Arsénico (As) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,003 mg/L	0,01 mg/L
Plomo (Pb) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Cadmio (Cd) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,001 mg/L
Cobre (Cu) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	1 mg/L
Estaño (Sn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	2 mg/L
Mercurio total (Hg) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	SR**
Níquel (Ni) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,025 mg/L
Zinc (Zn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	3 mg/L

Informe de Resultados No. 1-0532/23

Fósforo total (P) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,34 mg/L**	0,050 mg/L

Observaciones: Los resultados obtenidos sólo afectan a la muestra recolectada y analizada en EcoNatura, un laboratorio del Grupo Multilab S.A.

*Referencia tomada de la Resolución Nº 222/02 emitida por la Secretaria del Medio Ambiente, por la cual se establece el padrón de calidad de las aguas en el territorio nacional. Clase 2. Art. 3º.

**SR: Sin Referencia

***Bifenilos Policlorados monitoreados: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 y PCB 180.

Comentarios: No se registran.

Analizado por:	Autorizado por:
Viviana Báez Bioquímica Responsable del Laboratorio de Medio Ambiente	**Alicia Salgueiro.** Bioquímica - Reg. Prof. No. 1898 Director Técnico

Fecha y Hora del Informe: 24/04/2023; 11:35 h
Fin del informe.

Informe de Resultados Nº 781/23

Determinación Solicitada: Análisis Microbiológico según Art. Nº 7 de la Resolución 222/02 de la SEAM.	**Matriz:** Agua de Rio.
Solicitado por: JGP CONSULTORIA E PARTICIPAÇÕES LTDA.	**Dirección:** Rua Américo Brasiliense, 615, Chácara San Antonio, São Paulo /SP-CEP: 04715-003, Brasil.

Datos de la muestra

Identificación de la muestra: Agua de Rio - 781/23.

Nombre del Producto: Agua de Rio Py 1 – Arriba.

Contenido: Agua de Rio.

Presentación: Frasco estéril.

No. de Lote: N/A.

Vencimiento/Fecha de elaboración: N/A.

Cantidad de muestra: 2 frascos x 80mL.

Fecha y Hora de Recolección de la muestra: 21/03/2023; 10:40 h.

Fecha y Hora de Recepción de la muestra: 21/03/2023; 15:29 h.

Muestra recolectada por: Téc. Carlos Ruiz y Téc. Genaro Cañiza.

Descripción del punto de muestreo: La muestra se tomó con el muestreador a 150 mts. aproximadamente de la costa. Temperatura de muestreo: 31,1ºC.

Descripción de la muestra: Apariencia turbia. Temperatura de recepción: 10ºC.

Código interno: 3-11.114.

Metodología Analítica:

_*Coliformes Fecales o Termotolerantes, Coliformes Totales:* Técnica NMP/100mL (Número más probable): Caldo Lactosado. Temperatura de Incubación: 35°C - 37 °C. Tiempo de Incubación: 24 - 48 h. Caldo *E. coli*. Temperatura de Incubación: 44°C. Tiempo de incubación: 24 h.

Fecha de inicio del Análisis: 23/03/2023

Fecha de finalización del Análisis: 25/03/2023

Ensayos	Especificaciones*	Resultados
Coliformes Totales	Informativo	54200 NMP/100mL
Coliformes Fecales	4000 NMP/100mL	542 NMP/100mL

*Referencia tomada de la Resolución Nº 222/02 – Artículo 7 de la Secretaría del Ambiente.

Observaciones Generales: Los resultados obtenidos solo afectan a la muestra recepcionada y analizada en BioControl, un Laboratorio del Grupo Multilab S.A.

Comentarios: No se registran.

Analizado por:	Revisado y Autorizado por:
Lic. Biotec. Andrea Magali Planás Lugo Reg. Prof. Nº 055 **Analista**	**Q.F. Grecia Doldán** Reg. Prof. Nº. 1.657 **Director Técnico**

Fecha de Informe: 27/03/2023

Fin de Informe.

El laboratorio no es responsable de la información proporcionada por el cliente, que puede afectar la validez de los resultados.

Informe de Resultados Nº 782/23

Determinación Solicitada: Análisis Microbiológico según Art. Nº 7 de la Resolución 222/02 de la SEAM.	**Matriz:** Agua de Rio.
Solicitado por: JGP CONSULTORIA E PARTICIPAÇÕES LTDA.	**Dirección:** Rua Américo Brasiliense, 615, Chácara San Antonio, São Paulo /SP-CEP: 04715-003, Brasil.

Datos de la muestra

Identificación de la muestra: Agua de Rio - 782/23.

Nombre del Producto: Agua de Rio Py 2 – Punto medio.

Contenido: Agua de Rio.

Presentación: Frasco estéril.

No. de Lote: N/A.

Vencimiento/Fecha de elaboración: N/A.

Cantidad de muestra: 2 frascos x 80mL.

Fecha y Hora de Recolección de la muestra: 21/03/2023; 11:00 h.

Fecha y Hora de Recepción de la muestra: 21/03/2023; 15:29 h.

Muestra recolectada por: Téc. Carlos Ruiz y Téc. Genaro Cañiza.

Descripción del punto de muestreo: La muestra se tomó con el muestreador a 100 mts. aproximadamente de la costa. Temperatura de muestreo: 32,1ºC.

Descripción de la muestra: Apariencia turbia. Temperatura de recepción: 9,2ºC.

Código interno: 3-11.115.

Metodología Analítica:

_*Coliformes Fecales o Termotolerantes, Coliformes Totales:* Técnica NMP/100mL (Número más probable): Caldo Lactosado. Temperatura de Incubación: 35°C - 37 °C. Tiempo de Incubación: 24 - 48 h. Caldo *E. coli*. Temperatura de Incubación: 44°C. Tiempo de incubación: 24 h.

Fecha de inicio del Análisis: 23/03/2023

Fecha de finalización del Análisis: 25/03/2023

Ensayos	Especificaciones*	Resultados
Coliformes Totales	Informativo	>240000 NMP/100mL
Coliformes Fecales	4000 NMP/100mL	1750 NMP/100mL

*Referencia tomada de la Resolución Nº 222/02 – Artículo 7 de la Secretaría del Ambiente.

Observaciones Generales: Los resultados obtenidos solo afectan a la muestra recepcionada y analizada en BioControl, un Laboratorio del Grupo Multilab S.A.
Comentarios: No se registran.

Analizado por:	Revisado y Autorizado por:
Lic. Biotec. Andrea Magali Planás Lugo Reg. Prof. Nº 055 **Analista**	**Q.F. Grecia Doldán** Reg. Prof. Nº. 1.657 **Director Técnico**

Fecha de Informe: 27/03/2023

Fin de Informe.

El laboratorio no es responsable de la información proporcionada por el cliente, que puede afectar la validez de los resultados.

GRUPO MULTILAB | Mcal. Estigarribia 1349 - Asunción, Paraguay
Tel. (595 21) 230 560 R.A.
www.multilab.com.py | BioControl Microbiología Industrial

Informe de Resultados Nº 783/23

Determinación Solicitada: Análisis Microbiológico según Art. Nº 7 de la Resolución 222/02 de la SEAM.	**Matriz:** Agua de Rio.
Solicitado por: JGP CONSULTORIA E PARTICIPAÇÕES LTDA.	**Dirección:** Rua Américo Brasiliense, 615, Chácara San Antonio, São Paulo /SP-CEP: 04715-003, Brasil.

Datos de la muestra

Identificación de la muestra: Agua de Rio - 783/23.

Nombre del Producto: Agua de Rio Py 3 – Abajo.

Contenido: Agua de Rio.

Presentación: Frasco estéril.

No. de Lote: N/A.

Vencimiento/Fecha de elaboración: N/A.

Cantidad de muestra: 2 frascos x 80mL.

Fecha y Hora de Recolección de la muestra: 21/03/2023; 11:20 h.

Fecha y Hora de Recepción de la muestra: 21/03/2023; 15:29 h.

Muestra recolectada por: Téc. Carlos Ruiz y Téc. Genaro Cañiza.

Descripción del punto de muestreo: La muestra se tomó con el muestreador a 100 mts. aproximadamente de la costa. Temperatura de muestreo: 31,4ºC.

Descripción de la muestra: Apariencia turbia. Temperatura de recepción: 9,4ºC.

Código interno: 3-11.116.

Metodología Analítica:

_*Coliformes Fecales o Termotolerantes, Coliformes Totales:* Técnica NMP/100mL (Número más probable): Caldo Lactosado. Temperatura de Incubación: 35°C - 37 °C. Tiempo de Incubación: 24 - 48 h. Caldo *E. coli*. Temperatura de Incubación: 44°C. Tiempo de incubación: 24 h.

Fecha de inicio del Análisis: 23/03/2023

Fecha de finalización del Análisis: 25/03/2023

Ensayos	Especificaciones*	Resultados
Coliformes Totales	Informativo	24000 NMP/100mL
Coliformes Fecales	4000 NMP/100mL	700 NMP/100mL

*Referencia tomada de la Resolución Nº 222/02 – Artículo 7 de la Secretaría del Ambiente.

Observaciones Generales: Los resultados obtenidos solo afectan a la muestra recepcionada y analizada en BioControl, un Laboratorio del Grupo Multilab S.A.

Comentarios: No se registran.

Analizado por:	Revisado y Autorizado por:
Lic. Biotec. Andrea Magali Planás Lugo Reg. Prof. Nº 055 **Analista**	**Q.F. Grecia Doldán** Reg. Prof. Nº. 1.657 **Director Técnico**

BioControl Microbiología Industrial

Fecha de Informe: 27/03/2023

Fin de Informe.

El laboratorio no es responsable de la información proporcionada por el cliente, que puede afectar la validez de los resultados.

Informe de Resultados No. 1-1611/23

Determinación solicitada	Matriz
Análisis fisicoquímicos **Elementos químicos**	Agua de río

*Datos del cliente**	*Datos de la muestra*
Solicitante: Sra. Renata Moretti – JGP CONSULTORÍA E PARTICIPAÇÕES LTDA **Dirección:** Villeta **Muestra identificada como:** AGUA DE RIO PY 1 – ARRIBA	**Código interno de EcoNatura**: 1-29042 **Fecha de recolección:** 14/06/2023 **Descripción de la muestra:** La muestra fue recolectada por personal de Grupo Multilab S.A. en 2 (dos) botellas de vidrio ámbar y 1 (una) botella de plástico conteniendo aproximadamente 1 (un) litro cada una.
Fecha de inicio del análisis: 14/06/2023 **Fecha de finalización del análisis:** 12/07/2023	

*El Laboratorio es responsable de la información suministrada en el informe, excepto cuando la misma es proporcionada por el cliente.

Resultados

Análisis	Resultados	Valores de referencia**
pH Método: Potenciométrico	7,88	6,00 a 9,00
Turbidez Método: Nefelométrico ORBECO HELLIGE	10 NTU	100 NTU
Cloruros Método Espectrofotométrico: 90 LOVIBOND	10 mg/L Cl^-	SR***
Sulfatos Método Espectrofotométrico: 360 LOVIBOND	< 2 mg/L SO_4^{-2}	250 mg/L SO_4^{-2}

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1611/23

Amonio no ionizable Método Espectrofotométrico: 62 LOVIBOND	0,02 mg/L NH_3	0,02 mg/L NH_3
Nitrato Método Espectrofotométrico: 8039 HACH	0,6 mg/L N	10 mg/L N
Nitrito Método Espectrofotométrico: 8507 HACH	0,003 mg/L N	1 mg/L N
Color Método Espectrofotométrico: 203 ORBECO HELLIGE	**112 mg/L Pt-Co**	75 mg/L Pt-Co
DBO (5 días, 20°C) Método: SM 5210 B	1,9 mg/L O_2	5 mg/L
Oxígeno disuelto Método: Medidor de oxígeno disuelto ORION STAR A223/RDO	8,58 mg/L O_2	No inferior a 5 mg/L O_2
Nitrógeno total Método Espectrofotométrico: 10071 HACH	**2,3 mg/L N**	0,6 mg/L N
Sólidos totales disueltos Método: APHA 2540 C	133 mg/L	500 mg/L
Cianatos Método: APHA 4500 – CN L	< 0,2 mg/L	0,2 mg/L
Cromo hexavalente Método Espectrofotométrico: 10218/10219 HACH	0,14 mg/L	0,5 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1611/23

Cromo trivalente Método Espectrofotométrico: 10219 HACH	< 0,03 mg/L	2 mg/L
Bifenilos Policlorados (PCB)**** Método: GC/MS	< 0,0002 mg/L	SR***
Dureza cálcica Método: Titulométrico	31 mg/L $CaCO_3$	300 mg/L $CaCO_3$
Materia Flotante Método: NMX-AA-006-SCFI-2000	Ausencia	Ausencia
Aceites y grasas Método: SM 5520 B	8 mg/L	Ausencia
Pesticidas		
Endosulfan I y II Método: GC/MS Límite de cuantificación: 0,010 mg/L	< 0,010 mg/L	0,056 mg/L
Diazinon Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,005 mg/L
4,4 DDT Método: GC/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,002 mg/L
Endrin Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,002 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1611/23

Elementos químicos		
Aluminio (Al) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**1,46 mg/L**	0,2 mg/L
Hierro soluble (Fe) Método: ICP/MS Límite de cuantificación: 0,1 mg/L	**1,0 mg/L**	0,3 mg/L
Sodio (Na) Método: ICP/MS Límite de cuantificación: 1 mg/L	18 mg/L	200 mg/L
Selenio (Se) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Manganeso (Mn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	0,1 mg/L
Bario (Ba) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,06 mg/L	2 mg/L
Arsénico (As) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,002 mg/L	0,01 mg/L
Plomo (Pb) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Cadmio (Cd) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,001 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1611/23

Cobre (Cu) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	1 mg/L
Estaño (Sn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	2 mg/L
Mercurio total (Hg) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	SR***
Níquel (Ni) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,002 mg/L	0,025 mg/L
Zinc (Zn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	3 mg/L
Fósforo total (P) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,12 mg/L**	0,050 mg/L

Observaciones: Los resultados obtenidos sólo afectan a la muestra recolectada y analizada en EcoNatura, un laboratorio del Grupo Multilab S.A.

**Referencia tomada de la Resolución Nº 222/02 emitida por la Secretaria del Medio Ambiente, por la cual se establece el padrón de calidad de las aguas en el territorio nacional. Clase 2. Art. 3º.

***SR: Sin Referencia.

****Bifenilos Policlorados monitoreados: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 y PCB 180.

Comentarios: No se registran.

Analizado por:	Autorizado por:
Viviana Báez Bioquímica Responsable del Laboratorio de Medio Ambiente	**Alicia Salgueiro** Bioquímica - Reg. Prof. No. 1898 Director Técnico

Fecha y Hora del Informe: 13/07/2023; 14:21 h
Fin del informe.

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1612/23

Determinación solicitada	Matriz
Análisis fisicoquímicos **Elementos químicos**	Agua de río

*Datos del cliente**	*Datos de la muestra*
Solicitante: Sra. Renata Moretti – JGP CONSULTORÍA E PARTICIPAÇÕES LTDA **Dirección:** Villeta **Muestra identificada como:** AGUA DE RIO PY 2 – MEDIO PUNTO AGUAS ARRIBA DEL VERTIDO DE EFLUENTES	**Código interno de EcoNatura**: 1-29043 **Fecha de recolección:** 14/06/2023 **Descripción de la muestra:** La muestra fue recolectada por personal de Grupo Multilab S.A. en 2 (dos) botellas de vidrio ámbar y 1 (una) botella de plástico conteniendo aproximadamente 1 (un) litro cada una.
Fecha de inicio del análisis: 14/06/2023 **Fecha de finalización del análisis:** 12/07/2023	

*El Laboratorio es responsable de la información suministrada en el informe, excepto cuando la misma es proporcionada por el cliente.

Resultados

Análisis	Resultados	Valores de referencia**
pH Método: Potenciométrico	7,64	6,00 a 9,00
Turbidez Método: Nefelométrico ORBECO HELLIGE	10 NTU	100 NTU
Cloruros Método Espectrofotométrico: 90 LOVIBOND	8 mg/L Cl^-	SR***
Sulfatos Método Espectrofotométrico: 360 LOVIBOND	< 2 mg/L SO_4^{-2}	250 mg/L SO_4^{-2}

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1612/23

Amonio no ionizable Método Espectrofotométrico: 62 LOVIBOND	0,02 mg/L NH_3	0,02 mg/L NH_3
Nitrato Método Espectrofotométrico: 8039 HACH	0,4 mg/L N	10 mg/L N
Nitrito Método Espectrofotométrico: 8507 HACH	0,002 mg/L N	1 mg/L N
Color Método Espectrofotométrico: 203 ORBECO HELLIGE	**110 mg/L Pt-Co**	75 mg/L Pt-Co
DBO (5 días, 20°C) Método: SM 5210 B	2,0 mg/L O_2	5 mg/L
Oxígeno disuelto Método: Medidor de oxígeno disuelto ORION STAR A223/RDO	8,30 mg/L O_2	No inferior a 5 mg/L O_2
Nitrógeno total Método Espectrofotométrico: 10071 HACH	**0,9 mg/L N**	0,6 mg/L N
Sólidos totales disueltos Método: APHA 2540 C	130 mg/L	500 mg/L
Cianatos Método: APHA 4500 – CN L	< 0,2 mg/L	0,2 mg/L
Cromo hexavalente Método Espectrofotométrico: 10218/10219 HACH	0,24 mg/L	0,5 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1612/23

Cromo trivalente Método Espectrofotométrico: 10219 HACH	< 0,03 mg/L	2 mg/L
Bifenilos Policlorados (PCB)**** Método: GC/MS	< 0,0002 mg/L	SR***
Dureza cálcica Método: Titulométrico	33 mg/L $CaCO_3$	300 mg/L $CaCO_3$
Materia Flotante Método: NMX-AA-006-SCFI-2000	Ausencia	Ausencia
Aceites y grasas Método: SM 5520 B	9 mg/L	Ausencia
Pesticidas		
Endosulfan I y II Método: GC/MS Límite de cuantificación: 0,010 mg/L	< 0,010 mg/L	0,056 mg/L
Diazinon Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,005 mg/L
4,4 DDT Método: GC/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,002 mg/L
Endrin Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,002 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1612/23

Elementos químicos		
Aluminio (Al) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**1,43 mg/L**	0,2 mg/L
Hierro soluble (Fe) Método: ICP/MS Límite de cuantificación: 0,1 mg/L	**1,0 mg/L**	0,3 mg/L
Sodio (Na) Método: ICP/MS Límite de cuantificación: 1 mg/L	14 mg/L	200 mg/L
Selenio (Se) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Manganeso (Mn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	0,1 mg/L
Bario (Ba) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,06 mg/L	2 mg/L
Arsénico (As) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,003 mg/L	0,01 mg/L
Plomo (Pb) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Cadmio (Cd) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,001 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1612/23

Cobre (Cu) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	1 mg/L
Estaño (Sn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	2 mg/L
Mercurio total (Hg) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	SR***
Níquel (Ni) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,025 mg/L
Zinc (Zn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	3 mg/L
Fósforo total (P) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,10 mg/L**	0,050 mg/L

Observaciones: Los resultados obtenidos sólo afectan a la muestra recolectada y analizada en EcoNatura, un laboratorio del Grupo Multilab S.A.

**Referencia tomada de la Resolución Nº 222/02 emitida por la Secretaria del Medio Ambiente, por la cual se establece el padrón de calidad de las aguas en el territorio nacional. Clase 2. Art. 3º.

***SR: Sin Referencia.

****Bifenilos Policlorados monitoreados: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 y PCB 180.

Comentarios: No se registran.

Analizado por:	Autorizado por:
Viviana Báez Bioquímica Responsable del Laboratorio de Medio Ambiente	**Alicia Salgueiro** Bioquímica - Reg. Prof. No. 1898 Director Técnico

EcoNatura Laboratorio de Control de Alimentos y Medio Ambiente

Fecha y Hora del Informe: 13/07/2023; 14:25 h
Fin del informe.

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1613/23

Determinación solicitada	Matriz
Análisis fisicoquímicos **Elementos químicos**	Agua de río

*Datos del cliente**	*Datos de la muestra*
Solicitante: Sra. Renata Moretti – JGP CONSULTORÍA E PARTICIPAÇÕES LTDA **Dirección:** Villeta **Muestra identificada como:** AGUA DE RIO PY 3 PUNTO AGUAS ABAJO DEL VERTIDO DE EFLUENTES	**Código interno de EcoNatura**: 1-29044 **Fecha de recolección:** 14/06/2023 **Descripción de la muestra:** La muestra fue recolectada por personal de Grupo Multilab S.A. en 2 (dos) botellas de vidrio ámbar y 1 (una) botella de plástico conteniendo aproximadamente 1 (un) litro cada una.
Fecha de inicio del análisis: 14/06/2023 **Fecha de finalización del análisis:** 12/07/2023	

*El Laboratorio es responsable de la información suministrada en el informe, excepto cuando la misma es proporcionada por el cliente.

Resultados

Análisis	Resultados	Valores de referencia**
pH Método: Potenciométrico	7,68	6,00 a 9,00
Turbidez Método: Nefelométrico ORBECO HELLIGE	10 NTU	100 NTU
Cloruros Método Espectrofotométrico: 90 LOVIBOND	12 mg/L Cl^-	SR***
Sulfatos Método Espectrofotométrico: 360 LOVIBOND	< 2 mg/L SO_4^{-2}	250 mg/L SO_4^{-2}

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1613/23

Amonio no ionizable Método Espectrofotométrico: 62 LOVIBOND	0,02 mg/L NH_3	0,02 mg/L NH_3
Nitrato Método Espectrofotométrico: 8039 HACH	0,2 mg/L N	10 mg/L N
Nitrito Método Espectrofotométrico: 8507 HACH	0,003 mg/L N	1 mg/L N
Color Método Espectrofotométrico: 203 ORBECO HELLIGE	**111 mg/L Pt-Co**	75 mg/L Pt-Co
DBO (5 días, 20°C) Método: SM 5210 B	1,9 mg/L O_2	5 mg/L
Oxígeno disuelto Método: Medidor de oxígeno disuelto ORION STAR A223/RDO	8,51 mg/L O_2	No inferior a 5 mg/L O_2
Nitrógeno total Método Espectrofotométrico: 10071 HACH	**1,5 mg/L N**	0,6 mg/L N
Sólidos totales disueltos Método: APHA 2540 C	137 mg/L	500 mg/L
Cianatos Método: APHA 4500 – CN L	< 0,2 mg/L	0,2 mg/L
Cromo hexavalente Método Espectrofotométrico: 10218/10219 HACH	0,36 mg/L	0,5 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1613/23

Cromo trivalente Método Espectrofotométrico: 10219 HACH	< 0,03 mg/L	2 mg/L
Bifenilos Policlorados (PCB)**** Método: GC/MS	< 0,0002 mg/L	SR***
Dureza cálcica Método: Titulométrico	36 mg/L $CaCO_3$	300 mg/L $CaCO_3$
Materia Flotante Método: NMX-AA-006-SCFI-2000	Ausencia	Ausencia
Aceites y grasas Método: SM 5520 B	7 mg/L	Ausencia
Pesticidas		
Endosulfan I y II Método: GC/MS Límite de cuantificación: 0,010 mg/L	< 0,010 mg/L	0,056 mg/L
Diazinon Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,005 mg/L
4,4 DDT Método: GC/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,002 mg/L
Endrin Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,002 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1613/23

Elementos químicos		
Aluminio (Al) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**1,37 mg/L**	0,2 mg/L
Hierro soluble (Fe) Método: ICP/MS Límite de cuantificación: 0,1 mg/L	**1,0 mg/L**	0,3 mg/L
Sodio (Na) Método: ICP/MS Límite de cuantificación: 1 mg/L	13 mg/L	200 mg/L
Selenio (Se) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Manganeso (Mn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	0,1 mg/L
Bario (Ba) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,06 mg/L	2 mg/L
Arsénico (As) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,002 mg/L	0,01 mg/L
Plomo (Pb) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,01 mg/L
Cadmio (Cd) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,001 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-1613/23

Cobre (Cu) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	1 mg/L
Estaño (Sn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	2 mg/L
Mercurio total (Hg) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	SR***
Níquel (Ni) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,025 mg/L
Zinc (Zn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	3 mg/L
Fósforo total (P) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,10 mg/L**	0,050 mg/L

Observaciones: Los resultados obtenidos sólo afectan a la muestra recolectada y analizada en EcoNatura, un laboratorio del Grupo Multilab S.A.

**Referencia tomada de la Resolución Nº 222/02 emitida por la Secretaria del Medio Ambiente, por la cual se establece el padrón de calidad de las aguas en el territorio nacional. Clase 2. Art. 3º.

***SR: Sin Referencia.

****Bifenilos Policlorados monitoreados: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 y PCB 180.

Comentarios: No se registran.

Analizado por:	Autorizado por:
Viviana Báez Bioquímica Responsable del Laboratorio de Medio Ambiente	**Alicia Salgueiro** Bioquímica - Reg. Prof. No. 1898 Director Técnico

EcoNatura Laboratorio de Control de Alimentos y Medio Ambiente

Fecha y Hora del Informe: 13/07/2023; 14:28 h
Fin del informe.

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados Nº 1709/23

Determinación Solicitada: Análisis Microbiológico según Art. Nº 7 de la Resolución 222/02 de la SEAM.	**Matriz:** Agua de Rio.
Solicitado por: JGP CONSULTORIA E PARTICIPAÇÕES LTDA.	**Dirección:** Villeta – Paraguay.

Datos de la muestra

Identificación de la muestra: Agua de Rio - 1709/23.

Nombre del Producto: Agua de Rio Py 1 arriba.

Contenido: Agua de Rio.

Presentación: Frasco estéril.

No. de Lote: N/A.

Vencimiento/Fecha de elaboración: N/A.

Cantidad de muestra: 2 frascos x 80mL.

Fecha y Hora de Recolección de la muestra: 14/06/2023; 11:00 h.

Fecha y Hora de Recepción de la muestra: 14/06/2023; 17:52 h.

Muestra recolectada por: Téc. Carlos Ruiz.

Descripción del punto de muestreo: La muestra se tomó con el muestreador de mango largo a 30 mts. aprox. de la orilla. Temperatura de muestreo: 17ºC.

Descripción de la muestra: Apariencia turbia. Temperatura de recepción: 13,2ºC.

Código interno: 3-12.042.

Metodología Analítica:

_*Coliformes Fecales o Termotolerantes, Coliformes Totales:* Técnica NMP/100mL (Número más probable): Caldo Lactosado. Temperatura de Incubación: 35°C - 37 °C. Tiempo de Incubación: 24 - 48 h. Caldo *E. coli*. Temperatura de Incubación: 44°C. Tiempo de incubación: 24 h.

Fecha de inicio del Análisis: 15/06/2023

Fecha de finalización del Análisis: 19/06/2023

Ensayos	Especificaciones*	Resultados
Coliformes Totales	Informativo	9180 NMP/100mL
Coliformes Fecales	4000 NMP/100mL	348 NMP/100mL

*Referencia tomada de la Resolución Nº 222/02 – Artículo 7 de la Secretaría del Ambiente.

Observaciones Generales: Los resultados obtenidos solo afectan a la muestra recepcionada y analizada en BioControl, un Laboratorio del Grupo Multilab S.A.

Comentarios: No se registran.

Analizado por:	Revisado y Autorizado por:
Lic. Biotec. Andrea Magali Planás Lugo Reg. Prof. Nº 055 **Analista**	**Q.F. Grecia Doldán** Reg. Prof. Nº. 1.657 **Director Técnico**

Fecha de Informe: 19/06/2023

Fin de Informe.

El laboratorio no es responsable de la información proporcionada por el cliente, que puede afectar la validez de los resultados.

Informe de Resultados Nº 1710/23

Determinación Solicitada: Análisis Microbiológico según Art. Nº 7 de la Resolución 222/02 de la SEAM.	**Matriz:** Agua de Rio.
Solicitado por: JGP CONSULTORIA E PARTICIPAÇÕES LTDA.	**Dirección:** Villeta – Paraguay.

Datos de la muestra

Identificación de la muestra: Agua de Rio - 1710/23.

Nombre del Producto: Agua de Rio Py 2 medio, punto aguas arriba del vertido de efluentes.

Contenido: Agua de Rio.

Presentación: Frasco estéril.

No. de Lote: N/A.

Vencimiento/Fecha de elaboración: N/A.

Cantidad de muestra: 2 frascos x 80mL.

Fecha y Hora de Recolección de la muestra: 14/06/2023; 11:30 h.

Fecha y Hora de Recepción de la muestra: 14/06/2023; 17:52 h.

Muestra recolectada por: Téc. Carlos Ruiz.

Descripción del punto de muestreo: La muestra se tomó con el muestreador de mango largo a 20 mts. aprox. de la orilla. Temperatura de muestreo: 19,9ºC.

Descripción de la muestra: Apariencia turbia. Temperatura de recepción: 13,5ºC.

Código interno: 3-12.043.

Metodología Analítica:

_*Coliformes Fecales o Termotolerantes, Coliformes Totales:* Técnica NMP/100mL (Número más probable): Caldo Lactosado. Temperatura de Incubación: 35°C - 37 °C. Tiempo de Incubación: 24 - 48 h. Caldo *E. coli*. Temperatura de Incubación: 44°C. Tiempo de incubación: 24 h.

Fecha de inicio del Análisis: 15/06/2023

Fecha de finalización del Análisis: 19/06/2023

Ensayos	Especificaciones*	Resultados
Coliformes Totales	Informativo	5420 NMP/100mL
Coliformes Fecales	4000 NMP/100mL	330 NMP/100mL

*Referencia tomada de la Resolución Nº 222/02 – Artículo 7 de la Secretaría del Ambiente.

Observaciones Generales: Los resultados obtenidos solo afectan a la muestra recepcionada y analizada en BioControl, un Laboratorio del Grupo Multilab S.A.

Comentarios: No se registran.

Analizado por:	Revisado y Autorizado por:
Lic. Biotec. Andrea Magali Planás Lugo Reg. Prof. Nº 055 **Analista**	**Q.F. Grecia Doldán** Reg. Prof. Nº. 1.657 **Director Técnico**

Fecha de Informe: 19/06/2023

Fin de Informe.

El laboratorio no es responsable de la información proporcionada por el cliente, que puede afectar la validez de los resultados.

Informe de Resultados Nº 1711/23

Determinación Solicitada: Análisis Microbiológico según Art. Nº 7 de la Resolución 222/02 de la SEAM.	**Matriz:** Agua de Rio.
Solicitado por: JGP CONSULTORIA E PARTICIPAÇÕES LTDA.	**Dirección:** Villeta – Paraguay.

Datos de la muestra

Identificación de la muestra: Agua de Rio - 1711/23.

Nombre del Producto: Agua de Rio Py 3, punto aguas abajo del vertido de efluentes.

Contenido: Agua de Rio.

Presentación: Frasco estéril.

No. de Lote: N/A.

Vencimiento/Fecha de elaboración: N/A.

Cantidad de muestra: 2 frascos x 80mL.

Fecha y Hora de Recolección de la muestra: 14/06/2023; 11:50 h.

Fecha y Hora de Recepción de la muestra: 14/06/2023; 17:52 h.

Muestra recolectada por: Téc. Carlos Ruiz.

Descripción del punto de muestreo: La muestra se tomó con el muestreador de mango largo a 20 mts. aprox. de la orilla. Temperatura de muestreo: 17,8ºC.

Descripción de la muestra: Apariencia turbia. Temperatura de recepción: 13,1ºC.

Código interno: 3-12.044.

Metodología Analítica:

_*Coliformes Fecales o Termotolerantes, Coliformes Totales:* Técnica NMP/100mL (Número más probable): Caldo Lactosado. Temperatura de Incubación: 35°C - 37 °C. Tiempo de Incubación: 24 - 48 h. Caldo *E. coli*. Temperatura de Incubación: 44°C. Tiempo de incubación: 24 h.

Fecha de inicio del Análisis: 15/06/2023

Fecha de finalización del Análisis: 19/06/2023

Ensayos	Especificaciones*	Resultados
Coliformes Totales	Informativo	5420 NMP/100mL
Coliformes Fecales	4000 NMP/100mL	348 NMP/100mL

*Referencia tomada de la Resolución Nº 222/02 – Artículo 7 de la Secretaría del Ambiente.

Observaciones Generales: Los resultados obtenidos solo afectan a la muestra recepcionada y analizada en BioControl, un Laboratorio del Grupo Multilab S.A.

Comentarios: No se registran.

Analizado por:	Revisado y Autorizado por:
Lic. Biotec. Andrea Magali Planás Lugo Reg. Prof. Nº 055 **Analista**	**Q.F. Grecia Doldán** Reg. Prof. Nº. 1.657 **Director Técnico**

Fecha de Informe: 19/06/2023

Fin de Informe.

El laboratorio no es responsable de la información proporcionada por el cliente, que puede afectar la validez de los resultados.

Informe de Resultados No. 1-2828/23

Determinación solicitada	Matriz
Análisis fisicoquímicos **Elementos químicos**	Agua de piezómetro

*Datos del cliente**	*Datos de la muestra*
Solicitante: Sra. Renata Moretti – JGP CONSULTORÍA E PARTICIPAÇÕES LTDA **Dirección:** Villeta **Muestra identificada como:** AGUA DE PIEZÓMETRO	**Código interno de EcoNatura**: 1-30259 **Fecha de recolección:** 27/06/2023 **Descripción de la muestra:** La muestra fue recolectada por personal de Grupo Multilab S.A. en 2 (dos) botellas de vidrio ámbar y 1 (una) botella de plástico conteniendo aproximadamente 1 (un) litro cada una.
Fecha de inicio del análisis: 27/06/2023 **Fecha de finalización del análisis:** 26/07/2023	

*El Laboratorio es responsable de la información suministrada en el informe, excepto cuando la misma es proporcionada por el cliente.

Resultados

Análisis	Resultados	Valores de referencia**
pH Método: Potenciométrico	7,17	6,00 a 9,00
Turbidez Método: Nefelométrico ORBECO HELLIGE	14 NTU	100 NTU
Cloruros Método Espectrofotométrico: 8113 HACH	20 mg/L Cl^-	SR***
Sulfatos Método Espectrofotométrico: 360 LOVIBOND	3 mg/L SO_4^{-2}	250 mg/L SO_4^{-2}

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
1ppb = 1 µg/kg = 1 µg/L = 1 ng/mL
LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-2828/23

Amonio no ionizable Método Espectrofotométrico: 62 LOVIBOND	0,02 mg/L NH_3	0,02 mg/L NH_3
Nitrato Método Espectrofotométrico: 8039 HACH	1 mg/L N	10 mg/L N
Nitrito Método Espectrofotométrico: 8507 HACH	< 0,002 mg/L N	1 mg/L N
Color Método Espectrofotométrico: 203 ORBECO HELLIGE	46 mg/L Pt-Co	75 mg/L Pt-Co
DBO (5 días, 20°C) Método: SM 5210 B	**202 mg/L O_2**	5 mg/L
Oxígeno disuelto Método: Medidor de oxígeno disuelto ORION STAR A223/RDO	**0,22 mg/L O_2**	No inferior a 5 mg/L O_2
Nitrógeno total Método Espectrofotométrico: 10071 HACH	**2,9 mg/L N**	0,6 mg/L N
Sólidos totales disueltos Método: APHA 2540 C	**597 mg/L**	500 mg/L
Cianatos Método: APHA 4500 – CN L	< 0,2 mg/L	0,2 mg/L
Cromo hexavalente Método Espectrofotométrico: 10218/10219 HACH	0,27 mg/L	0,5 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
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1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
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LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-2828/23

Cromo trivalente Método Espectrofotométrico: 10219 HACH	< 0,03 mg/L	2 mg/L
Bifenilos Policlorados (PCB)**** Método: GC/MS	< 0,0002 mg/L	SR***
Dureza cálcica Método: Titulométrico	102 mg/L $CaCO_3$	300 mg/L $CaCO_3$
Materia Flotante Método: NMX-AA-006-SCFI-2000	Ausencia	Ausencia
Aceites y grasas Método: SM 5520 B	4 mg/L	Ausencia
Pesticidas		
Endosulfan I y II Método: GC/MS Límite de cuantificación: 0,010 mg/L	< 0,010 mg/L	0,056 mg/L
Diazinon Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,005 mg/L
4,4 DDT Método: GC/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,002 mg/L
Endrin Método: GC/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,002 mg/L

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
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LMR = Límite Máximo de Residuo
LOQ = Límite de Cuantificación

Informe de Resultados No. 1-2828/23

Elementos químicos		
Aluminio (Al) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,20 mg/L	0,2 mg/L
Hierro soluble (Fe) Método: ICP/MS Límite de cuantificación: 0,1 mg/L	**0,7 mg/L**	0,3 mg/L
Sodio (Na) Método: ICP/MS Límite de cuantificación: 1 mg/L	94 mg/L	200 mg/L
Selenio (Se) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	< 0,001 mg/L	0,01 mg/L
Manganeso (Mn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**1,16 mg/L**	0,1 mg/L
Bario (Ba) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	0,08 mg/L	2 mg/L
Arsénico (As) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	**0,058 mg/L**	0,01 mg/L
Plomo (Pb) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,002 mg/L	0,01 mg/L
Cadmio (Cd) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	0,001 mg/L

Equivalencias:
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1 ppm = 0,000001 kg/kg (peso/peso)
1ppm = 1 mg/kg = 1 mg/L = 1 µg/mL
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Informe de Resultados No. 1-2828/23

Cobre (Cu) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	1 mg/L
Estaño (Sn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	2 mg/L
Mercurio total (Hg) Método: ICP/MS Límite de cuantificación: 0,0005 mg/L	< 0,0005 mg/L	SR***
Níquel (Ni) Método: ICP/MS Límite de cuantificación: 0,001 mg/L	0,001 mg/L	0,025 mg/L
Zinc (Zn) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	< 0,05 mg/L	3 mg/L
Fósforo total (P) Método: ICP/MS Límite de cuantificación: 0,05 mg/L	**0,24 mg/L**	0,050 mg/L

Observaciones: Los resultados obtenidos sólo afectan a la muestra recolectada y analizada en EcoNatura, un laboratorio del Grupo Multilab S.A.

**Referencia tomada de la Resolución Nº 222/02 emitida por la Secretaria del Medio Ambiente, por la cual se establece el padrón de calidad de las aguas en el territorio nacional. Clase 2. Art. 3º.

***SR: Sin Referencia.

****Bifenilos Policlorados monitoreados: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 y PCB 180.

Comentarios: No se registran.

Analizado por:	Autorizado por:
Viviana Báez Bioquímica Responsable del Laboratorio de Medio Ambiente	**Alicia Salgueiro** Bioquímica - Reg. Prof. No. 1898 Director Técnico

Fecha y Hora del Informe: 27/07/2023; 16:27 h
Fin del informe.

Equivalencias:
1 ppb = 0,000000001 kg/kg (peso/peso)
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UNIVERSIDAD NACIONAL DE ASUNCIÓN

Facultad de Ciencias Exactas y Naturales

Laboratorio de Calidad de Agua

INFORME DE ENSAYO

INF.1534/2023

Solicitante: JGP Y PARTICIPACIONES LTDA.	Solicitud de trabajo Nº: 850/2023
Dirección: San Pablo – Brazil	Código de Ítem: 1502

Descripción de ítem: Datos conforme a la cadena custodio N° 130/2023: Sedimento de fondo proveniente del agua de Río Paraguay. Ubicación: -25.710233S, -57.726728W. Distrito: Villeta. Departamento: Central. Fecha de muestreo: 19/09/2023. Hora de muestreo: 08:57. Responsable del muestreo: Personal de Laboratorio.

Fecha de recepción: 19/09/2023	Fecha de ejecución del ensayo: 19/09/2023	Fecha del informe: 12/10/2023

Determinaciones	Métodos	Resultados	Unidad	Referencia No Aplica
Temperatura	SM 2550 B	25,0	ºC	--
Humedad	Gravimétrico - NN	40,6	% p/p	--
Fósforo total	SM 4500-P B, SM 4500-P E	103,0	mg/kg	--
Sólidos totales	SM 2540 B	351,85	mg/kg	--
N. T. K. (como N)	SM 4500-N B	7,30	mg/kg	--
N-Organico Disuelto (como N)	SM 4500-N B	5,00	mg/kg	--
Aluminio (Al)	SM 3500-Al D	6,65	mg/kg	--
Boro (B)	SM 4500-B B	<5,0	mg/kg	--
Hierro Total (Fe^{+3})	SM 3500-Fe D	2597,50	mg/kg	--
Cadmio (Cd)	SM 3500-Cd B	0,30	mg/kg	--
Cromo (Cr) Total	SM 3500-Cr D	6,90	mg/kg	--
Cromo (+6) hexavalente	SM 3500-Cr D	1,33	mg/kg	--
Níquel (Ni)	SM 3030, SM 3500-Ni B	22,50	mg/kg	--
Plomo (Pb)	SM 3500-Pb B	<0,1	mg/kg	--
Plata (Ag)	SM 303, SM 3500-Ag B	9,60	mg/kg	--
Mercurio (Hg) total	SM 3500-Hg B	<0,1	mg/kg	--
Zinc (Zn)	SM 3030, SM 3500-Zn B	50,30	mg/kg	--

Abreviaturas: ºC = grados Celsius, % p/p = porcentaje peso/peso, mg/kg = miligramos por kilogramo, N.T.K. = Nitrógeno total kjeldahl, < = menor que, SM = Método Estándar - Métodos Normalizados para el análisis de aguas potables y residuales, edición Nº 17 (APHA-AWWA-WPCF). NN = no normalizado.

Ítem: muestra ensayada

Notas:

- Este informe no podrá ser reproducido parcialmente sin la aprobación por escrito del Laboratorio.
- El(Los) resultado(s) obtenido(s) corresponde(n) únicamente a la(s) muestra(s) ensayada(s) que se refieren a la cadena de custodia mencionada.
- Nombre del contacto: Ing. Silvio Jara Telefono: 0981 455 493
- Ubicación del punto de muestreo:

Laboratorio de Calidad de Agua FACEN Facultad de Ciencias Exactas y Naturales Universidad Nacional de Asunción

Prof. MSc. Estanislaa Acosta Morales
Jefe, Laboratorio de Calidad de Agua

Fin del informe

REG 063.07

Annex 3 – Flooding and Surface Runoff Study

STUDY OF FLOODABILITY AND SURFACE RUNOFF PATTERN

Determination of maximum water levels and safety level for the platform of a hydrogen and green ammonia production industry in Villeta.

Brief

The purpose of this study is to develop design recommendations for the ATOME industrial plant through the modeling of the rainwater runoff pattern in a property destined for the installation of an industry. Likewise, comments are presented regarding the impact of Climate Change on the availability of water resources and the levels of the Paraguay River

Ing. Benito Andres Pereira Zelaya, M.Sc.

[redacted]

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1. Introduction

ATOME Paraguay S.A. is a subsidiary of the first company dedicated to the production of hydrogen (H2), ammonia (NH3) and green fertilizers listed on the London Stock Exchange, ATOME Energy PLC. Currently, ATOME Paraguay is developing a project in the district of Villeta dedicated to the production of green fertilizers with an electrical power demand of 120 MW. The Villeta project will be phase 1 of a project that includes a total of 420 MW of power. Phase 2 of the project will be carried out in the future in another area of the country and will also focus on the production of hydrogen, ammonia and green fertilizers. Phase 1 of the ATOME project involves the construction of the largest green ammonia and calcium ammonium nitrate (CAN) plant in Latin America (120 MW), which is expected to start operating in early 2026. This plant will be the first with the capacity to produce green fertilizers on an industrial scale and at a constant rate (250,000 tons/year of CAN), from hydroelectricity; 100% renewable energy.

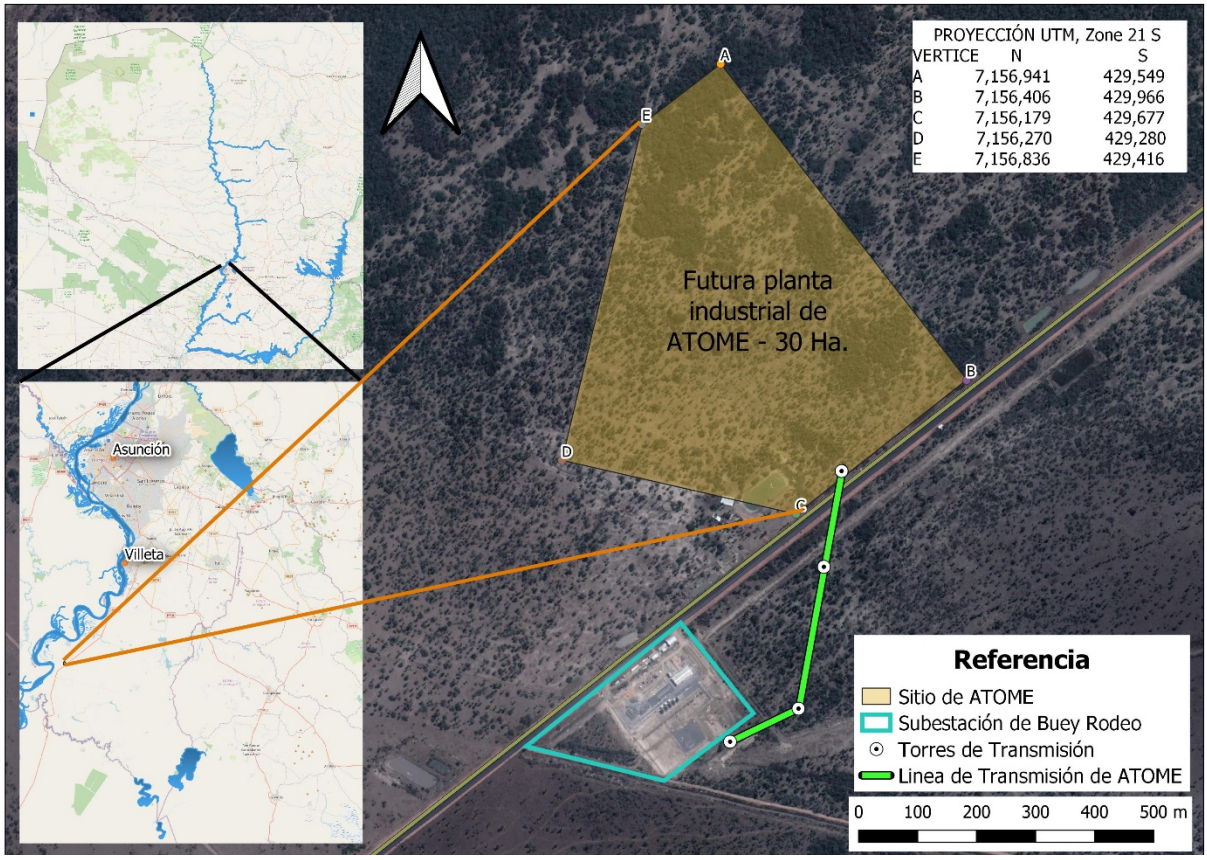

Figure 1 Location of the ATOME industrial plant in the district of Villeta. The industrial plant will be focused on the production of green fertilizers based on green hydrogen and with a power consumption of 120 MW

In this way, the Project will have the capacity to produce the world's first truly green fertilizer and the potential to avoid 525,000 t-CO2-eq/year of carbon emissions in the fertilizer sector. When considering the useful life of the Project (25 years), this impact would translate into 13,125,000 t CO2-eq avoided, allowing the country to position itself as an agent of change in compliance with the United Nations

Framework Convention and SDG 13 regarding the adoption of action measures against climate change and its effects.

This document is a summary of the hydrological and hydraulic studies carried out to evaluate the maximum water levels and runoff pattern on the property where the hydrogen and green fertilizer production industry will be installed.

2. Topography

In order to make the level of the Paraguay River compatible with the topography used in the ATOME industrial project, a link was made between the Villeta hydrometric rule and the First Order Point of the Geodetic Network of Paraguay 100056 Guyrati (UTM coordinates - WGS84 N: 7.170476.537; This 443,061.765) was the basis of the topographic study of the project carried out by the consulting firm IKE.

Based on the topographic analysis, the delta H necessary to adapt the level levels of the Paraguay River in Villeta to the project datum is determined.

Table 1 Difference Between Project Datum and Villeta Hydrometric Rule Datum

Zero of the Villeta Hydrometric Rule (NMM)[1]	52.86
Zero of the Villeta Hydrometric Rule (Pyto's Datum associated with the first-order cairn 100056 Guyrati)	68.33
Delta H	15.47

As the ATOME industrial site is located 49 km downstream of the Villeta hydrometer, an adjustment must be made to the level, as it will be lower (in elevation) in the vicinity of ATOME (see the following figures).

[1] Mean Sea Level (Associated with the Mar del Plata tide gauge)

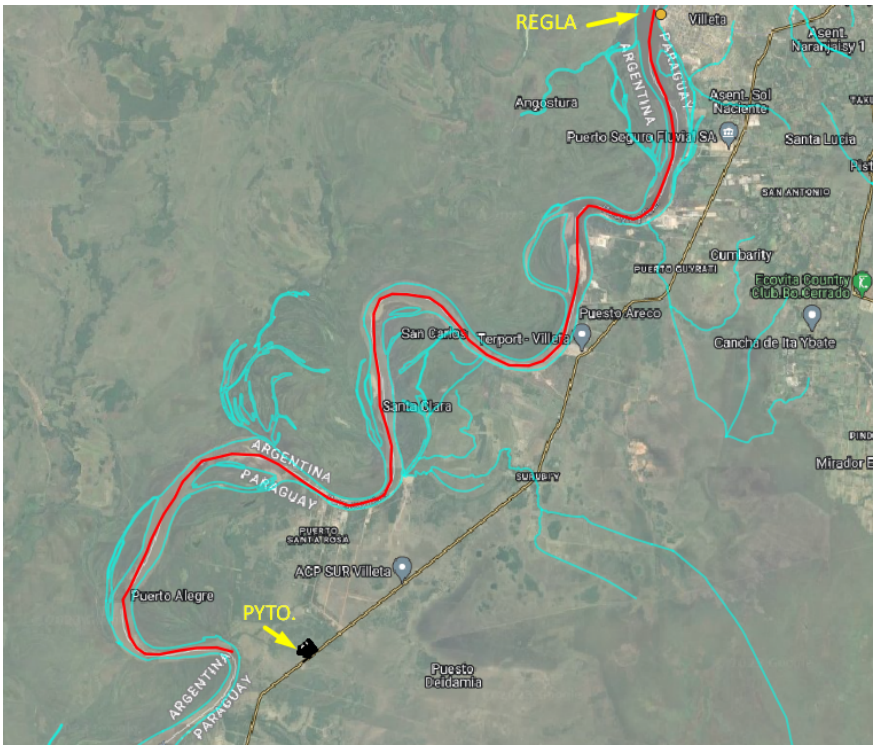

Figure 2 Distance of 49 km (red line) between the location of the Villeta rule (orange dot) and the project area

This difference in the level of the water between Villeta and the vicinity of ATOME is obtained from a hydrodynamic model of the Paraguay River (Universidad Católica Nuestra Señora de la Asunción (UCA), 2018) that includes bathymetric information from the city of Porto Murtinho to Pilar, including the analyzed stretch.

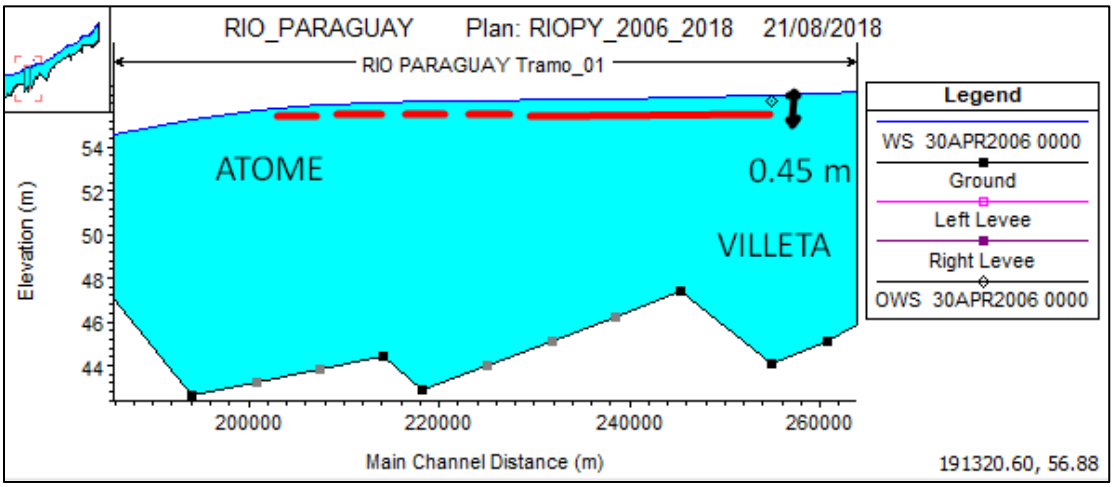

Figure 3 Longitudinal profile of the Paraguay River between Villeta and the ATOME riparian area

As shown in the figure above, this difference in water level is around 45 cm.

3. Area of Study

The study area has a rather complex general runoff due to important anthropic intervention in the area. Large canals are observed that strategically conduct water for industrial or cultivation purposes, considerably reducing the area of contribution to the study site. This is seen in sufficient detail in the figure below.

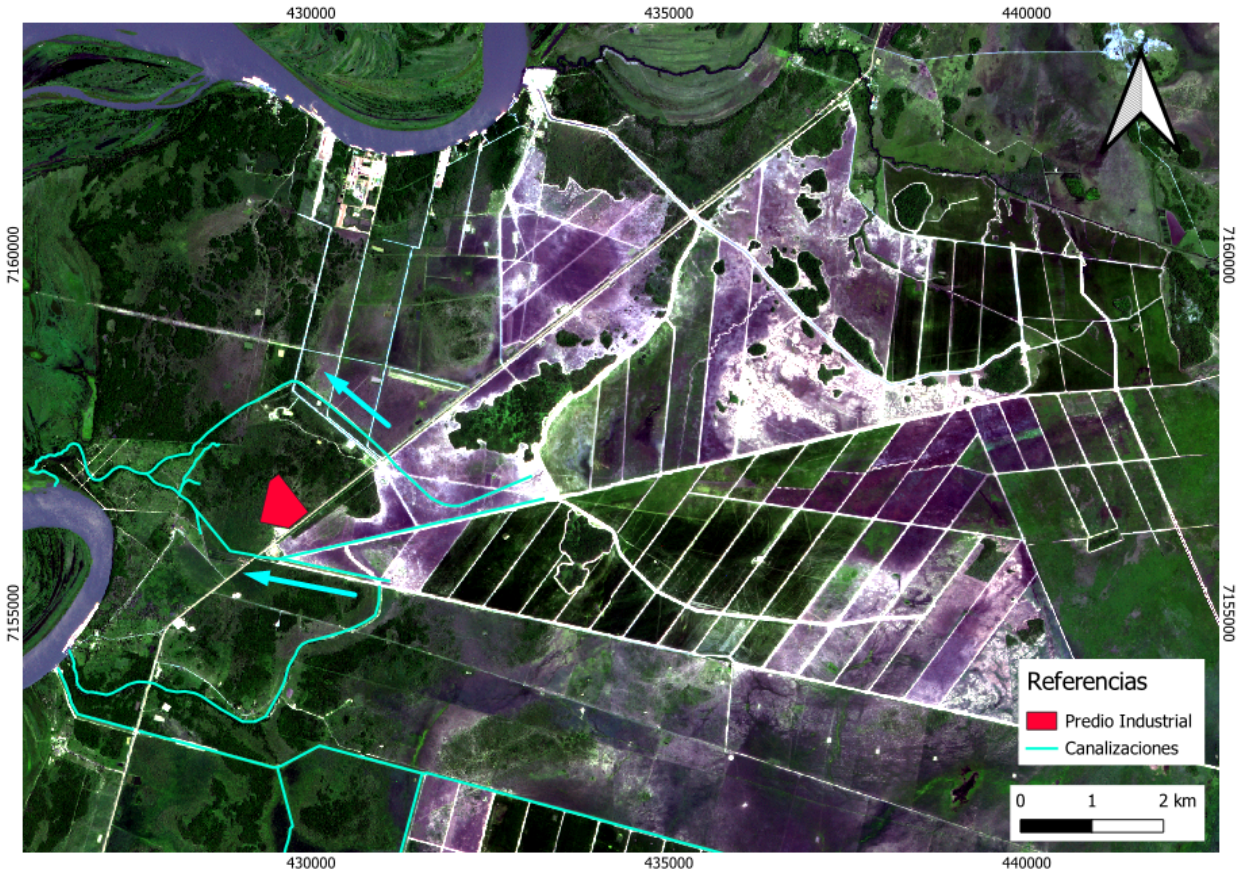

Figure 4 General runoff. Rice crops and pipelines in the area.

Independently of the existing pipes that lead the water out of the study area, three works of art (sewers) were observed on the route, whose use is probably the passage of surplus water from the southeast to the property subject to analysis.

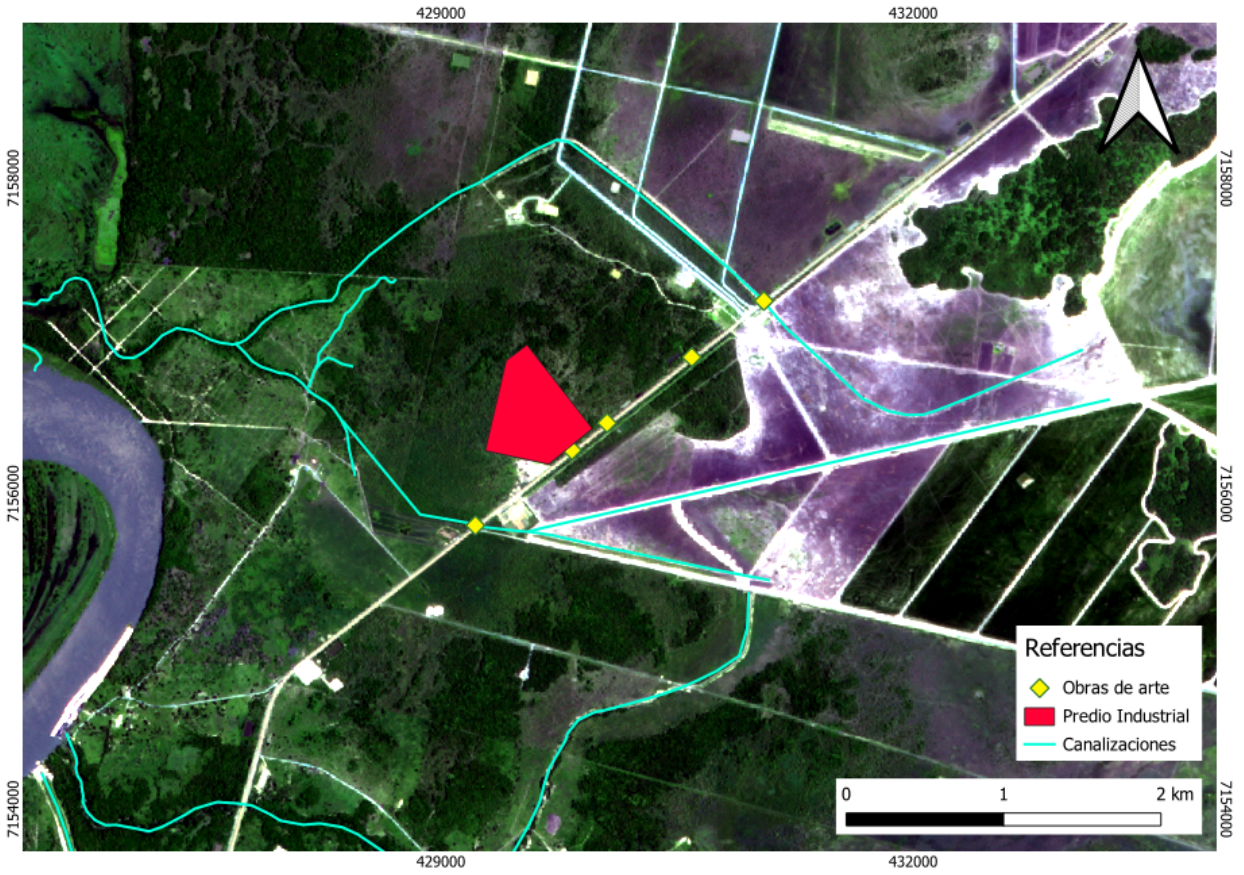

Figure 5 Location of existing artworks along the route

In addition to the existence of the works of art on the road, it is concluded that the natural drainage of the water was altered and redirected by the rice plantations, deriving the excess away from the property where the industrial property will be implanted. Under this scenario, the contribution of water on the property is practically local, that is, the rain that falls on the property itself. Another important point to mention is the fact that the route is a dam that retains part of the water on the east side, which limits the flow of water that can cross into the ATOME property.

Regarding the possible extensions of flooding of the Paraguay River, FIUNA prepared flood charts in 1996 in a project called "Zoning of Floodable Areas of the Paraguay River", as shown in the following figure.

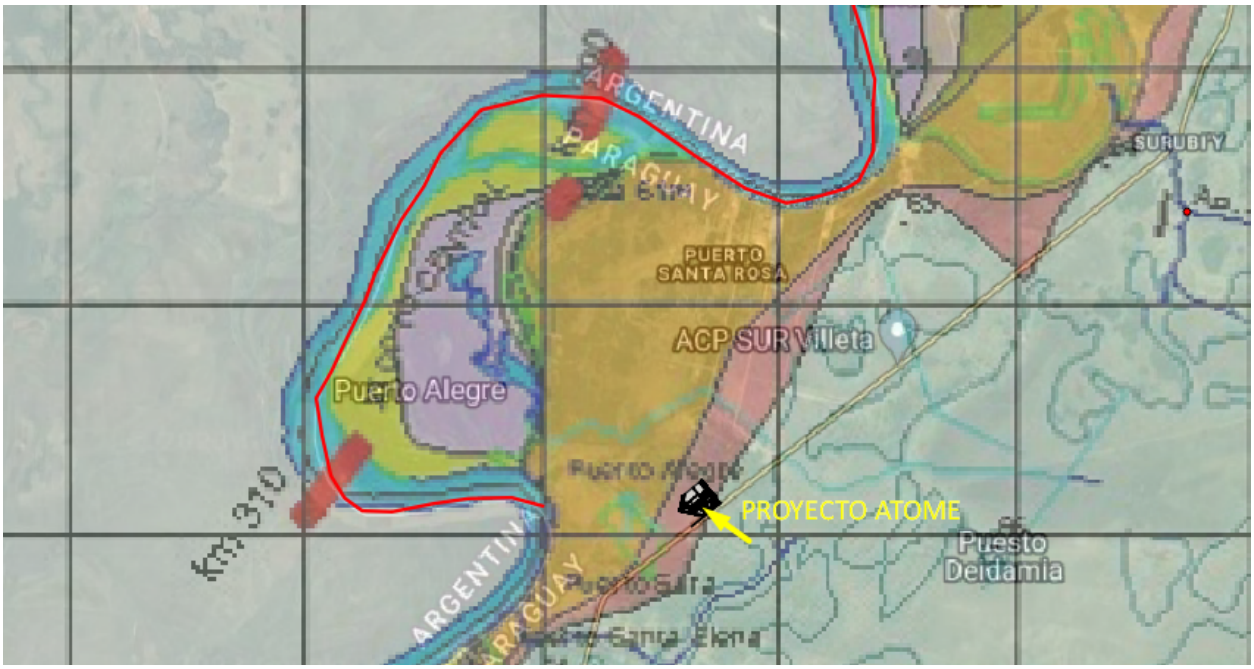

Figure 6 Flood charts in the vicinity of the industrial site (FIUNA, 1996)

The salmon color shown in the figure above symbolizes a 100-year recurrence or a 1% chance of occurrence. Although these charts are quite old, they allow you to orient yourself in the work area, concluding that the probability of flooding is low but possible. A more detailed analysis of the levels of the Paraguay River in the area of the industrial site is carried out later.

Regarding the rainfall in the area, it is characterized by practically the same regime as Asunción, given the proximity between the two cities. The Asunción rain gauge station has data from 1960 to the present, as shown in the following figure.

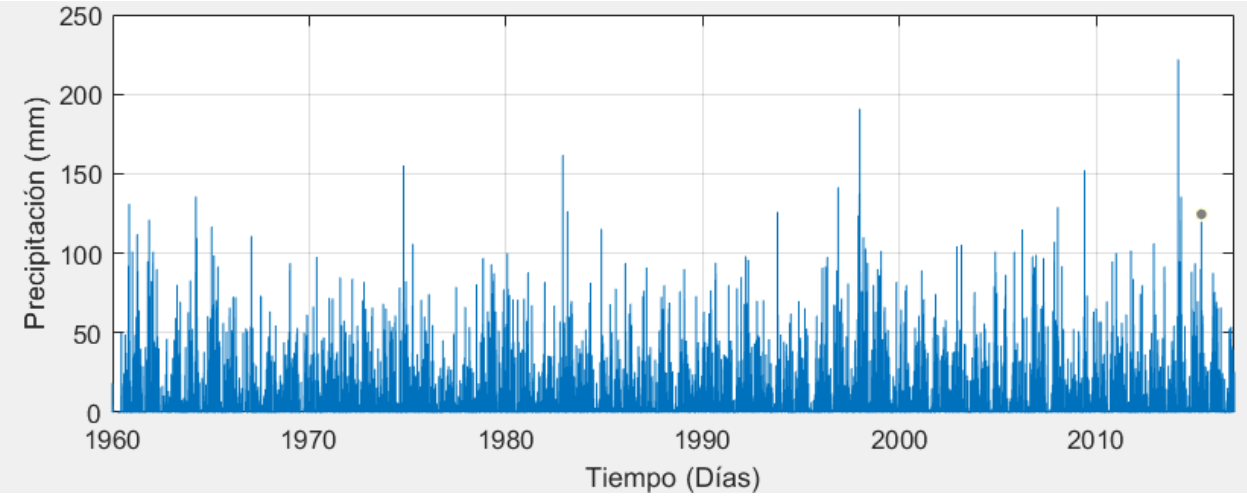

Figure 7 Historical series available from Asunción Station

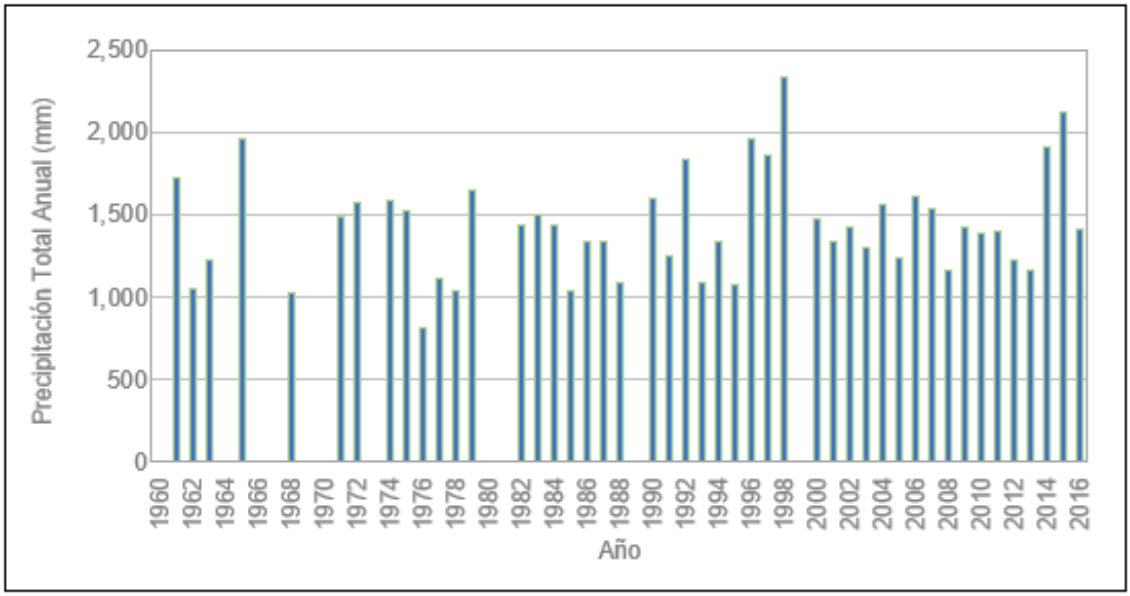

Figure 8 Annual Rainfall at Asunción Station

Based on the series of available data, it is possible to characterize the rainfall regime of the area.

It is observed that the rainfall regime has two distinct periods: October to April (WET) and May to September (DRY), with a general average of 146 mm/month and 75 mm/month, respectively.

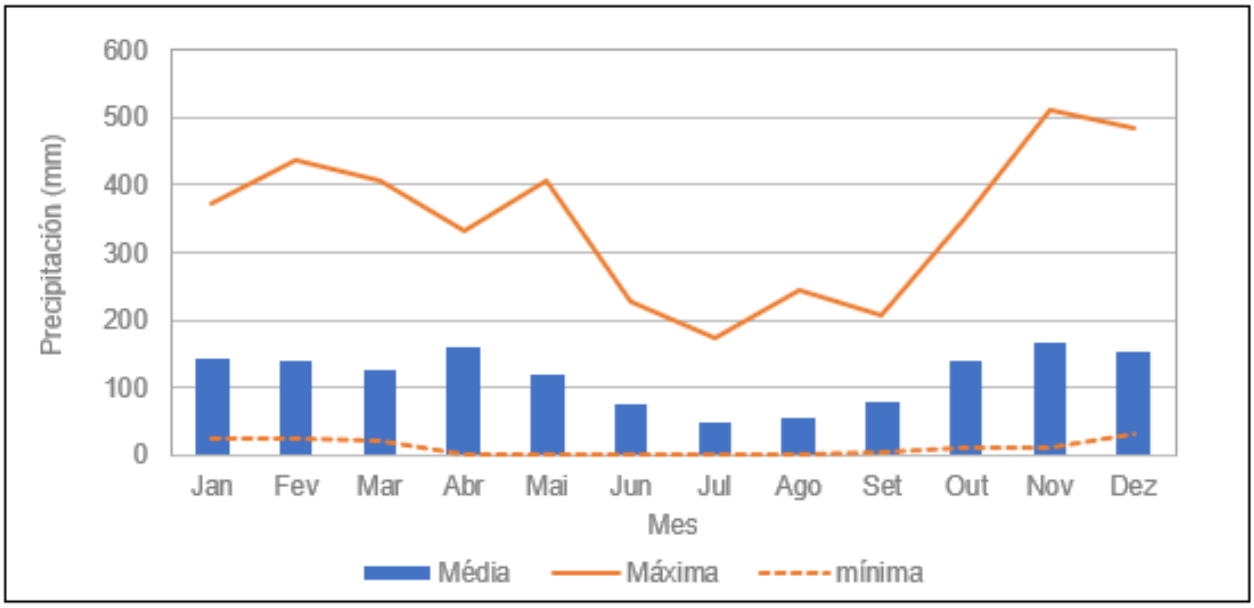

Figure 9 Total Monthly Precipitation

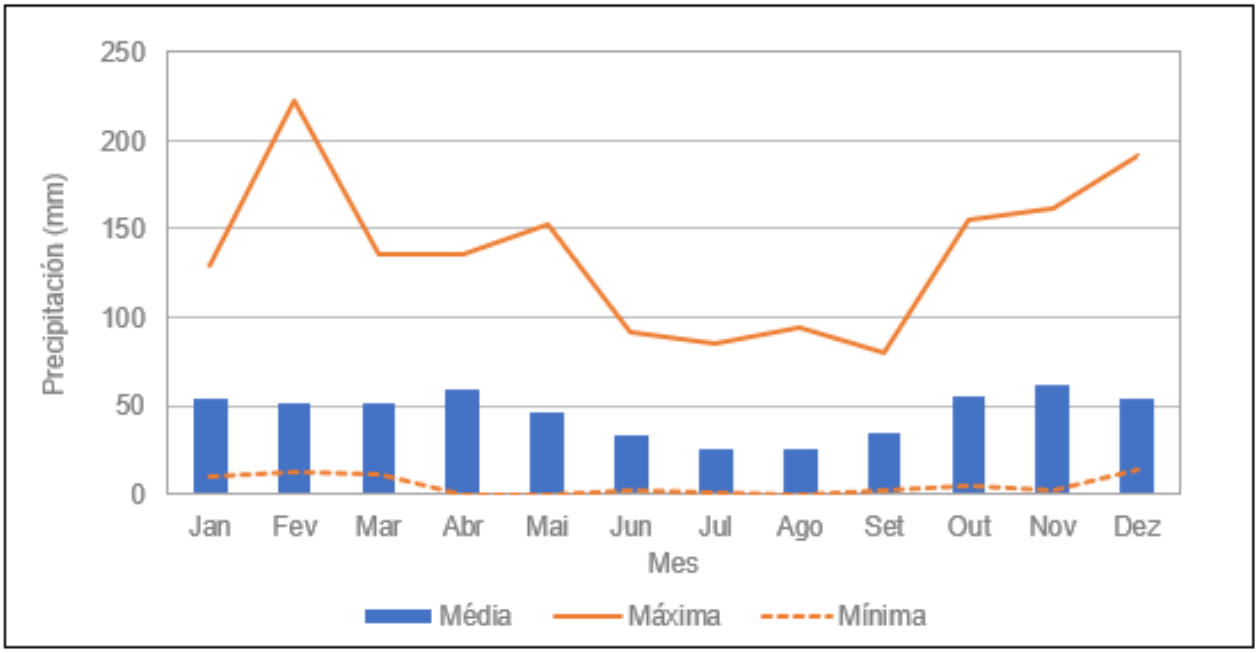

Figure 10 Monthly Daily Maximum Rainfall

Regarding the number of days with rain at the monthly level, there is evidence of a general monthly average of around 8 days.

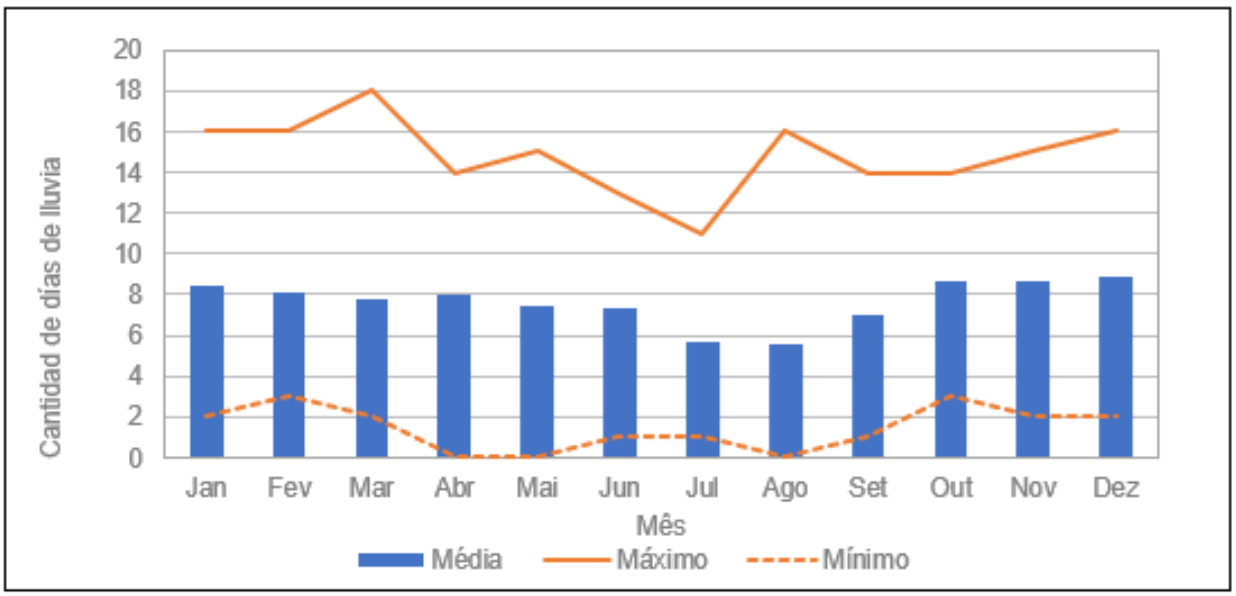

Figure 11 Number of Monthly Rainy Days

4. Evaluation of the runoff pattern

To evaluate the runoff pattern and the maximum water levels reached, the HEC-RAS hydraulic model in its 2D hydrodynamic version (two dimensions) is used. The main input of this type of model is a surface that

adequately represents the relief of the area subject to analysis. This surface was obtained from an aerophotogrammetric flight, the results of which were made available for the purposes of this study.

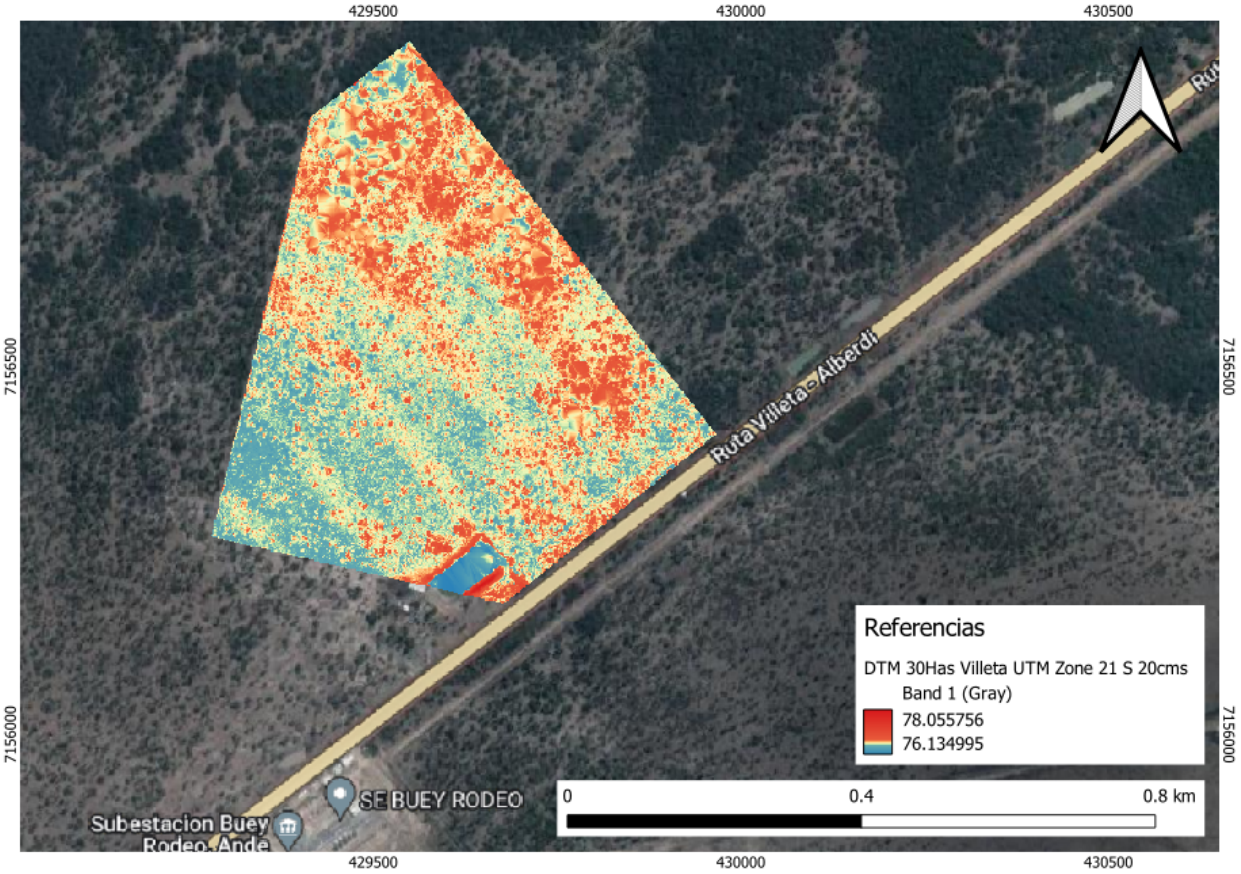

Figure 12 Digital Terrain Model. Source: Topography surveyed by the consulting firm IKE.

On the other hand, it is important to properly define the edge conditions of the model. In the case of the simulation mesh boundary, a "normal height" edge condition is adopted, which basically allows a constant slope to be assumed (in this case an extremely low slope).

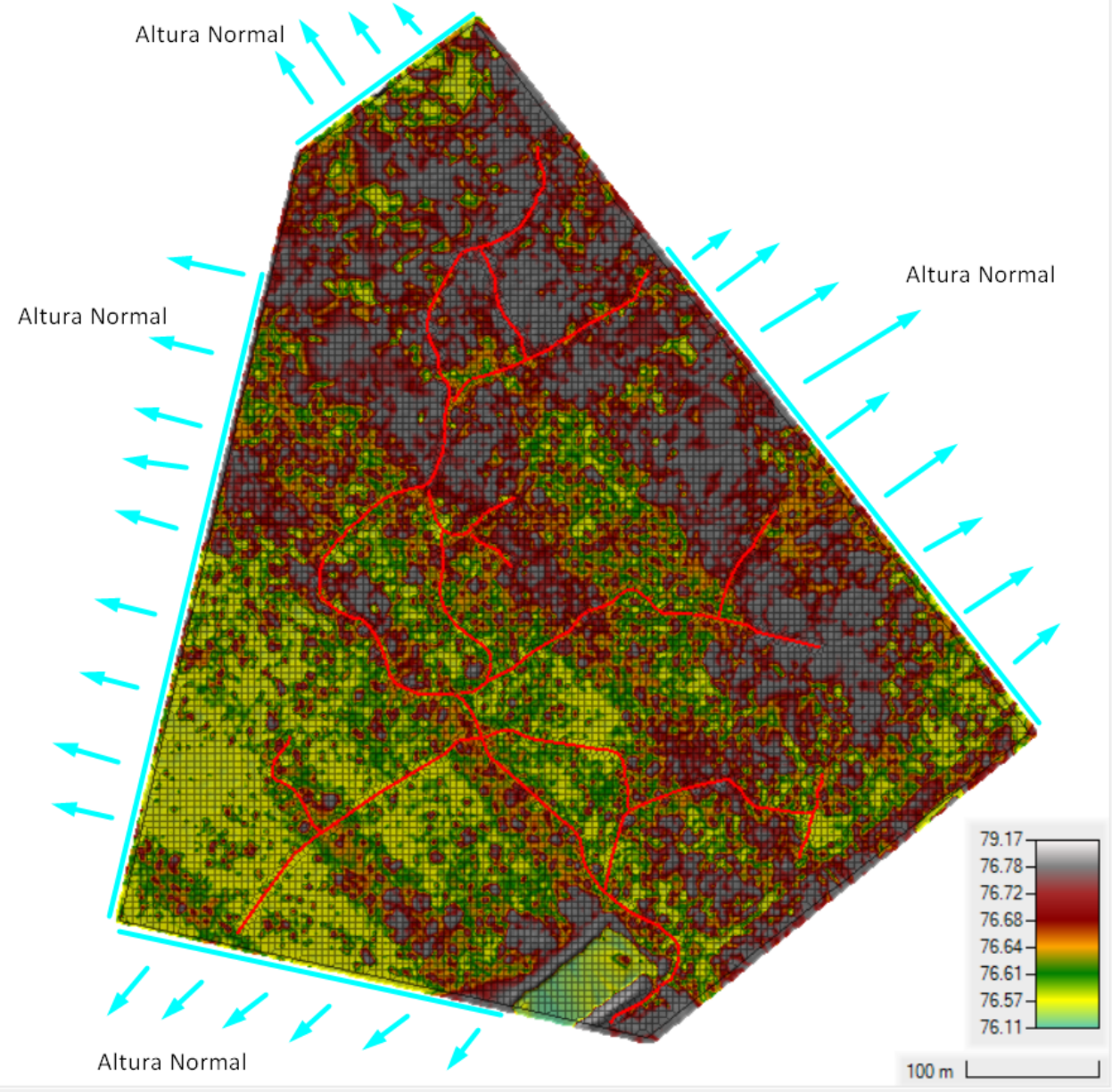

Figure 13 Edge Conditions

With respect to design rainfall, in the absence of input basins, it is decided to adopt a storm duration of 3 hours for a recurrence of 25 years (this choice is made in order to be conservative since the concentration time in flat areas is generally longer). This rainfall is generated from the IDF curves of Paraguay, particularly using the curve corresponding to the Asunción station.

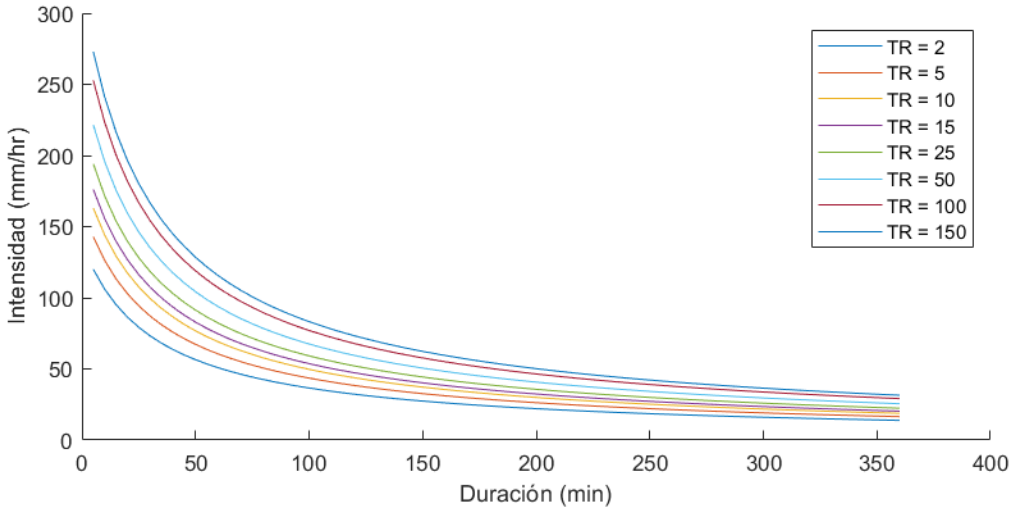

Figure 14 Asunción IDF Curves

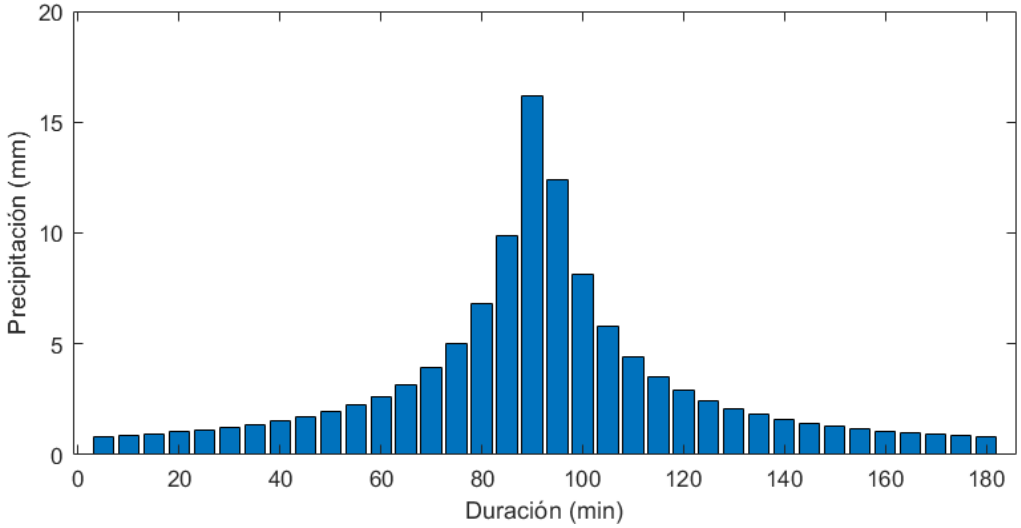

Figure 15 Design rain. 3hrs duration. 5 min interval. TR = 25 years

5. Results obtained and recommendations for water management

The results obtained show that the general pattern of runoff is to the west, which suggests that the system of perimeter canals for the drainage of rainwater from the industrial site should be in the same direction.

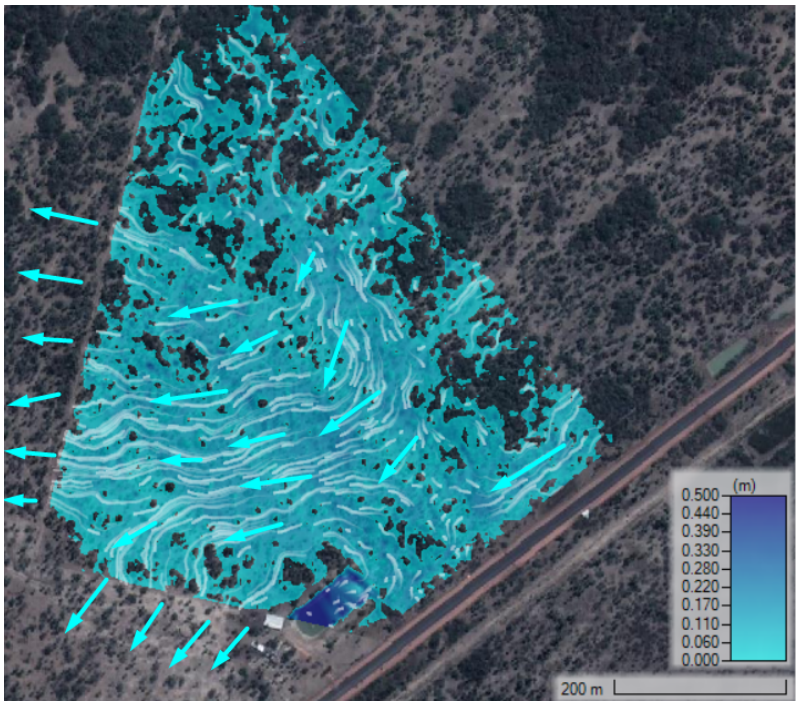

Figure 16 Runoff pattern in the study area

In addition to the direction of runoff, the water depths and the maximum water level were also analyzed, which should be used as a reference to define the shelf level.

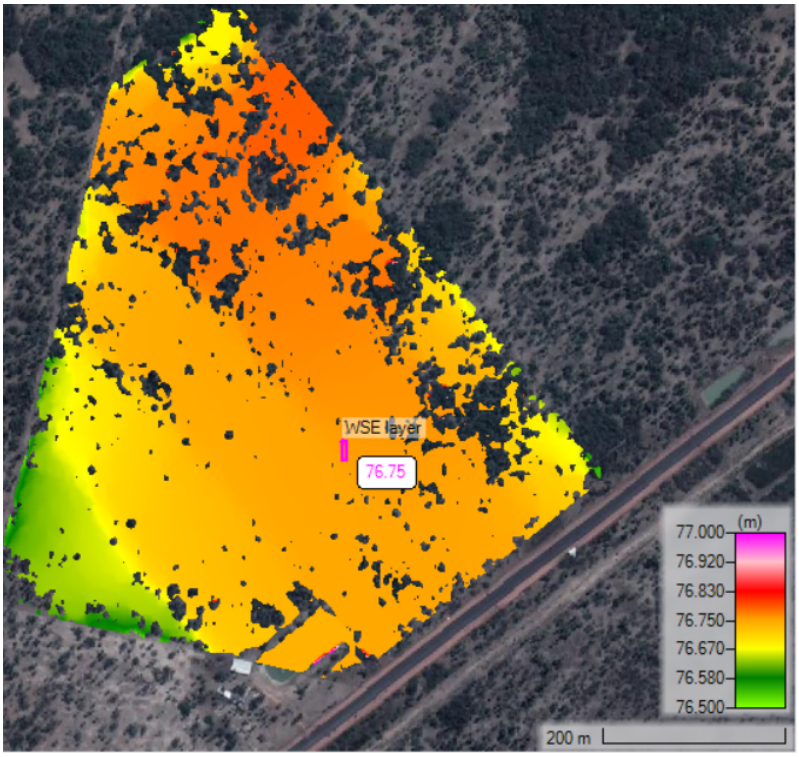

Figure 17 Maximum water level along the property

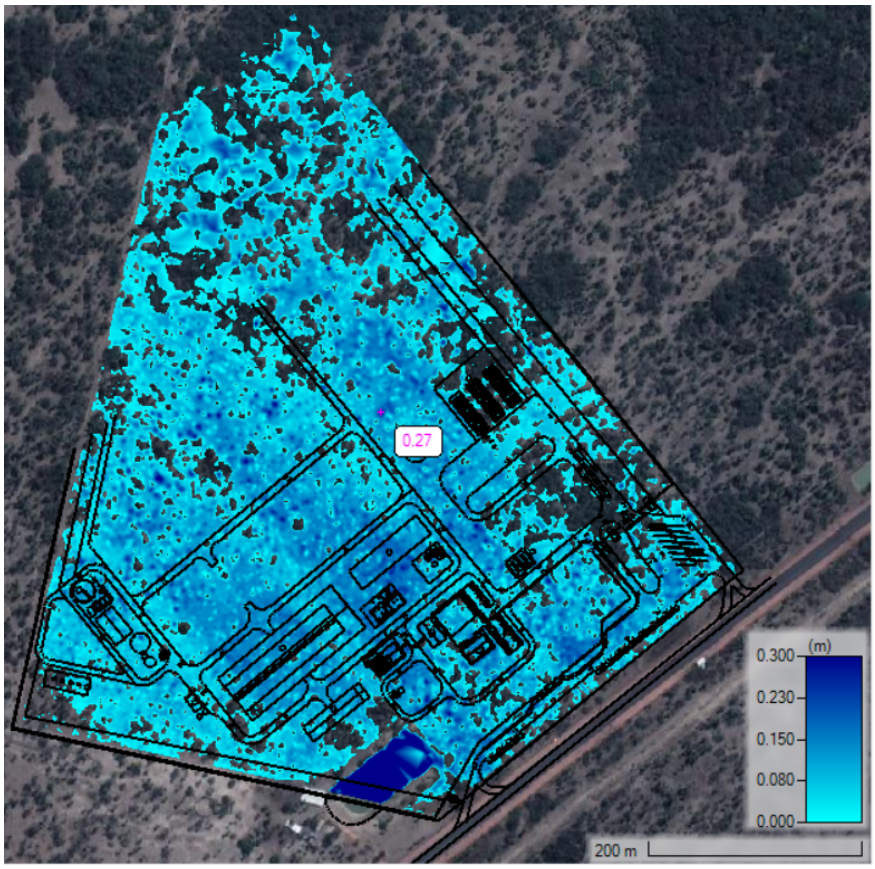

Figure 18 Water depth in the field for a rainfall with a recurrence period of 25 years

As can be seen in the figure above, the maximum depth of water on the ground would be between 25 and 30 cm for a recurrence of 25 years.

According to the maximum water level obtained (+76.80) by a rainfall of 25 years of recurrence, the suggested minimum shelf level is +77.80. It is important to mention that the drainage of the platform should have at least 0.5% to drain the water by gravity without pumping requirements.

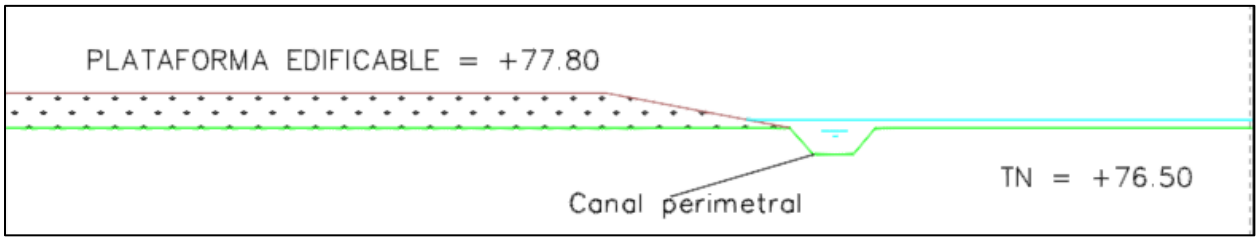

Figure 19 Suggested Building Platform

For rainwater management, it is suggested to incorporate perimeter channels that allow water to be conducted towards the channels or furrows formed by water runoff, as shown in the following figure.

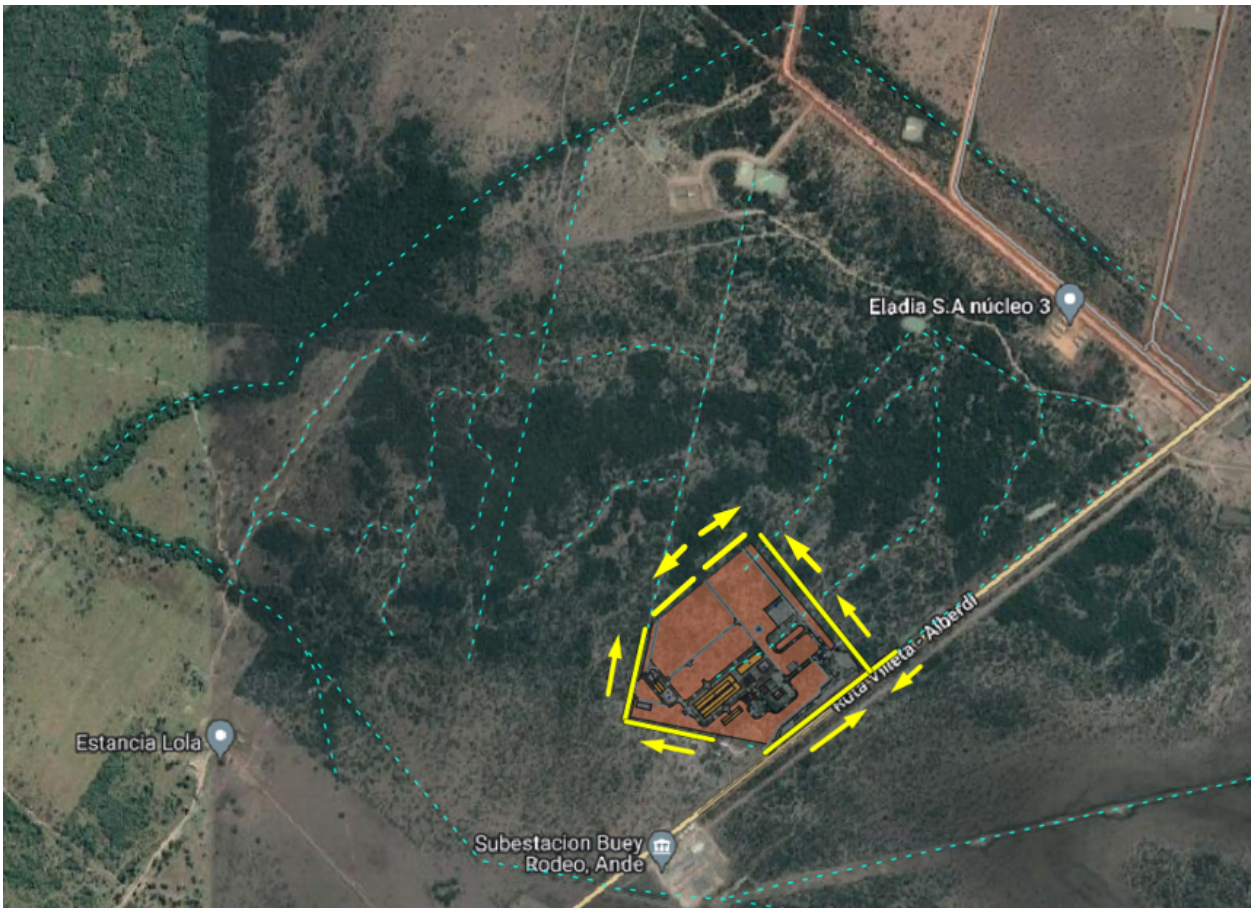

Figure 20 Perimeter channels (in yellow) and terrain flow lines in light blue

The perimeter channels could adopt a trapezoidal shape with a base of 1.00 m and a height of 1.00 m (1:1 slope). For the internal drainage of the property, it is suggested to distribute the water in two areas, as shown in the following figure.

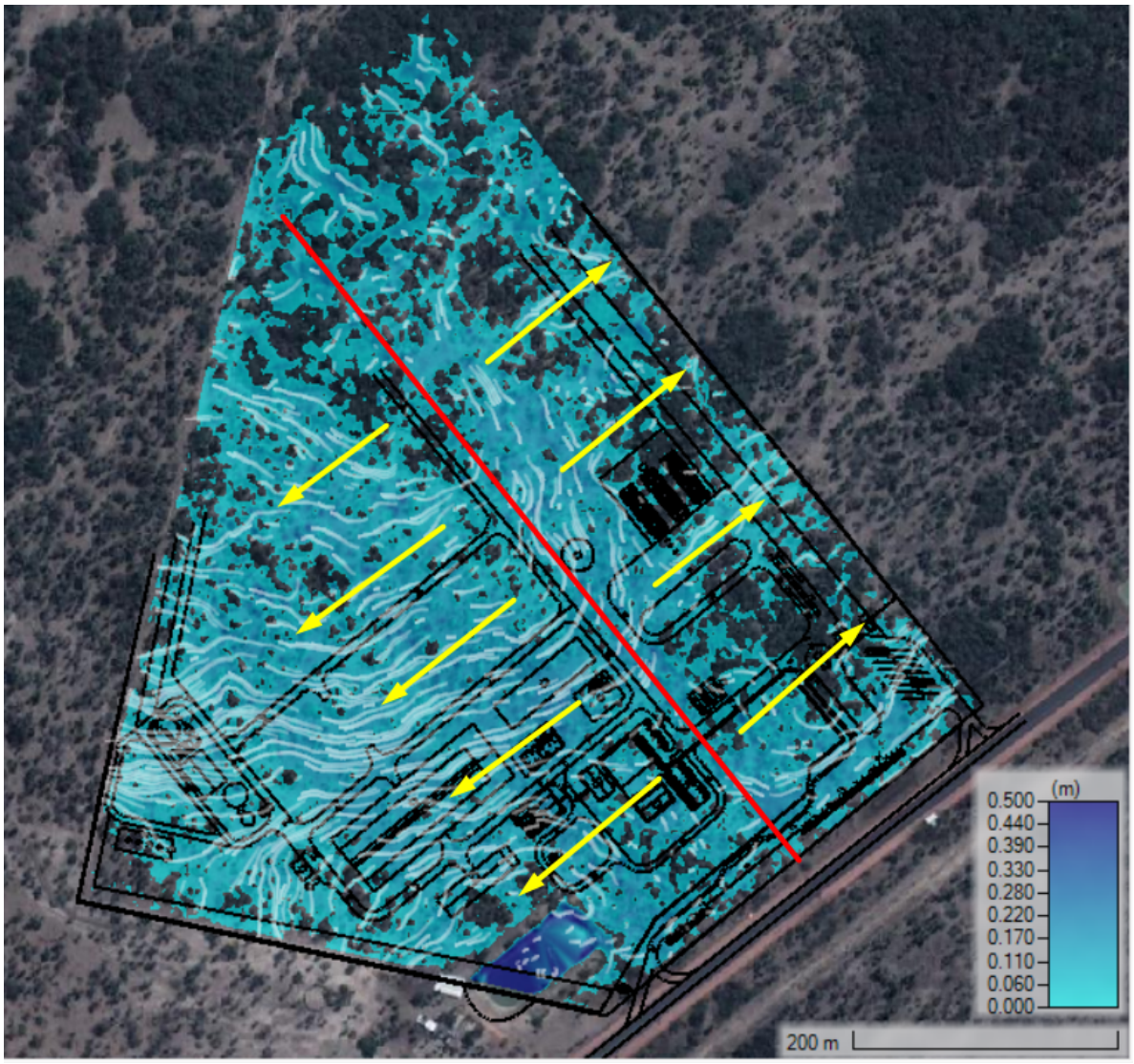

Figure 21 Concept of water distribution on the property (red line: dividing water management sectors)

6. Statistical study of the water levels of the Paraguay River in Villeta

In order to evaluate the flood zones, the level of the river in Villeta is first statistically studied. The Villeta river level data series extends from 1980 to the present (40 years of data). Although the length of the series is reasonable, it is possible to extend it using the Asunción river level series, which has data from 1904 to the present (116 years of data). To extend the Villeta series with the levels recorded in Asunción, a correlation between the two data is first sought, which is presented in the following figure.

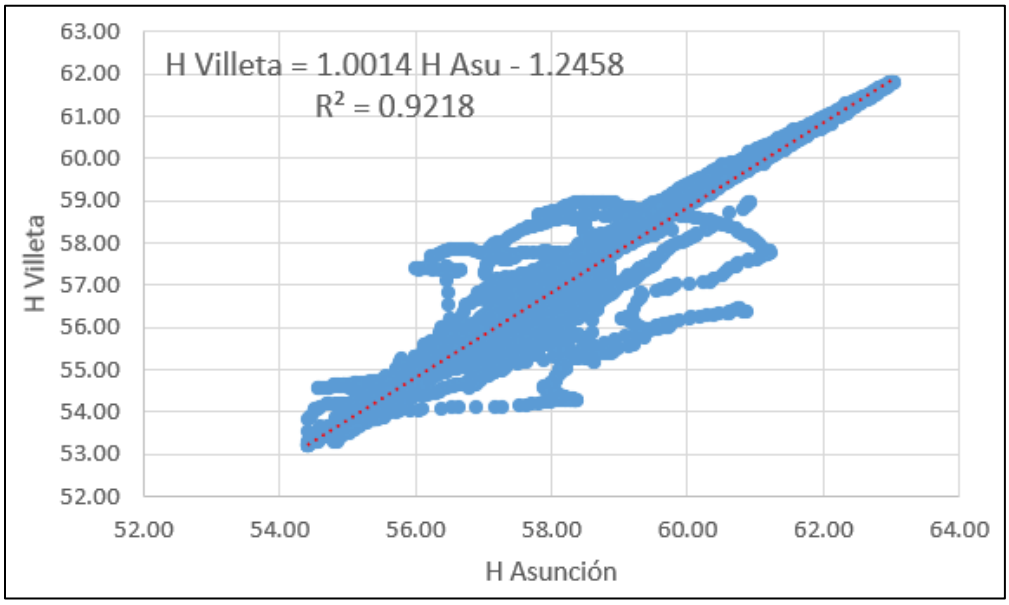

Figure 22 Correlation between Paraguay River levels in Asunción and Villeta (NMM)

Using the equation obtained in this correlation, a prolonged series of levels for Villeta is obtained, which is shown in the following figure.

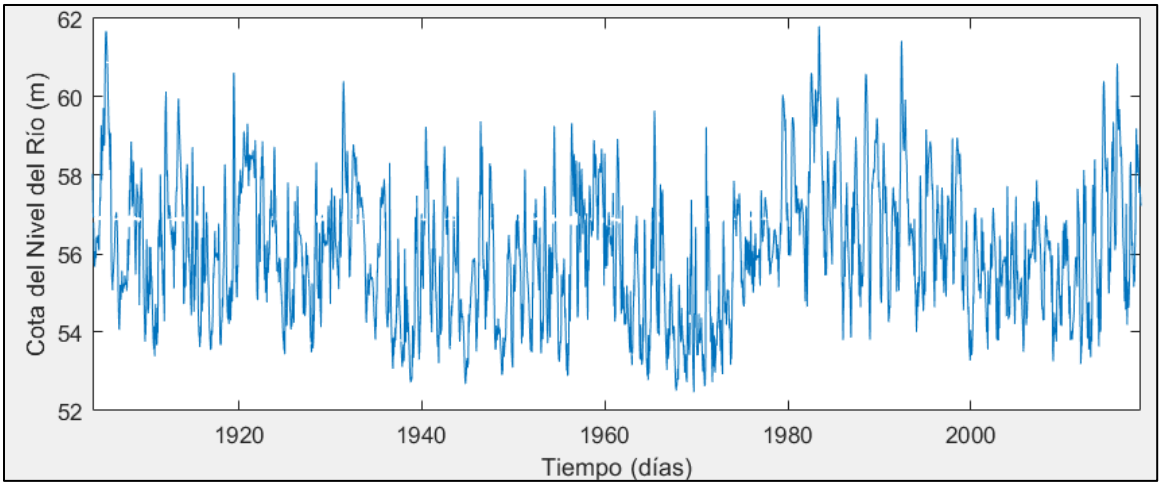

Figure 23 Extended series of levels of the Paraguay River in Villeta (NMM)

For the association of river water levels to recurrence periods, theoretical probability distributions are used.

Based on the extended series generated in the previous section, several theoretical probability distributions were used (Gumbel, Normal, Log Normal and Log Pearson Type III), and the fit of each of them was verified with the empirical distribution (observed data). The following figure shows these settings.

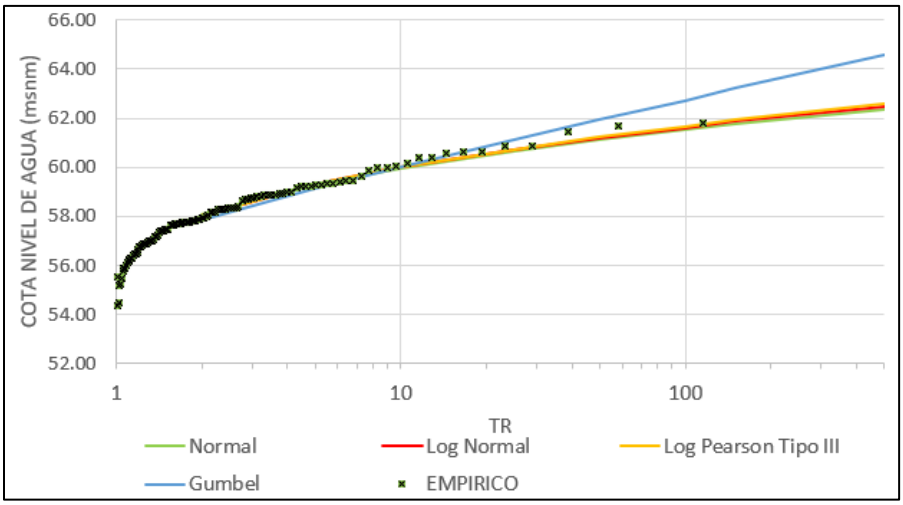

Figure 24 Theoretical Probability Distribution Adjustments (in Black Dots the Empirical Distribution) - NMM

Based on the adjustments shown in the previous figure, we chose to use the normal distribution. Finally, the values were transformed to the project datum, obtaining the following table.

Table 2 Paraguay River Levels in Villeta Associated with Recurrence Periods (adjusted for normal distribution)

TR (years)	Water Level Elevation in Villeta	Elevation of the Water Level of the Paraguay River in the area of the ATOME property
2	73.54	73.09
5	74.79	74.34
10	75.45	75
25	76.14	75.69
50	76.59	76.14
100	77	76.55
150	77.26	76.81
500	77.82	77.37

From the series of available data, the maximum level recorded in the Villeta rule is 8.94 m (on 30/05/1983), which translates to a height of +77.27 in the Project datum (Guyrati). Moving this level to the vicinity of the ATOME property, which is located 50 km downstream from Villeta, a delta H of approximately 45 cm is estimated, corresponding to a maximum water level of +76.82 in the project datum for this area. As can

be seen in the table above, this maximum recorded limit corresponds to a recurrence of approximately 150 years.

Regarding the general behavior of the Paraguay River in the vicinity of the ATOME property, the following figure shows the permanence of levels in this area.

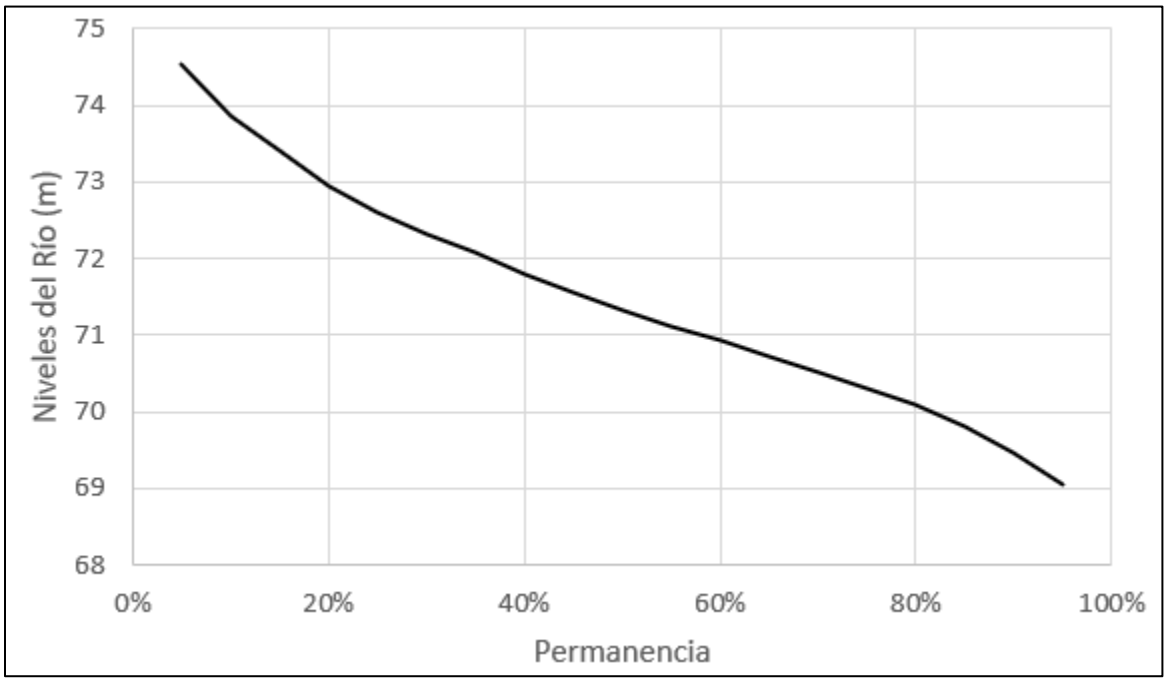

Figure 25 Permanence of levels

As can be seen in the dwell curve in the figure above, values above 76 m occur less than 1% of the time.

7. Assessment of possible effects of climate change on entrepreneurship

Climate change, or rather, the effects associated with climate change, could have an impact on the expected rainfall and river regime in the project area. In view of this, the latest projections available in international literature are used to assess whether the effects of climate change could require an adaptation of the infrastructure works of the hydrogen and green ammonia producing industry.

7.1 Temperature and Precipitation Trends due to the Effects of Climate Change

Regarding temperature projections, the most recent study is the one carried out by Lovino et al (2021).[2] This study presents upward temperature and precipitation projections for almost all scenarios. In this study, the so-called RCP (Representative Concentration Trajectories) are no longer used, but rather the new nomenclature used, which would be the SSP (Shared Socio-Economic Trajectories). The study

[2] Evaluation of historical CMIP6 model simulations and future projections of temperature and precipitation in Paraguay

considered three integrated scenarios of socio-economic development and greenhouse gas emissions: SSP1-2.6; SSP2-4.5 and SSP5-8.5.

In general terms, Lovino's (2021) study evaluated the ability of the 19 climate models of the CMIP6 (Coupled Model Intercomparison Phase 6) to simulate Paraguay's future climate.

Temperature Trend

For the most conservative scenario (SSP1-2.6), an average increase of 1.7 °C is estimated.

For the intermediate scenario (SSP2-4.5) an average increase of 3 °C is estimated.

For the worst-case scenario (SSP3-8.5), an average increase of 5.5 °C is estimated.

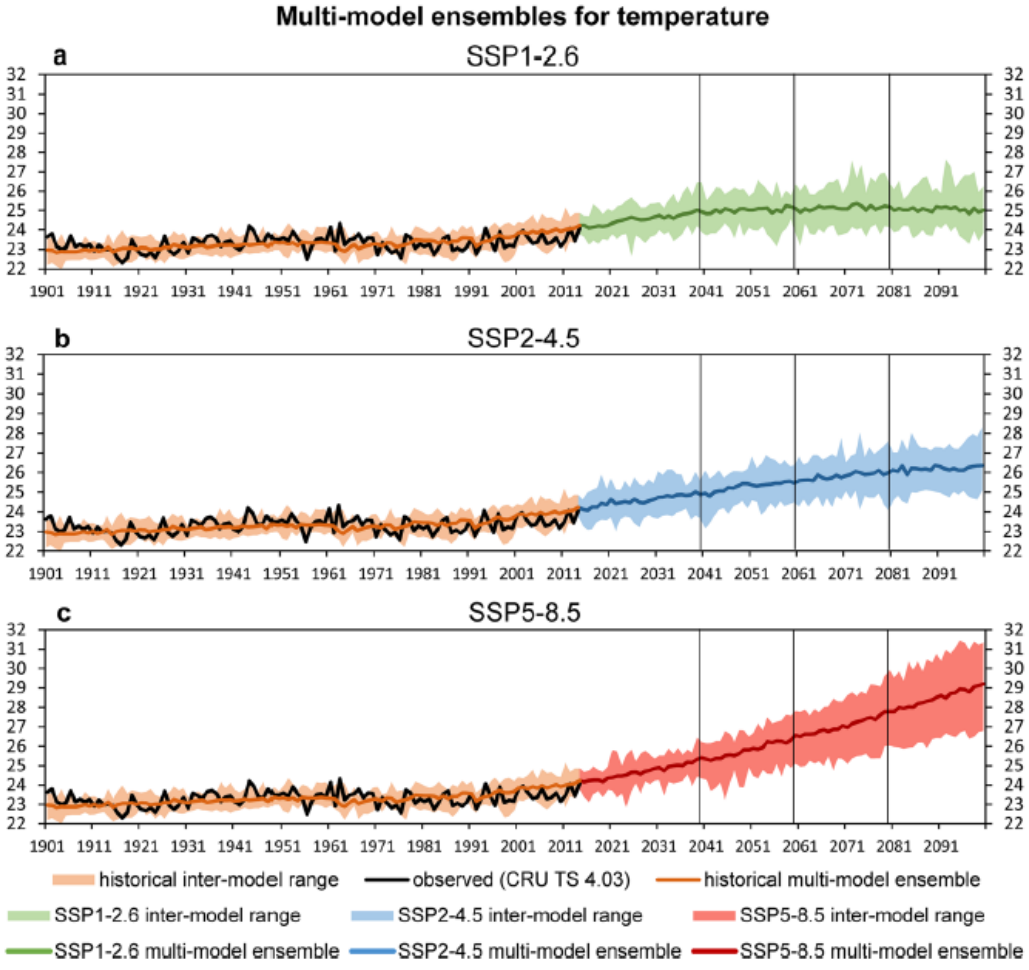

Figure 26 Average temperature trend over the next 80 years *(Lovino, 2021)*

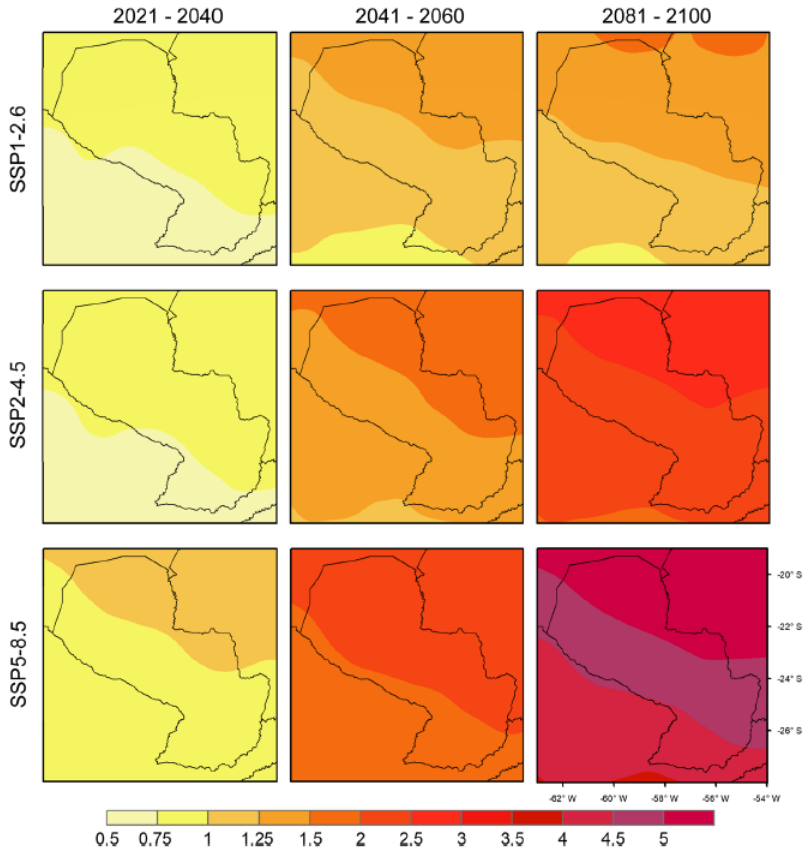

Figure 27 Spatial distribution of mean annual temperature change for different scenarios over 20-year intervals (Lovino, 2021)

Regarding extreme temperature values, a study called "Flood Risks in Bañados de Asunción – Effects of Climate Change" (IDB, 2023) is used as a reference. This study shows an overall increase in both maximum and minimum temperatures.

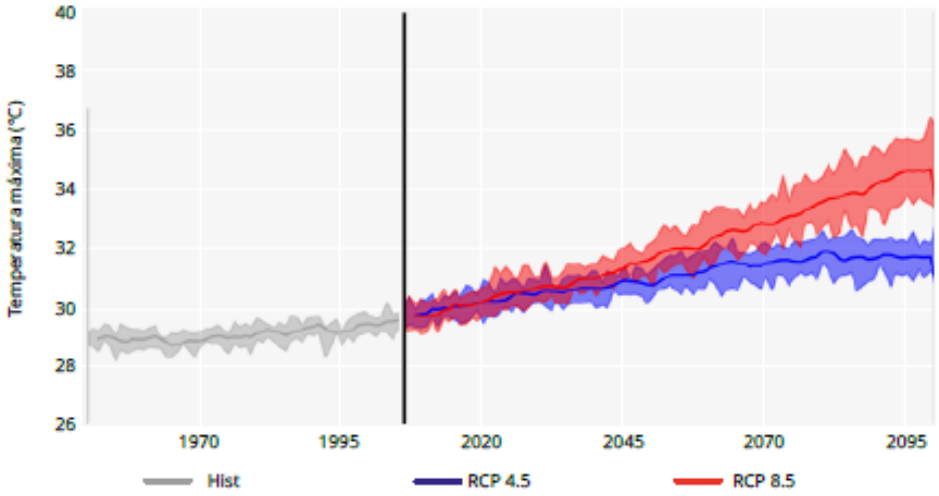

Figure 28 Maximum temperature trend in Asunción

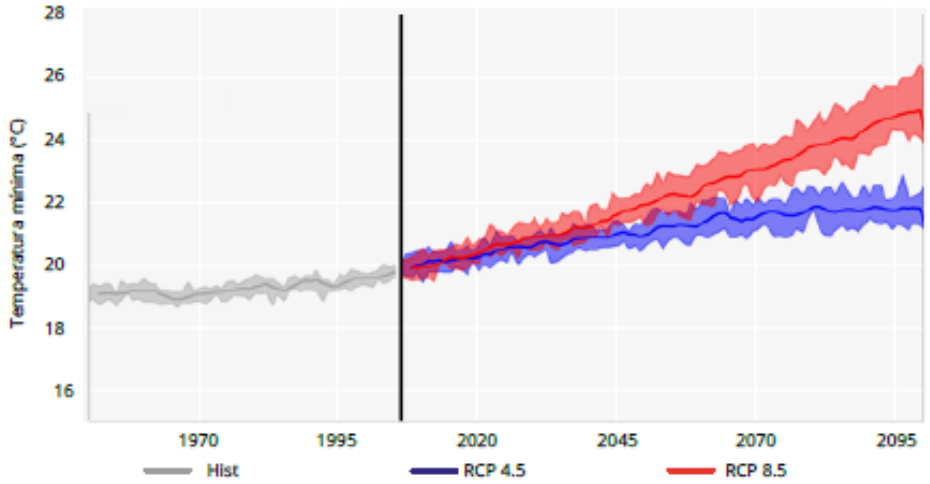

Figure 29 Minimum temperature trend in Asunción

Table 3 Summary of the variation of maximum and minimum temperatures for two emission scenarios

CPR 4.5	CPR 8.5
*** For the period 2011 - 2040**	
the change in the maximum temperature is +0.91 °C and +0.97 °C for the minimum temperature	the change in the maximum temperature is +0.99 °C and +1.11 °C for the minimum temperature
*** For the period 2041 - 2070**	
the change in the maximum temperature is +0.70 °C and +1.01 °C for the minimum temperature	the change in the maximum temperature is +2.08 °C and +2.10 °C for the minimum temperature
*** For the period 2071 - 2100**	
the change in the maximum temperature is +1.34 °C and +1.53 °C for the minimum temperature	the change in the maximum temperature is +2.8 °C and +3.2 °C for the minimum temperature

Precipitation Trend

The ensemble model (CMIP6) estimates a slight decrease in precipitation to the northwest (less than 50 mm) and an increase to the southeast (more than 200 mm).

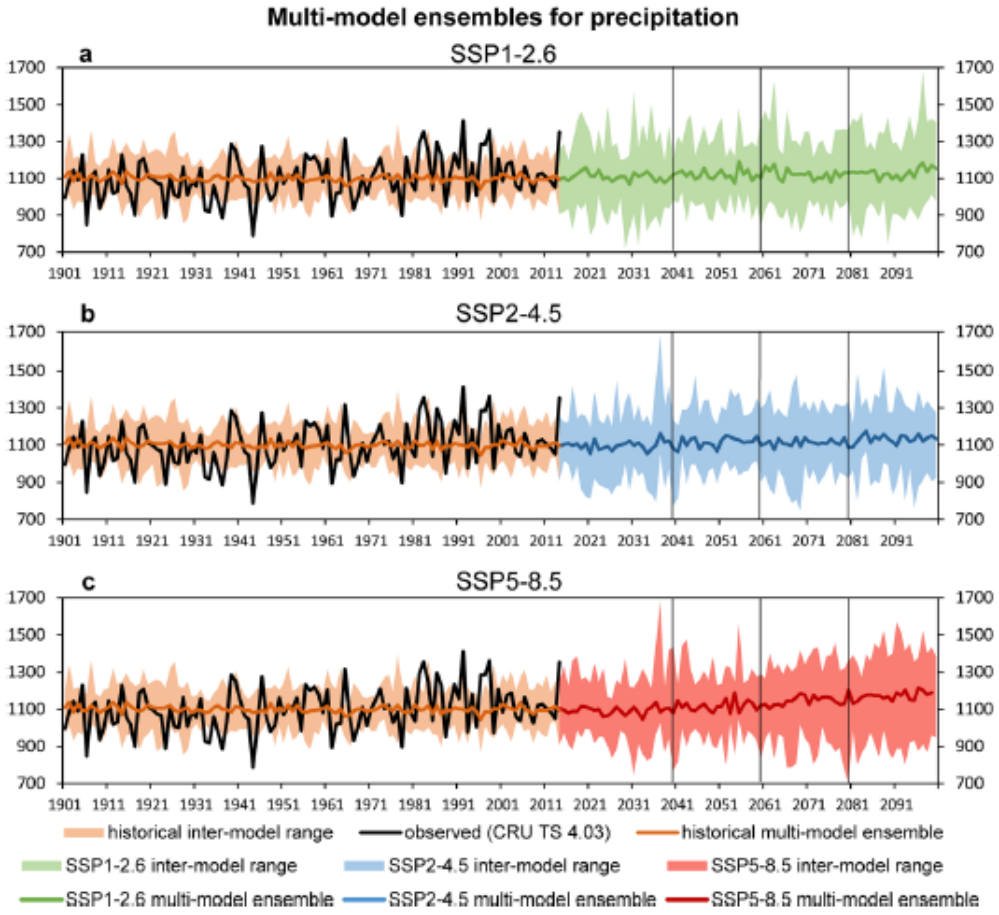

Figure 30 Trend of average annual precipitation over the next 80 years (Lovino, 2021)

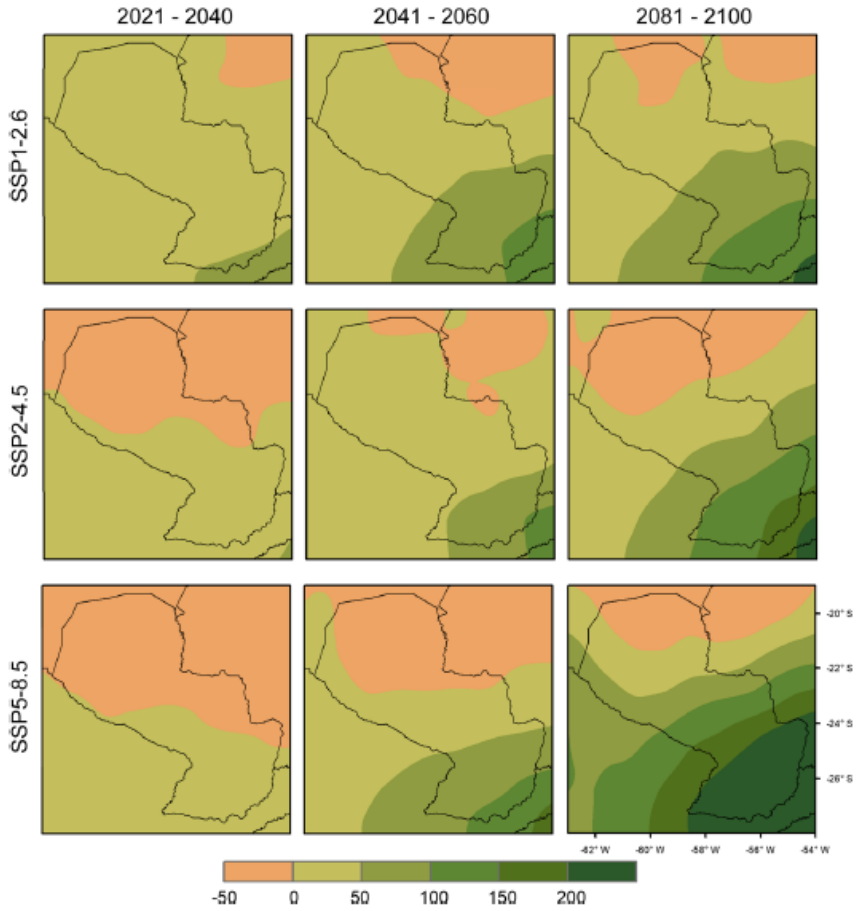

Figure 31 Spatial distribution of the change in mean annual precipitation for the different scenarios over a 20-year interval (Lovino, 2021)

With regard to maximum precipitation, intensity, duration and frequency curves (IDF curves) are used in the design of hydraulic works. These curves are used to estimate synthetic rainfall to model the behavior of hydraulic works in the face of extreme events associated with a specific recurrence period. The Bañados de Asunción Flood Risk Study (IDB, 2023) estimated the variation of these IDF curves for two emission scenarios at 30-year intervals, up to the year 2100. A summary of the results obtained is shown in the table below.

Table 4 Summary of the Variation Factors of the Asunción IDF Curves

T (PERIODO DE RETORNO)	RCP 4.5 2011-2040	RCP 4.5 2041-2070	RCP 4.5 2071-2100	RCP 8.5 2011-2040	RCP 8.5 2041-2070	RCP 8.5 2071-2100
2	1.08	1.15	1.03	1.03	1.10	1.12
5	1.07	1.16	1.03	1.04	1.18	1.11
10	1.05	1.15	1.02	1.06	1.22	1.12
25	1.03	1.13	1.01	1.11	1.25	1.13
50	1.01	1.11	1.00	1.15	1.27	1.14
100	0.99	1.09	1.00	1.20	1.29	1.15
200	0.97	1.07	0.99	1.26	1.30	1.16
500	0.96	1.05	0.99	1.35	1.32	1.18

For the present study, the IDF curve of Asunción was adopted as an input for the design of works and flood study, so it is considered appropriate to use the previous table as an indicator to evaluate the future increase in a very unfavorable scenario.

As shown in the table above, the maximum increase for the recurrences of construction design (10, 25, 50 and 100 years) is given for the RCP 8.5 scenario in the period 2041-2070, estimating an increase of approximately 30%. This increase is not considered very significant in terms of the design of works, since they are sized with a certain slack capable of accepting a certain additional flow. To get an idea of the magnitude of the increase, the following figure shows a comparison of two hyetograms, one of them was prepared from the current IDF curve and the other corresponds to the percentage increase of 30% for the RCP 8.5 scenario.

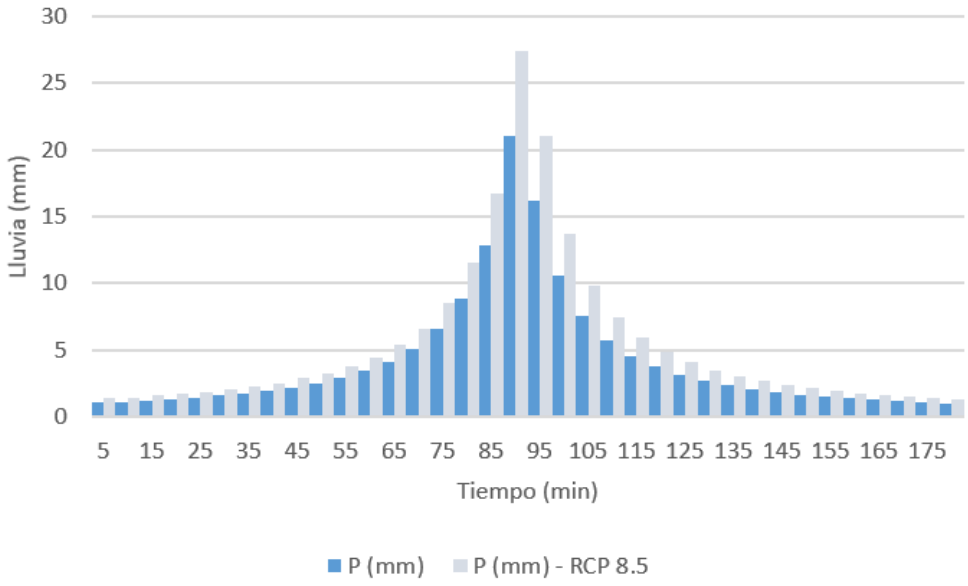

Figure 32 Comparison of a 3-hour hyetogram with the current IDF curves vs. a hyetogram associated with the RCP 8.5 scenario (+ 30%)

As seen in the figure above, the 30% increase is only 6 mm of additional rain for the peak of the storm. In terms of total volume, the difference is approximately 40 mm. This increase is insignificant for a flat and

extensive property, where water can spread considerably. In this case, the adoption of the rainfall corresponding to the RCP 8.5 scenario in the hydrodynamic model results in an increase of only 1cm in the water level, as a result of the large water spread area that exists in the area.

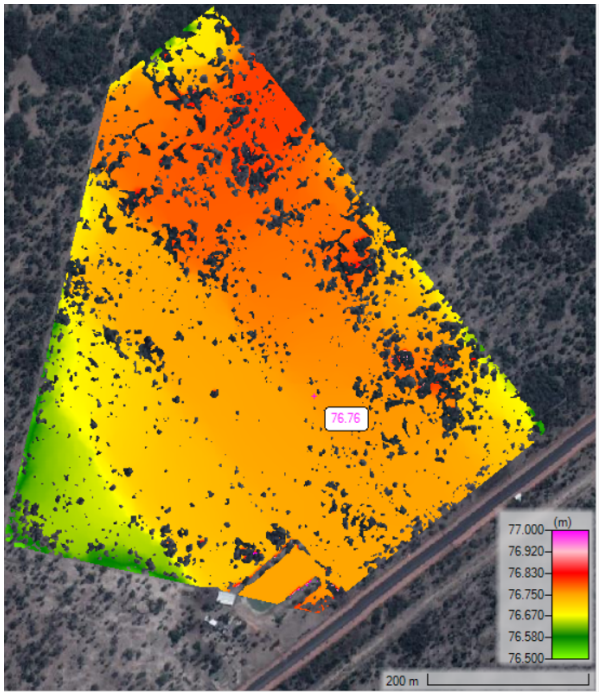

Figure 33 Maximum water level along the site for an 8.5 RCP scenario

Trend in the variation of the levels of the Paraguay River

Water levels in the Paraguay River could also vary in the coming decades as a result of regional rainfall projections. The Flood Risk Study in the Bañados de Asunción (IDB, 2023) estimated variations in the maximum water levels of the Paraguay River for different recurrence periods. For all the recurrence periods analysed, a decrease in maximum levels is estimated, so an increase in the risk of river flooding in the project area is considered unlikely.

Table 5 Summary of the variation of the maximum water levels of the Paraguay River in Asunción

T (PERIODO DE RETORNO)	2011-2040	2041-2070	2071-2100	PERIODO DE REFERENCIA
2	57.69	58.36	59.06	59.18
5	59.05	59.72	60.39	60.51
10	59.72	60.43	61.10	61.22
25	60.51	61.15	61.82	61.94
50	60.95	61.59	62.26	62.38
100	61.31	61.96	62.63	62.75
200	61.62	62.27	62.94	63.06
500	61.95	62.60	63.27	63.40

Note: *although the estimation of levels in the previous table corresponds to the city of Asunción, it is important to mention that there is a strong correlation between the levels in Asunción and Villeta, so it is considered appropriate to use this table as a reference.*

Availability of water for industrial use

Regarding the use of the plant's water, according to available data, it is estimated that the river water will be collected in the order of 243 m3/hr, returning approximately 77 m3/hr (with a peak of 84 m3/hr) after treatment. For reference, the most severe drought of the Paraguay River in the period from 1904 to the present corresponds to -0.70 m of the hydrometric rule of Asunción. In 2020, the flow associated with the -0.45 m level of the rule was measured, recording 970 m3/s.

Taking into consideration the minimum flow measured for -0.45 in the rule, the extreme drought level of -0.70 could be associated with an approximate flow of 600 m3/s, which would be approximately 2,160,000 m3/hr.

The flow that will be extracted from the river for the operation of the plant represents 0.0125% of the minimum flow associated with an extreme drought event. Based on these numbers, it is acceptable to conclude that there would be practically no impact on the Paraguay River, since the plant's consumption is negligible in relation to the availability of water in the most extreme case of low water.

8. Conclusions and Recommendations

The present study resulted in maximum water levels associated with extreme rainfall and river events. In both cases, an approximate water level of +76.80 was obtained. Based on this, it is recommended that the industry platform dimension be set at +77.80.

In addition, possible effects of climate change were evaluated, which resulted in a negligible increase in water level due to the 30% increase in extreme rainfall associated with the worst-case scenario RCP 8.5.

Regarding the need to extract water from the Paraguay River for industrial use, in the order of 243 m3/hr, it is considered insignificant in terms of impact on the body of water, considering the flow module of the Paraguay River. By way of reference, the most severe low water of the Paraguay River in the period from 1904 to the present corresponds to -0.70 m, associated with an approximate flow of 600 m3/s, which would be approximately 2,160,000 m3/hr. It is advisable to study water quality for different water availability scenarios, which was outside the scope of this study.

APPENDIX A- TOPOGRAPHIC STUDY OF ELEVATION LINKAGE

VINCULACION DE DATUM VERTICAL PUNTO 100056 GUYRATI A NMM REGLA HIDROMETRICA DE VILLETA

Se ha realizado una vinculación del punto de la red Geodésica Nacional con el nivel Medio del Mar de la regla Hidrométrica del Puerto de Villeta.

En primera instancia, se procedió a la verificación de las coordenadas partiendo del Punto de Primer Orden de la Red Geodésica del Paraguay **100056 Guyrati**, cuya coordenadas UTM -WGS84 N: 7.170476,537; Este 443.061,765 y Cota 87,47 desde el cual se procedió a realizar la lectura a la referencia de nivel denominado "**REGLA VILLETA**" que se encuentra en el Puerto de Villeta por el método RTK, además se tomaron los niveles del pelo de agua en las inmediaciones de la regla y la base de la segunda regla en fecha 07-09-2023.

En las planillas que se muestran a continuación las coordenadas de los puntos relevados, así como las fotografías del trabajo realizado.

Datos del archivo del proyecto			Sistema de coordenadas			
Nombre: 100056 Guyrati	Nombre:				World wide/UTM	
ıaño:	Zona:				21 South	
a horaria:	Datum de referencia global:				WGS 1984	
cripción:	Geoide:				EGM96 (Global)	
Lista de Puntos						
Nombre	Norte (Metro)	Este (Metro)	Elevación Elipsoidal	Elevación EGM96	Elevación NMM	Código de característica
100056GUYRATI	7.170.476,537	443.061,765	87,470	70,390	72,003	GUYRATI 1992 DSGM
100056MR1	7.170.446,963	443.058,962	87,980	70,900	72,513	GUYRATI MR1 1992 DSGM
0.00 regla Villeta	7.179.023,451	442.184,789	68,327	51,247	52,860	Base de la Regla
3.00 regla villeta	7.178.936,770	442.167,787	71,326	54,246	55,860	Base de la Regla
2	7.179.023,451	442.184,789	70,777	53,697	55,310	pelo agua regla 2.45
1	7.178.942,954	442.166,503	70,758	53,678	55,290	pelo de agua frente regla 3.00
7/9/2023 15:00						



Ing. Sandro Rafael Fernández Ruiz
Reg. MOPC 1742

EQUIPOS UTILIZADOS

Los trabajos topográficos fueron ejecutados con instrumentos modernos GPS - L1&L2, TRIMBLE R8S diferencial, con post procesamiento y Software Trimble Business Center. La precisión horizontal fue de 0.004 metros y la precisión vertical fue de 0.005 metros al Punto RN10.

GNSS Trimble R8s GNSS

- Medidas de fase portadora GNSS de muy bajo ruido con una precisión <1 mm de en un ancho de banda de 1 Hz

Horizontal . . . . . .8 mm + 0,5 ppm RMS

Vertical . . . . . 15 mm + 0,5 ppm RMS

Tiempo de inicialización5. . . . . Típico de >99,9%

- Receptor Base - Receptor Rover (Móvil) - Bastón de 2m de fibra de carbono - Estuche de plástico de transporte

- Controladora TSC3 - Radio TDL450- Software de Gabinete Trimble Business Center



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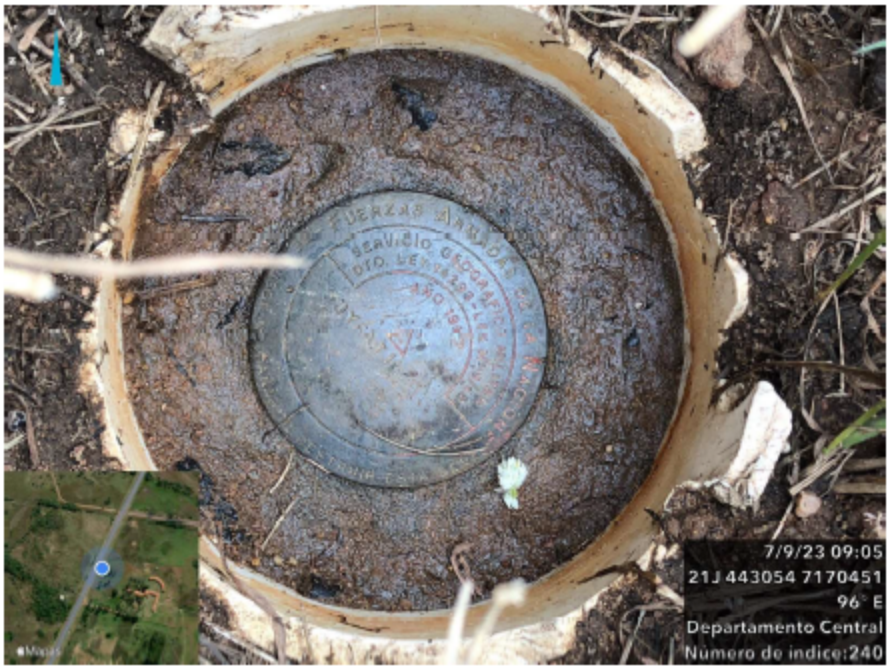
Fotografías





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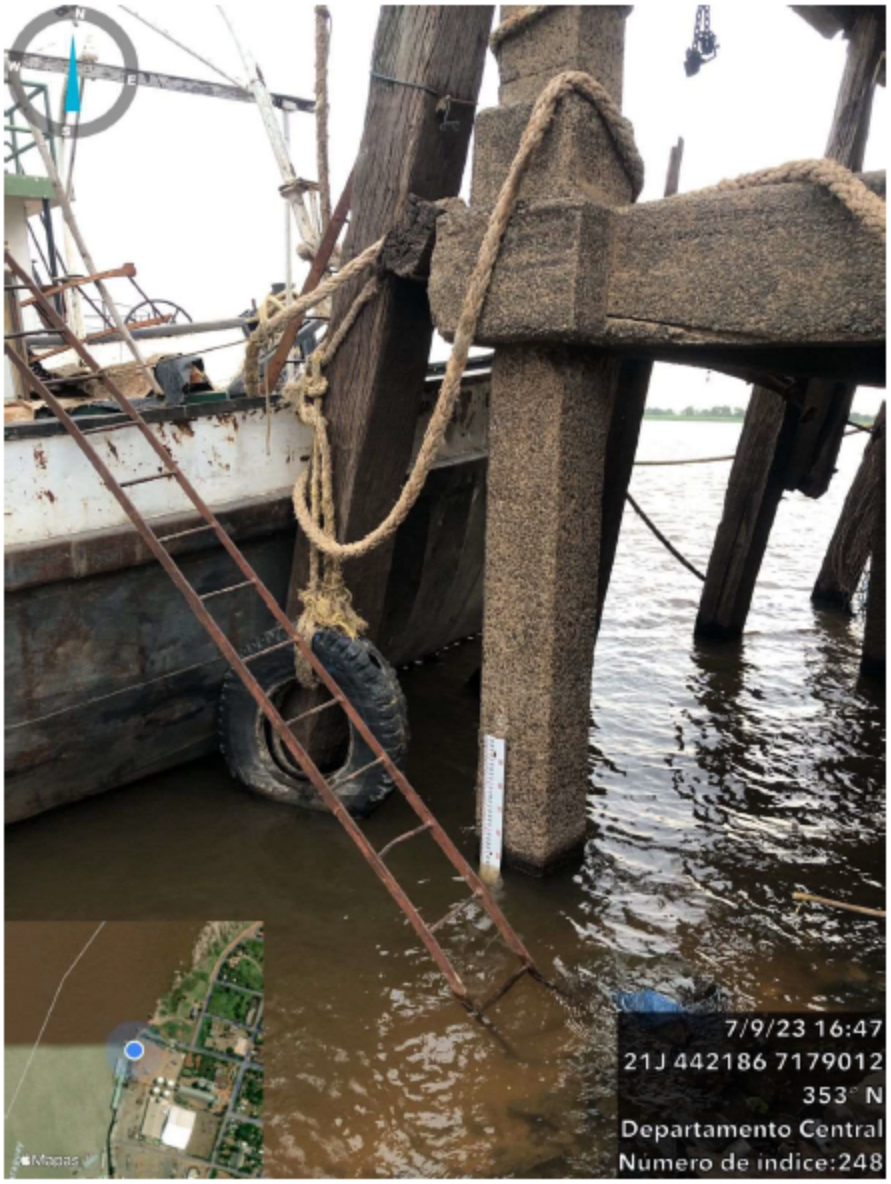

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Annex 4 – Air Quality Modelling Report



Air Quality Modelling

March 2024

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1. Introduction

An assessment was made of the potential impact on air quality due to the future operation of ATOME's green hydrogen, ammonia, and fertiliser production plant, which will be installed in the district of Villeta in the Central Department of the Republic of Paraguay.

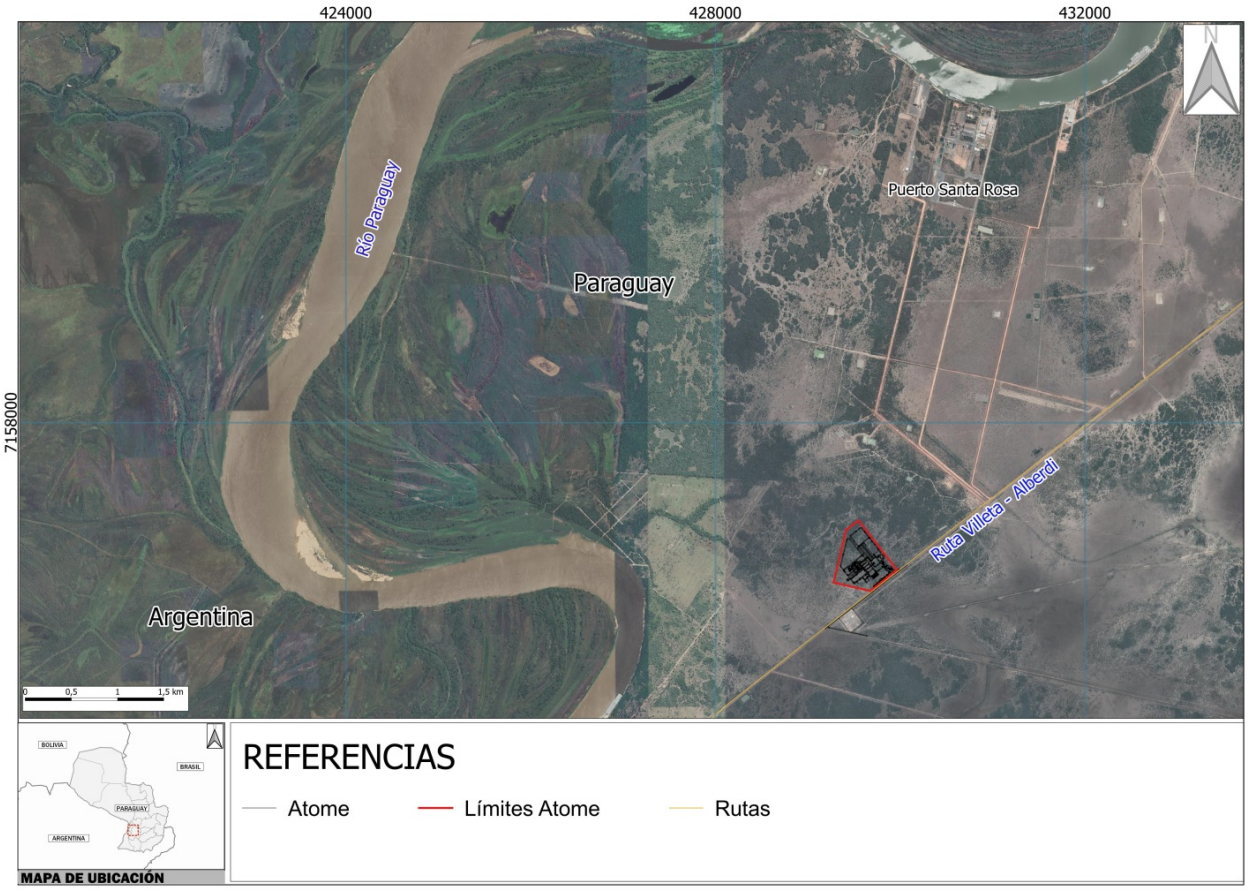
To this end, a mathematical simulation was carried out using the AERMOD model of the dispersion of pollutants (CO, NO2, PM10, PM2.5 and NH3) emitted by the main emission sources of the project and compared against the objective quality values included in national legislation, in Argentine legislation to analyse transboundary impacts and in international guidelines. Sources operating under regime conditions, always under normal operating conditions, were considered. Contingency situations were not studied.

It should be noted that no source operating in the regime will emit an appreciable amount of sulphur oxides, so this parameter was not modelled or considered in the evaluation.

ATOME described and characterised the emitting sources and the current air quality situation (baseline).

In Figure 1-1 the location of the industrial plant and the environment around it are visible.

Figure 1-1 Location of the industrial plant on satellite image



Source: Authors' creation

2. Regulations and Reference Guides

Resolution No. 259/15 of Paraguay was considered a reference regulation for pollutants, establishing the permissible air quality parameters (Table 2-1).

In addition, and to assess potential transboundary impacts, Law No. 1356/04 of the Autonomous City of Buenos Aires (Table 2-2). It should be noted that this law is used as a reference since there is no other regulation at the province of Formosa or at the national level in Argentina that establishes target air quality values.

Table 2-1 Resolution No. 259/15 Permissible air quality parameters - Paraguay

Parameter	Period	Limit (µg/m3)
CO	8 a.m.	10.000
NO2	1 h	200
	Annual	40
SO2	24 h	20
PM2.5	24 h	30
	Annual	15
PM10	24 h	150

Source: Resolution No. 259/15 – Paraguay

Table 2-2 Law 1356/04 Ambient Air Quality Standards - Buenos Aires

Parameter	Period	Limit (µg/m3)
CO	1h	40.000
	8 a.m.	10.000
$PM2._5$	24 h	65
	Annual	15
PM10	24 h	150
	Annual	50
SO2	3 h	1.300
	24 h	365
	Annual	80
NO2	Annual	100

Source: Law 1356/04 – Buenos Aires, Argentina

Also considered were the International Finance Corporation's (IFC) General Guidelines on Environment, Health and Safety, which state that projects with significant sources of air emissions that may cause substantial impacts on ambient air quality must prevent or minimise these emissions, ensuring that concentrations are not higher than those established in the current version of the World Health Organization (WHO) Air Quality Guidelines presented at Table 2-3. It sets out guiding values, objectives and progressive intermediate targets.

Table 2-3 IFC Ambient Air Quality Guidelines (WHO 2021)

Pollutant	Average Period	Level of air quality guidelines in µg/m3
NO2	1 year	40 (intermediate goal 1) 30 (intermediate goal 2) 20 (intermediate goal 3) 10 (guide)
	24 hours1	120 (intermediate goal 1) 50 (intermediate goal 2) 25 (guide)
	1 hour	200 (guide)
PM10	1 year	70 (intermediate goal 1) 50 (intermediate goal 2) 30 (intermediate goal 3) 20 (intermediate goal 4) 15 (guide)
	24 hours1	150 (intermediate goal 1) 100 (intermediate goal 2) 75 (intermediate target 3) 50 (intermediate goal 4) 45 (guide)
PM2.5	1 year	35 (intermediate goal 1) 25 (intermediate goal 2) 15 (intermediate goal 3) 10 (intermediate goal 4) 5 (guide)
	24 hours1	75 (intermediate goal 1) 50 (intermediate goal 2) 37.5 (intermediate target 3) 25 (intermediate goal 4) 15 (guide)
CO	24 hours1	7,000 (intermediate goal 1) 4,000 (guide)
	8 hours	10.000

Pollutant	Average Period	Level of air quality guidelines in µg/m3
	1 hour	35.000
	15 min	100.000
SO2	24 hours1	125 (intermediate goal 1) 50 (intermediate goal 2) 40 (guide)
	10 min	500

[1] 99th percentile (i.e. 3-4 days of exceedances per year).

Source: IFC Guidelines (WHO 2021)

To analyse air quality in terms of the presence of NH3, the Alberta *Ambient Air Quality Objectives and Guidelines Summary (*2019) was used as a reference, which sets an hourly concentration value of 1,400 µg/m3 (2 ppm) as the target quality value.

3. Calculation methodology and modelling

3.1. Description of the calculation model

AERMOD[1] is an atmospheric pollutant dispersion model recommended by the U.S. Environmental Protection Agency (EPA) for the evaluation of dispersion of pollutants from various sources. It is an emissions modelling system that simulates essential physical atmospheric processes and provides refined estimates of concentration and deposition over various meteorological conditions, considering that the average meteorology governs concentration and deposition at all distances in one hour.

It is a stationary Gaussian model for estimating air quality impacts in the near countryside (less than 50 km), applicable to both rural and urban areas, flat and complex terrain, and multiple types of sources (point, linear, surface, volumetric and *open pit*[2]).

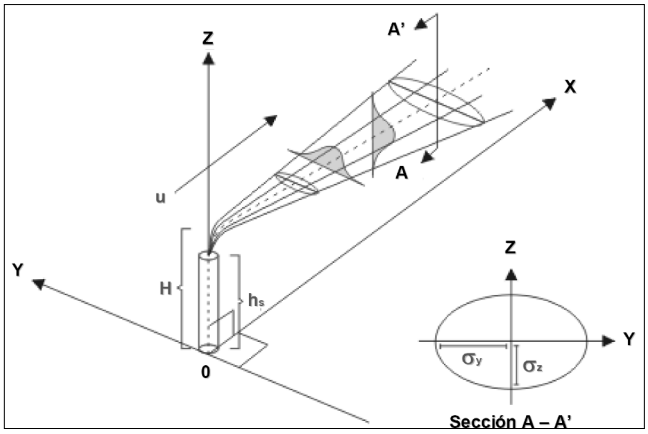
The mathematical formulation of the model uses the conservation equations of mass and transport to describe the concentration $c(x, y, z, t)$ of a given pollutant at a point (x, y, z) at time t. Assuming that the process is stationary – among other hypotheses – the following formulation is obtained:

$$c(x,y,z) = \frac{Q}{2\pi\, u\, \sigma_y\, \sigma_z} \cdot exp\left[-\frac{1}{2}\left(\frac{y^2}{{\sigma_y}^2} + \frac{(z-H_e)^2}{{\sigma_z}^2}\right)\right]$$

Where: Q is the total amount emitted, u is the wind speed, H_e is the effective height of the chimney, σ_y and σ_z are the horizontal and vertical standard deviations, respectively.

The model assumes a Gaussian concentration distribution around its symmetry axis defined by the wind's direction, as shown in Figure 3-1.

Figure 3-1 Gaussian AERMOD Model Geometry



Source: Cabrera et al (2008)

The model includes the following considerations:

[1] The AERMOD Gaussian plume dispersion model is used, with the AERMOD View software version 12.0.0 of Lakes Environmental.
[2] Sources emitted below ground level.

- It considers the effects of the turbulent wake caused by the presence of buildings, using the algorithms included in the Plume *Rise Model Enhancements* (hereinafter PRIME).
- The stable boundary layer assumes that the concentration distribution is Gaussian for both the x axis and the y axes. In contrast, the horizontal distribution is also assumed to be Gaussian in the convective boundary layer, but a biGaussian probability density function describes the vertical distribution.
- It incorporates, through a simple approach, basic concepts about the flow and dispersion of pollutants in complex terrains, where the plume is modelled both where it impacts the terrain and accompanying its altimetry variations.

The AERMOD model consists of two modular subprograms: the AERMOD *mapping program* (hereinafter AERMAP) and the AERMOD *meteorological pre-processor* (hereinafter AERMET).

AERMAP is a survey pre-processor that uses terrain data to calculate a representative ground influence height and create receiver grids.

AERMET is a meteorological pre-processor that processes the boundary layer and other parameters necessary for the operation of AERMOD.

3.2. Characterisation of emission sources under normal operation

The following point sources of emission operating under normal conditions were considered.

- Main NH3 flare
- Nitric acid abatement
- Secondary NH3 flare
- Granulation scrubber
- Milling discharge

Table 3-1 presents the description of the sources that operate under normal conditions continuously (in regime) and the characterisation of the emissions of each of them.

It should be noted that no source operating in the regime will emit an appreciable amount of sulphur oxides, so this parameter was not modelled or considered when evaluating air quality during operation (in regime). On the other hand, concerning the emission of particulate matter, for those sources in which the fraction of the emission of particulate matter corresponding to PM10 and PM2.5 is unknown, it was assumed that the total emission corresponds to the modelled pollutant (conservative premise).

Table 3-1 Characterisation of emission sources with continuous operation (in mode) – normal operation

		Main NH3 flare	Nitric acid abatement	Secondary NH3 flare	Granulation scrubber	Milling discharge
Characteristics of the issuer	Chimney outlet height above ground level (m)	16	59,2	16	72	15
	Inner diameter (m)	0,61	0,95	0,61	3,3	0,8
Emission characteristics	Emission Flux (Nm3/h)	98	58.212	98	220.000	17.000
	Outlet Temperature (°K)	1.173	433	1.173	323	358
Emission rates (g/s)	Particulate matter (PM10 and PM2.5)	-	-	-	3,06	PM10: 0.175 PM2.5:
	Nitrogen oxides (NO2)	0,0028	0,33	0,0028	-	-
	Carbon Monoxide (CO)	0,0153	-	0,0153	-	-
	Ammonia (NH3)	-	0,061	-	3,06	-

Source: Atome

The coordinates of the location of all the sources considered are presented in Table 3-2.

Table 3-2 Location and Operating Condition of Emitting Sources – Normal Operation

Fountain	UTM Coordinates (21H)		Normal Operation
	East (m)	South (m)	
Main NH3 flare	429.357	7.156.343	Continuous
Nitric acid abatement	429.531	7.156.432	Continuous
Secondary NH3 flare	429.510	7.156.489	Continuous
Granulation scrubber	429.600	7.156.543	Continuous
Milling discharge	429.570	7.156.483	Continuous

Source: Atome

3.3. Characterisation of local meteorology

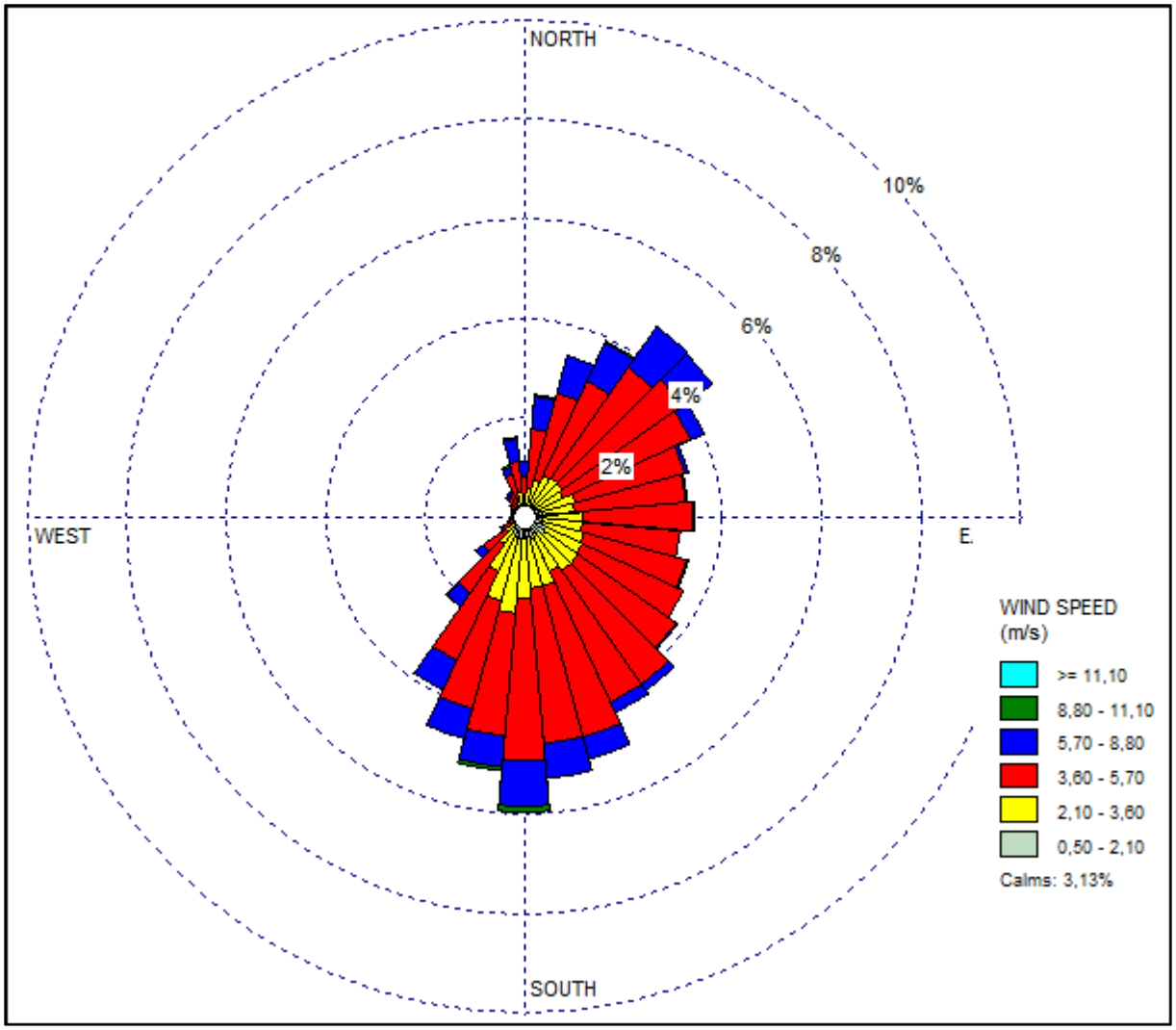
The AERMET pre-processor uses meteorological measurements representative of the modelling domain to estimate boundary layer parameters. The depth and the dispersion of the pollutants are influenced at the local scale by the surface characteristics of the area under study: roughness, albedo and Bowen radius. These surface variables, together with the basic meteorological observations (wind speed and direction, temperature, and cloud cover), are required by AERMET to calculate the parameters of the planetary boundary layer (friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale and surface heat flux). The stability of the planetary boundary layer is obtained through the analysis of surface heat flux.

The site under study does not have a weather station that records site-specific parameters. Therefore, the necessary meteorological data were obtained using the *Weather Research and Forecasting* (WRF) forecasting model, which uses information provided by the *National Centres for Environmental Prediction Global Reanalysis*. The WRF model is a state-of-the-art mesoscale numerical weather prediction system for atmospheric research and operational forecasting. It serves various meteorological applications at scales ranging from tens of meters to thousands of kilometres.

The meteorological characterisation used for this study was provided by ATOME and had the complete series of hourly values of the surface meteorological variables and higher borehole values (two per day) for the period from 2020 to 2022 in the project's location in Villeta, Paraguay.

The 2020–2022 compass rose in Figure 3–2 shows the main wind directions over the three years analysed. The predominant directions are located from the S direction to the N direction. The average wind speed is approximately 3.75 m/s, with 3.13% of calm winds recorded (< 0.5 m/s).

Figure 3-2 Compass rose (blowing from)



Note: The period considered is January 2020 - December 2022. Average speed: 3.75 m/s.
Source: ATOME

3.4. Characterisation of the land and main buildings within the industrial site

For the construction of the physical model, the general *layout* of the ATOME industrial plant was used (according to the plan "*VILLETA PLANT LAYOUT r05C*"), assigning names and heights to all the buildings, structures, and tanks.

The topographic survey carried out by the *Shuttle* Radar (SRTM)'s topographic mission (operated by NASA) was used for the terrain characterisation. This mission generated a high-resolution global topographic survey in February 2000. In the project area, the resolution of the study corresponds to a grid of approximately 90 m on each side.

3.5. Concentration conversion in integration periods of less than 1 hour

The calculation methodology of the AERMOD software includes hourly steps of 1-hour duration, so estimating the resulting concentration in shorter integration periods must be done using a conversion of the hourly concentration obtained.

Concentration in periods of less than 1 hour was estimated following the Ontario *Air Dispersion Modelling Guide*[3] recommendation as follows:

$$C_0 = C_1 \left(\frac{t_1}{t_0}\right)^n$$

Where:

$$t_1: Longer\ average\ time \quad t_0: Shorter\ average\ time \quad n: Stability\ exponent$$

As a conservative approach, n was considered equal to 3: n=0.28.

[3] Ontario. Ministry of the Environment. (2016). *Air Dispersion Modelling Guideline for Ontario: Guidance for Demonstrating Compliance with the Air Dispersion Modelling Requirements Set Out in Ontario Regulation 419/05, Air Pollution-Local Air Quality Made Under the Environmental Protection Act. Version 3.0*. Ministry of the Environment.

4. Baseline Characterisation

The baseline characterisation was provided by ATOME and is presented in Annex I[4]. The parameters surveyed were PTS, PM10, PM2.5, SO2, CO, CO2, O3 and NO2.

In Table 4-1 the main information obtained from the baseline characterisation report is presented, where the maximum concentration measured in periods of 10 minutes duration and periods of 24 h can be seen for all the parameters surveyed, and in periods of 1 h and 8 h for some.

In addition, Table 4-1 compares the measured air quality (baseline) with the standards and reference guide values considered. Green indicates the parameters that meet the target quality values.

For the interpretation of the information contained in the characterisation of the baseline (Annex I), hypotheses were made for the evaluation of those parameters whose objective quality values are expressed in integration periods that were not reported (15 minutes and 1 h of CO, and 3 h of SO2). In these cases, it was considered, as a conservative scenario, that the concentration in the unreported reference period can be assumed to be equivalent to the maximum concentration of 10 minutes surveyed for the comparison sought. In Table 4-1 The cases where such a hypothesis was made are indicated. The annual period was not analysed because the number of days surveyed is insufficient to estimate annual values under reasonable hypotheses.

[4] CSI Ingenieros did not perform a verification or validation analysis of the local air quality characterization (baseline) provided by ATOME.

Table 4-1 Baseline air quality representative values and comparison with standards and reference guides

Parameter	Period	Baseline Concentration (µg/m3)	Paraguay Resolution No. 259/15 (µg/m3)	Buenos Aires Law No. 1356/04 (µg/m3)	IFC Guidance (WHO 2021) (µg/m3)
CO	15 min	7682	-	-	100.000
	1 hour	7682	-	40.000	35.000
	8 hours	400	10.000	10.000	10.000
	24 hours	400	-	-	4.0001
NO2	1 hour	3,8	200	-	200
	24 hours	2,7	-	-	251
	1 year	No data	40	100	10
PM2.5	24 hours	10	30	65	151
	1 year	No data	15	15	5
PM10	24 hours	15	150	150	451
	1 year	No data	-	50	15

[1] 99th percentile (i.e. 3-4 days of exceedances per year).

[2] Maximum concentrations measured in 10 minutes

Source: Prepared by the authors based on ATOME (Annex I), Resolution No. 259/15, Law No. 1356/04 and IFC guides.

5. Results during normal operation in regime

This chapter shows the results obtained for each pollutant considered when the sources operate continuously (in regime) under normal conditions.

Table 5-1 summarises the maximum concentration values obtained for each pollutant and each integration period considered. The same table also includes the baseline characterisation (see paragraph 4), the resulting concentration foreseen in the future situation (operation project under regime + baseline), and the objective quality values provided for in the regulations and reference guides considered. The result of comparing the expected concentration in the future situation with these target quality values is indicated in colour.

The slides show the isoconcentration maps resulting from the operation of the plant under regime conditions for the periods of 1, 8 and 24 hours, as well as for the annual period. It should be noted that these Maps refer only to the expected concentration resulting from the operation of the project regime and do not include the current values (baseline). They reflect the incremental contribution expected by the project's operation under regime only and do not represent the future situation (project operation under regime + baseline).

In the case of PM10 and PM2.5 pollutants, the IFC's daily target quality value was compared using the 99th percentile, which corresponds to the 4th day with the highest concentration[5]. It should be recalled that in the PM10 and PM2.5 models carried out, the conservative hypothesis was assumed that 100% of the emission of particulate matter corresponded to each of the fractions modelled in those sources in which the particle size distribution of the emission of particulate matter emitted is not available. Although the IFC guidelines also consider the 99th percentile for the daily concentration of the CO and NO2 parameters, it was unnecessary to consider this percentile due to the low maximum daily concentration values obtained.

Concerning the results obtained for the CO parameter, as seen in Table 5-1, the incremental input the project will generate will be minimal compared to the values surveyed during the baseline characterisation. In addition, the expected concentrations in the future scenario (project Operation under regime + baseline) are significantly lower than the target quality values proposed by the regulations and reference guides.

For the NO2 parameter, both the incremental contribution of the project and the current situation (baseline) present low values in integration periods of 1 and 24 hours, so the target quality values are not expected to be exceeded in the future situation. With reasonable certainty, the annual target quality value is not likely to be exceeded (although the baseline characterisation is lacking in this integration period) because the incremental project contribution is expected to be very low. Notwithstanding the preceding, it is considered pertinent to characterise the baseline in the annual period to strengthen the conclusions reached for this integration period.

[5] The IFC guideline establishes that the maximum expected target quality value corresponds to the 99th percentile, which implies that it can be exceeded in 3 to 4 days a year (see numeral 4).

Regarding the emission of particles (PM10 and PM2.5), the incremental contribution that the project will generate operating under regime conditions is low, both for the daily period and for the annual period. The daily expected values in the future condition (project operating in regime + baseline) comply with the objective quality values established in Paraguayan and Argentine regulations and the guide value proposed by the IFC. For the annual concentration values of PM10 and PM2.5, in the absence of the characterisation of the current situation (baseline), it is not possible to predict the level of compliance with the future situation. Notwithstanding the above, it would be reasonable to assume that the annual values provided for Paraguayan regulations and reference guides will not be exceeded due to the limited incremental contribution the project is expected to generate. It is recommended that the characterisation of the current situation (baseline) be strengthened to predict the level of future compliance for both parameters on an annual basis and strengthen the conclusions reached regarding the daily concentrations expected in the future situation.

Concerning the emission of ammonia (NH3), the project foresees a low emission during the operation (in regime). The maximum hourly concentration of immission expected is significantly lower than the guide value established by the Environmental Authority of Alberta, Canada. This value is used as a reference, so the target quality value is not expected to be exceeded, even if the current air quality regarding this parameter (baseline) is unknown.

Table 5-1 Summary of results obtained for normal operation under the regime and comparison with the reference standard

Parameter	Period	Modelling results of normal operation in regime (µg/m3)	Baseline (µg/m3)	Expected future situation: modelling + baseline (µg/m3)	Normative Values / Guidelines			Remarks
					Paraguay Resolution No. 259/15 (µg/m3)	Buenos Aires Law No. 1356/04 (µg/m3)	IFC Guidance (WHO 2021) (µg/m3)	
CO	1 h	21,2	7682	789,2	-	40.000	35.000	Compliance with target quality values
	8 a.m.	7,7	400	407,7	10.000	10.000	10.000	Compliance with target quality values
	24 h	3,1	400	403,1	-	-	4.0003	Compliance with target quality values
NO2	1 h	3,5	3,8	7,3	200	-	200	Compliance with target quality values
	24 h	0,6	2,7	3,3	-	-	253	Compliance with target quality values
	Annual	0,05	No data	Not calculated due to lack of baseline value	40	100	10	Expected Fulfillment of Annual Target Quality Value
PM10	24 h	8,1	15	23,1	150	150	-	Compliance with Target Quality Value
	24 h – 99th percentile. 4th day senior concent3	5,5		20,5	-	-	453	Compliance with target quality values
	Annual	1,1	No data	Not calculated due to lack of baseline value	-	50	15	Expected Fulfillment of Annual Target Quality Value
PM2.5	24 h	4,2	10	14,2	30	65	-	Compliance with target quality values
	24 h – 99th percentile.	3,5		13,5	-	-	153	Compliance with target quality values

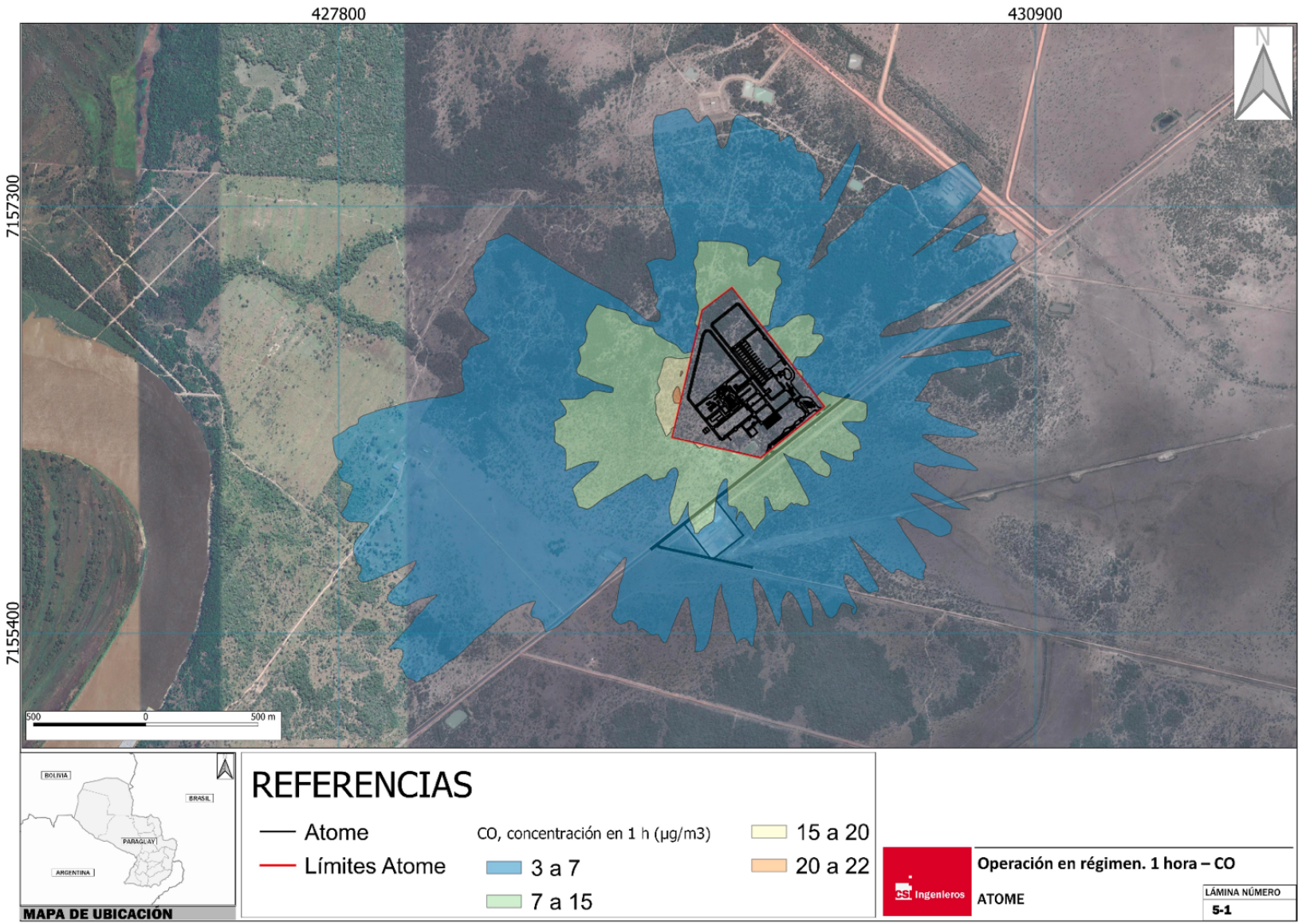
Parameter	Period	results of normal operation in regime (µg/m3)	Baseline (µg/m3)	Expected future situation: modelling + baseline (µg/m3)				Remarks
					Paraguay Resolution No. 259/15 (µg/m3)	Buenos Aires Law No. 1356/04 (µg/m3)	IFC Guidance (WHO 2021) (µg/m3)	
	4th day senior concent3							
	Annual	0,7	No data	Not calculated due to lack of baseline value	15	15	5	Expected Fulfillment of Annual Target Quality Value
NH3	1 h	11	No data	Not calculated due to lack of baseline value	-	-	-	Expected compliance with the target quality value of 1,400 µg/m3 (Value Guide Alberta, Canada)

[1] Modeling Result for Hourly Concentration

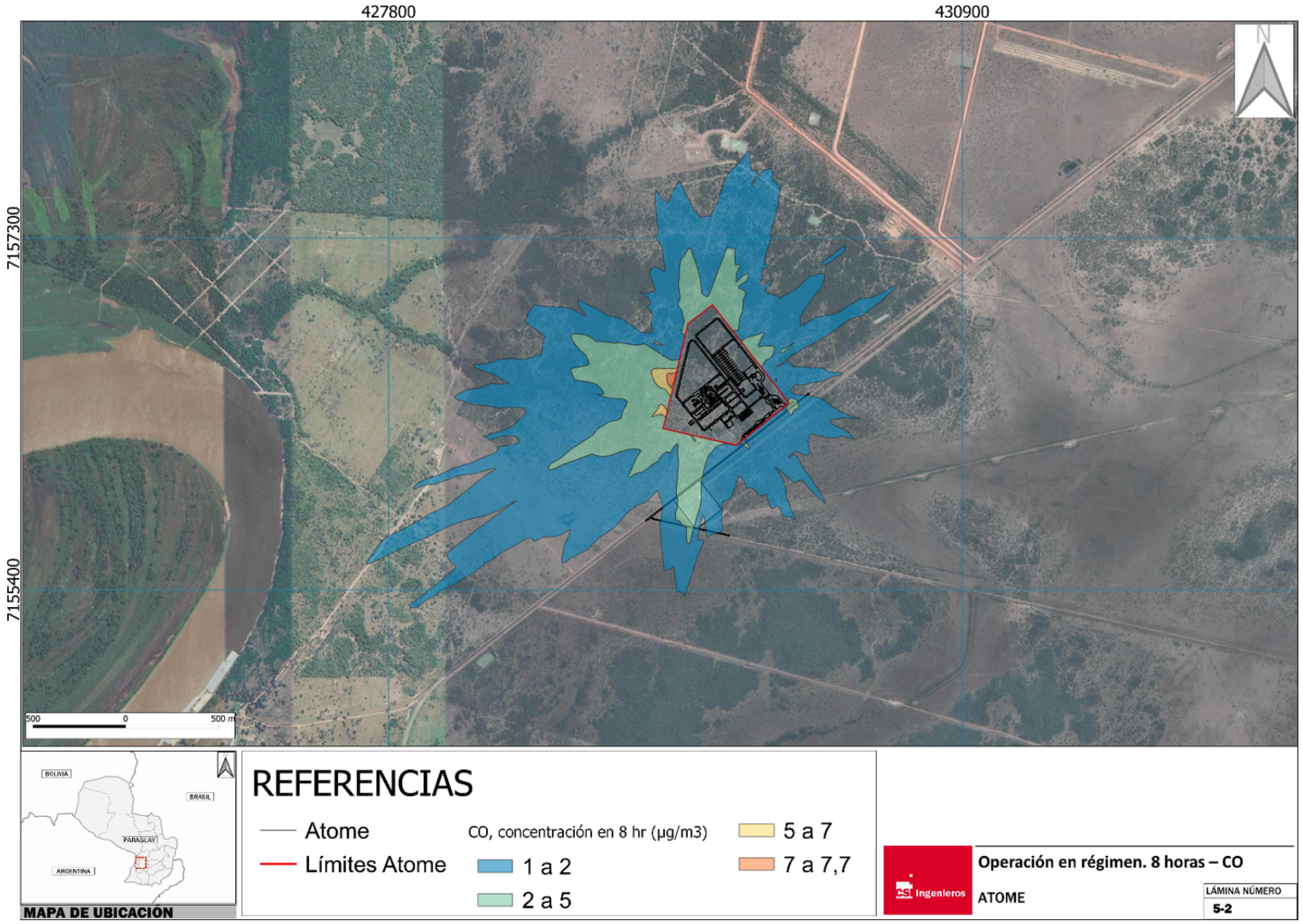
[2] Maximum concentration measured in 10 minutes

[3] 99th percentile (i.e., 3-4 days of exceedances per year).

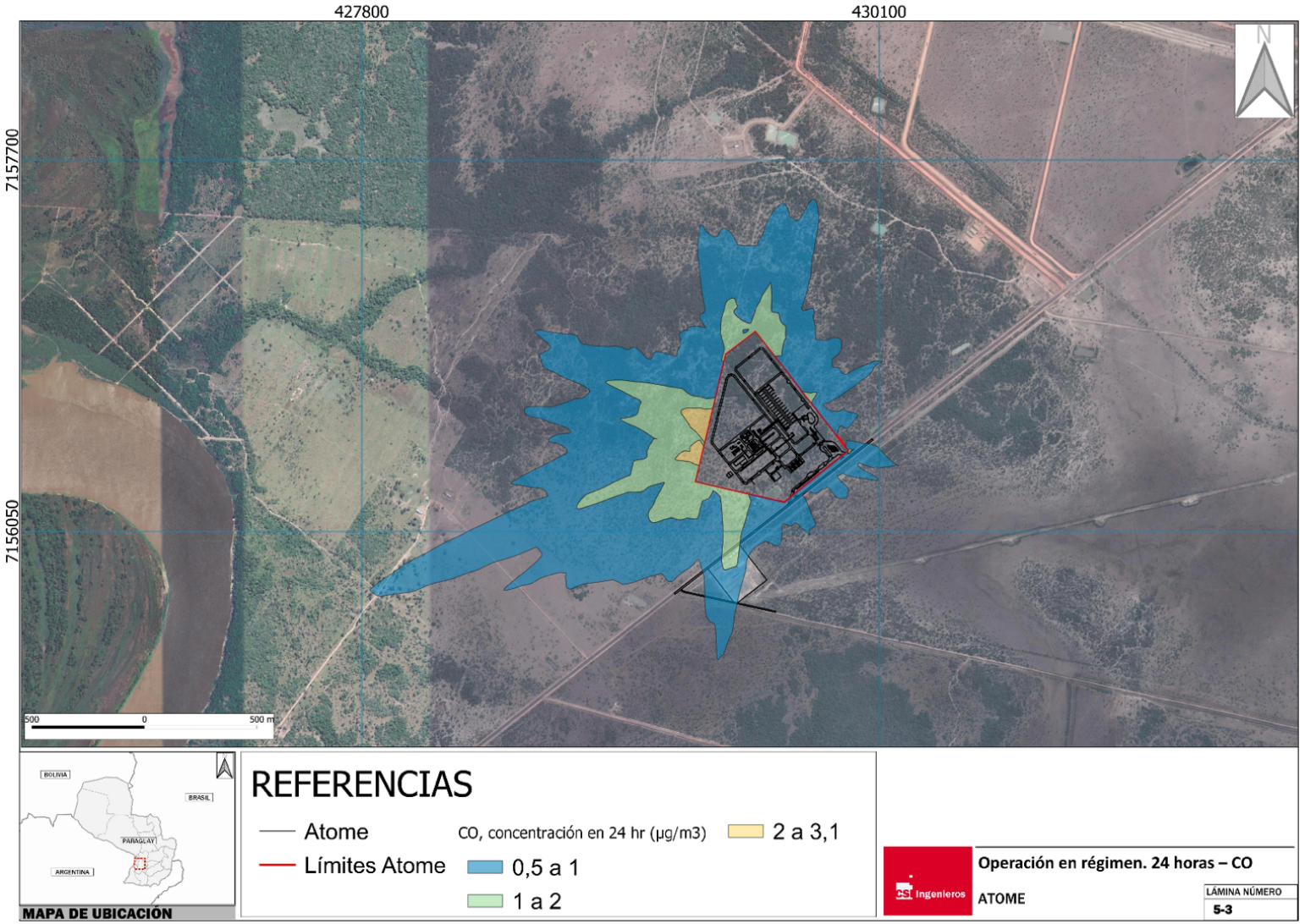
Map 5-1 Isoconcentration curves. Operation in regime. 1 hour – CO



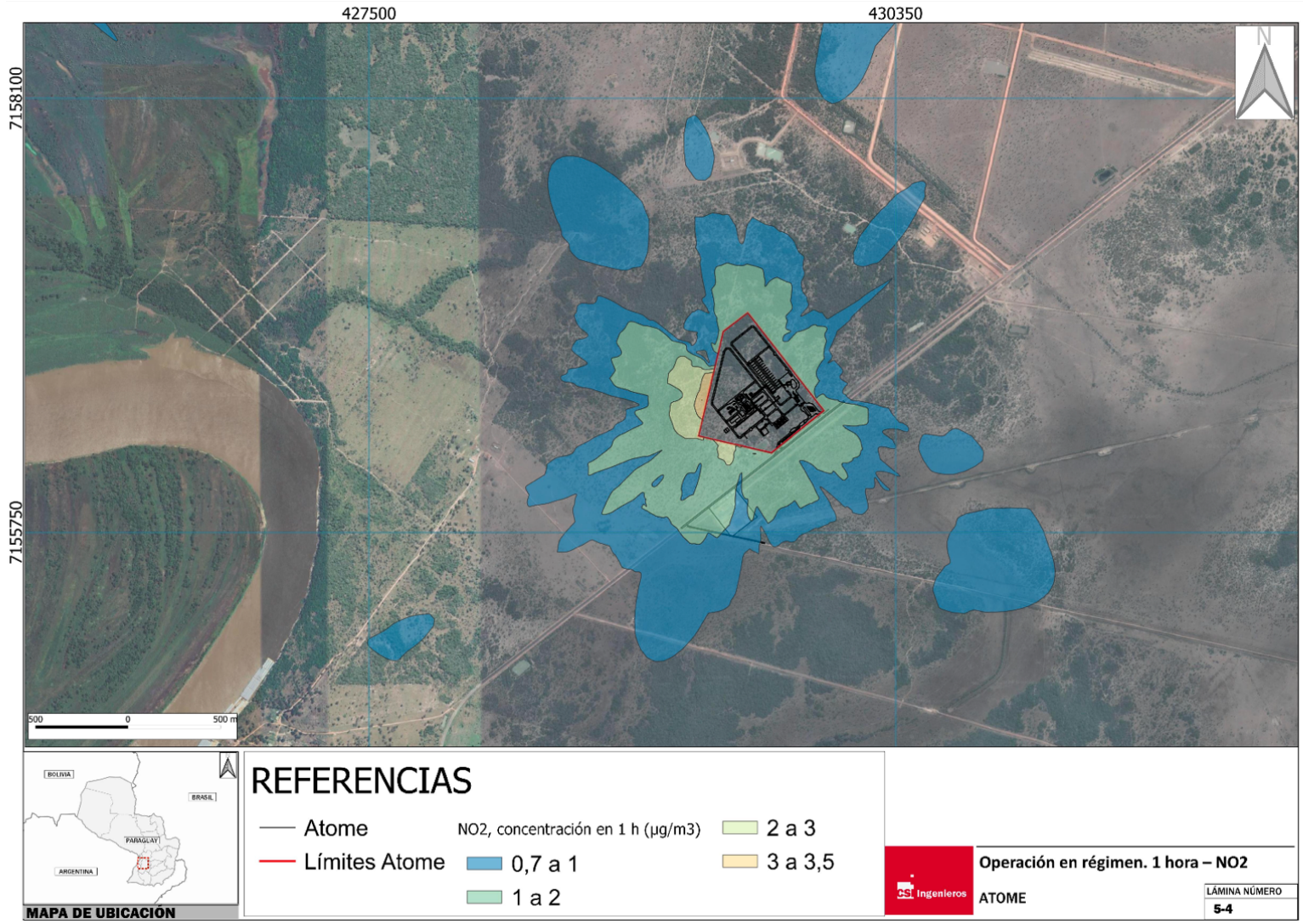
Map 5-2 Isoconcentration curves. Operation in regime. 8 hours – CO



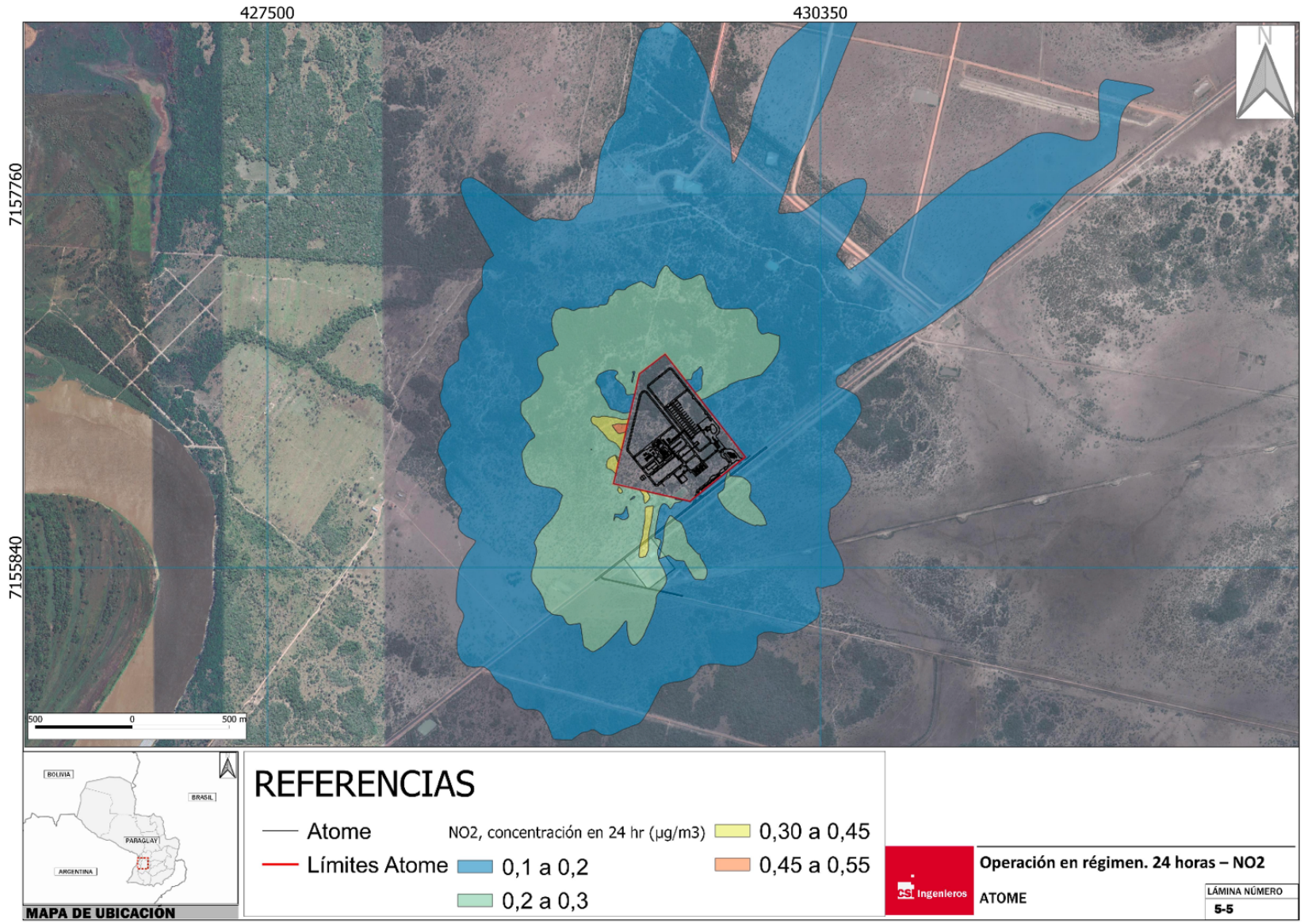
Map 5-3 Isoconcentration curves. Operation in regime. 24 Hours – CO



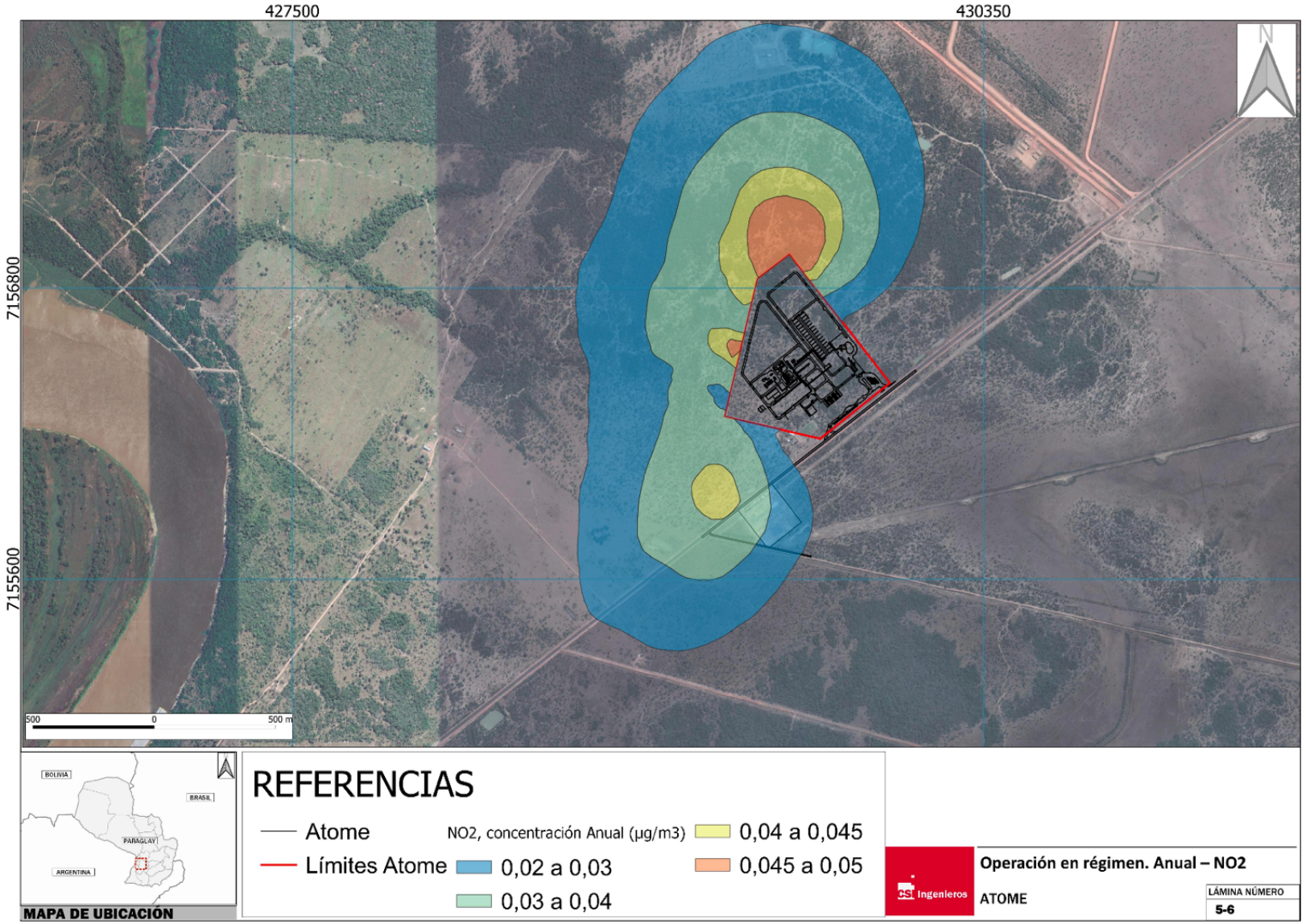
Map 5-4 Isoconcentration curves. Operation in regime. 1 hour – NO_2



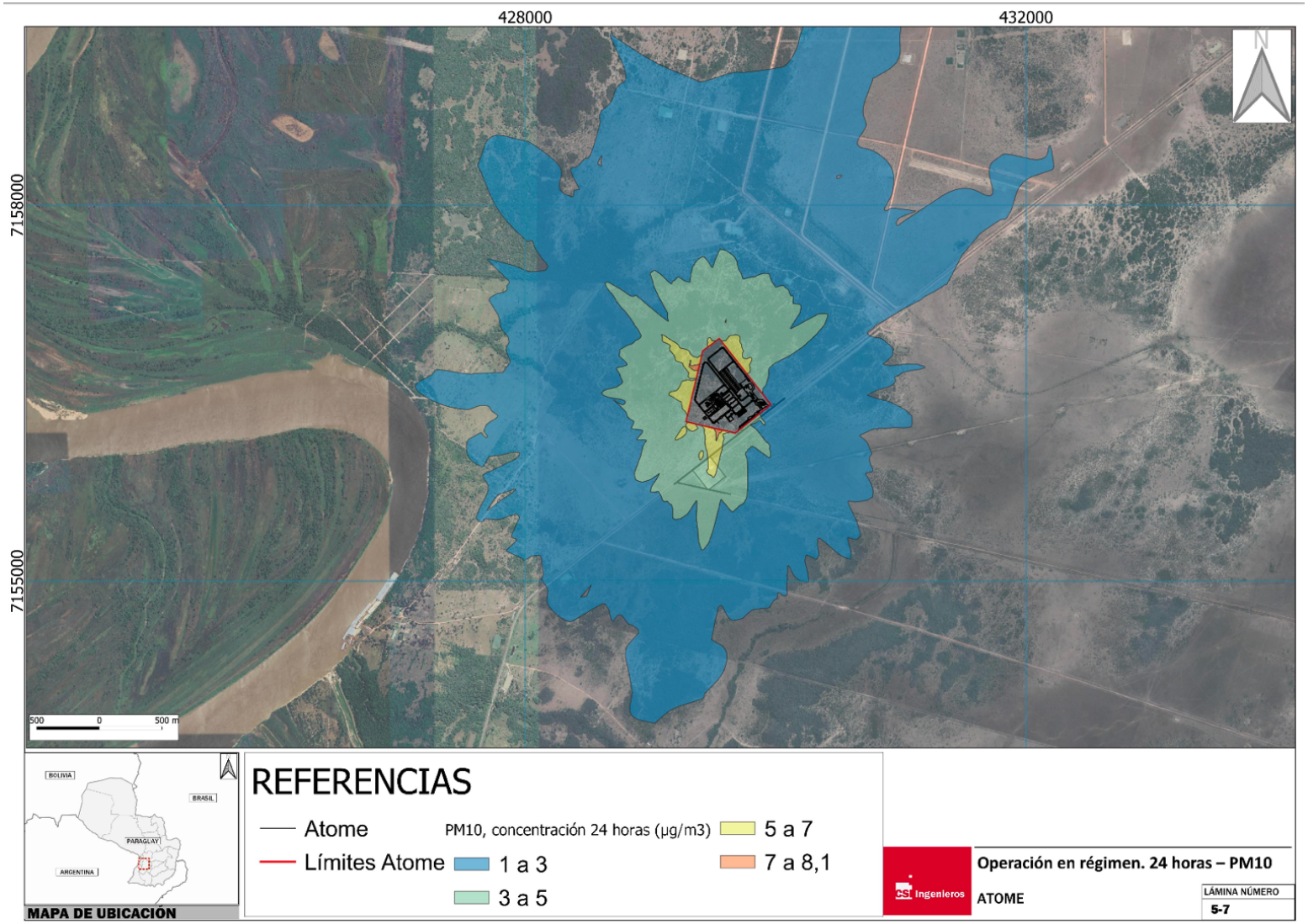
Map 5-5 Isoconcentration curves. Operation in regime. 24 hours – NO_2



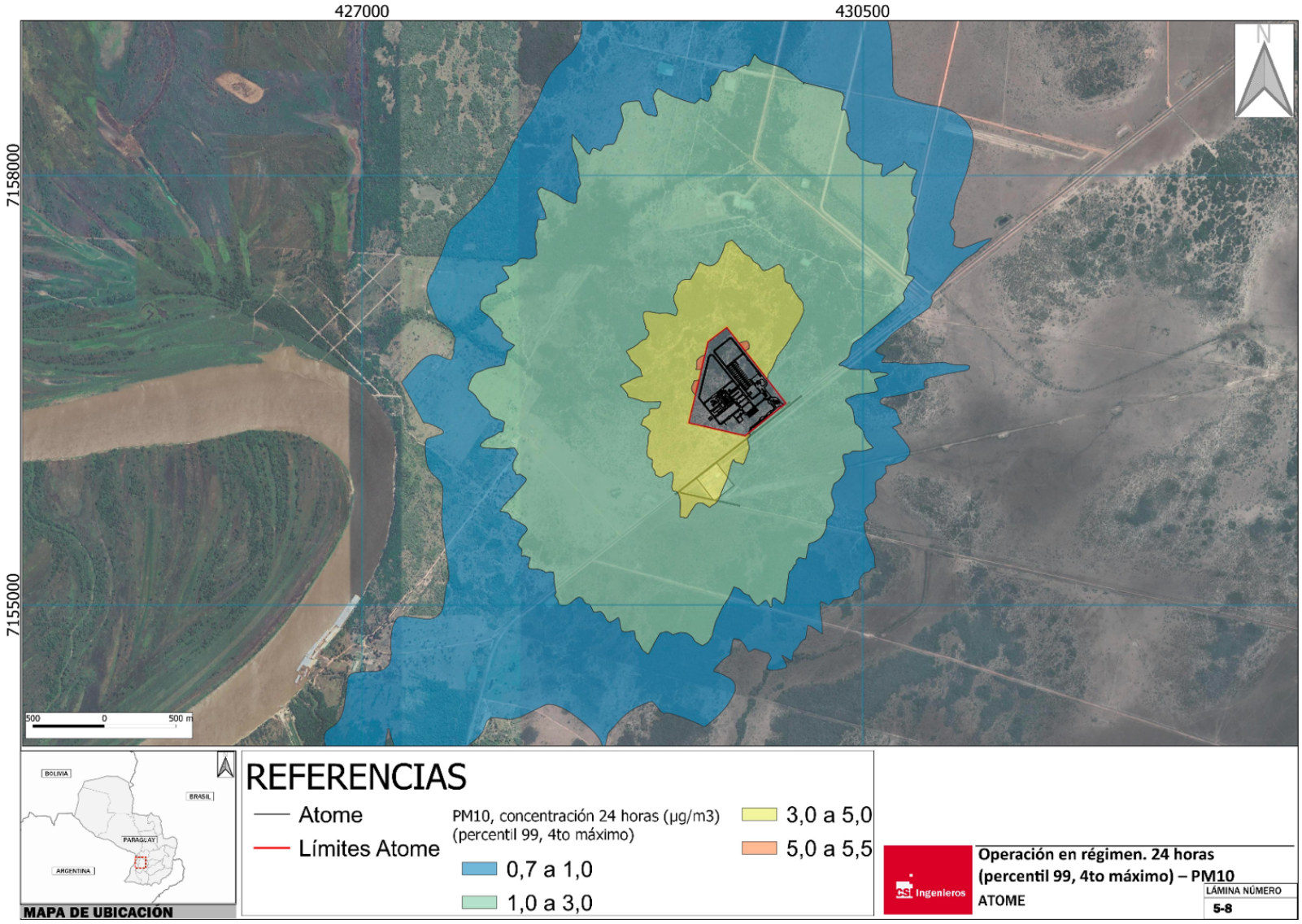
Map 5-6 Isoconcentration curves. Operation in regime. Yearly – NO_2



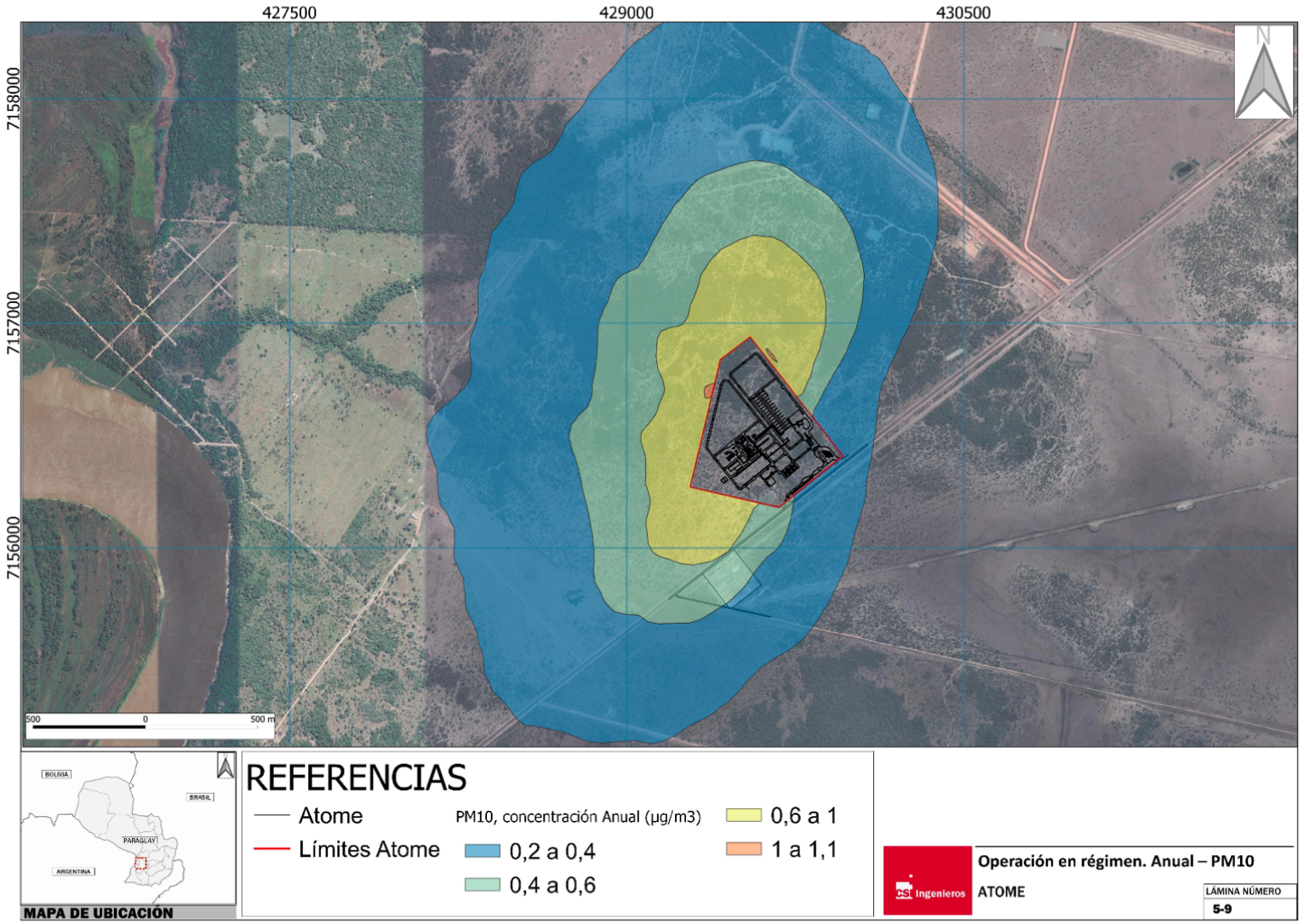
Map 5-7 Isoconcentration curves. Operation in regime. 24 hours – PM_{10}



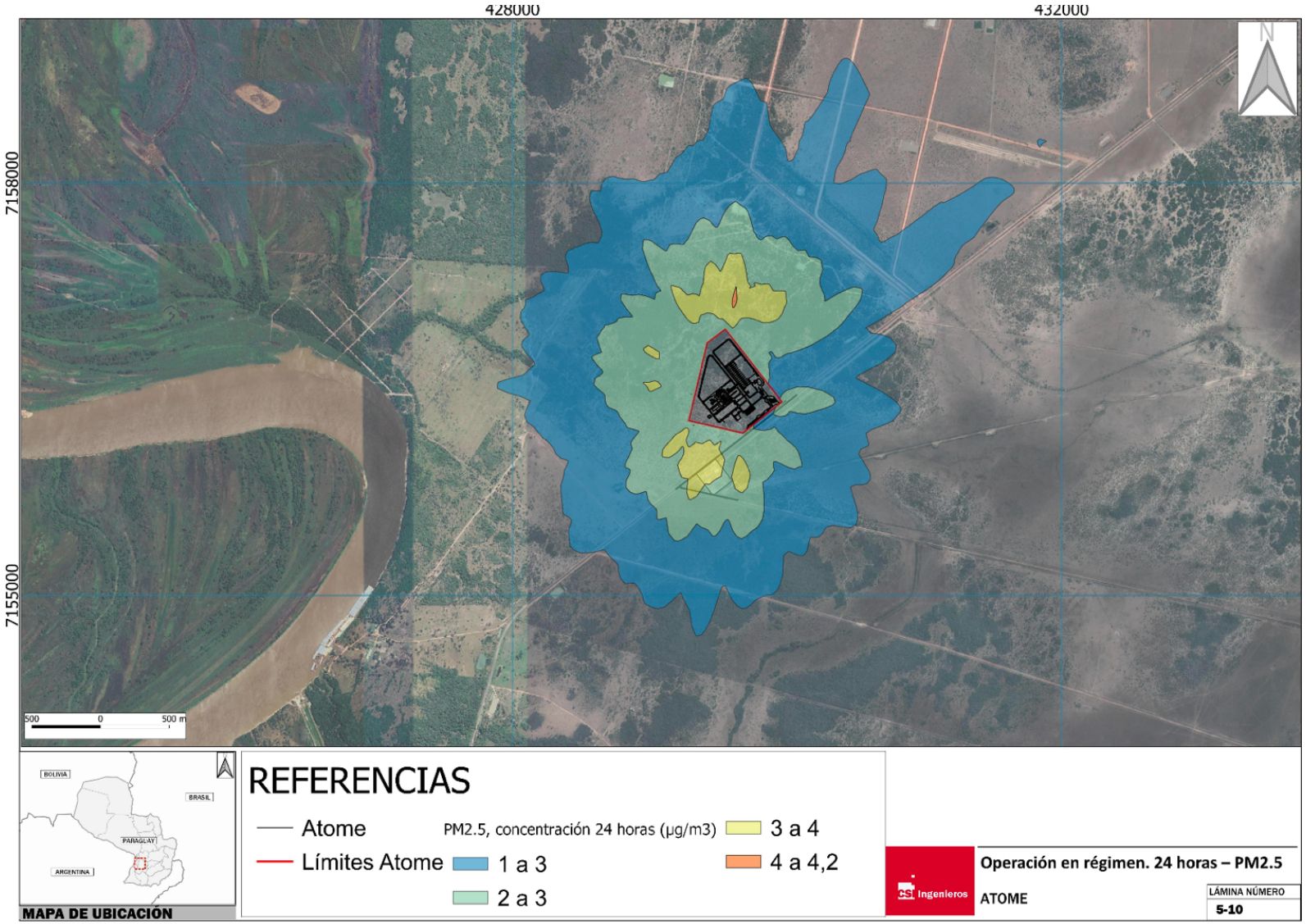
Map 5-8 Isoconcentration curves. Operation in regime. 24 hours (99th percentile, 4^{To} maximum) – PM10



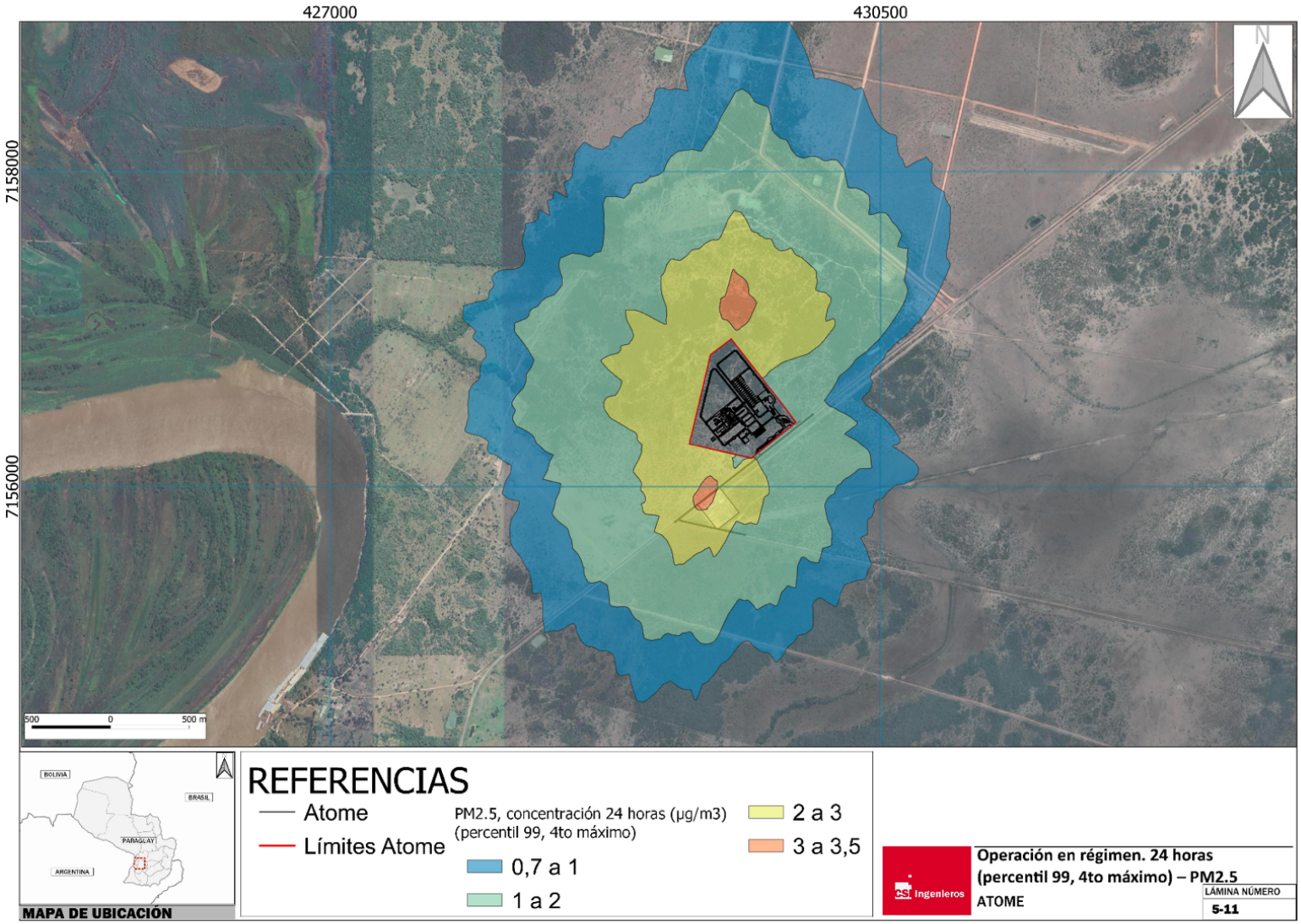
Map 5-9 Isoconcentration curves. Operation in regime. Annual – PM_{10}



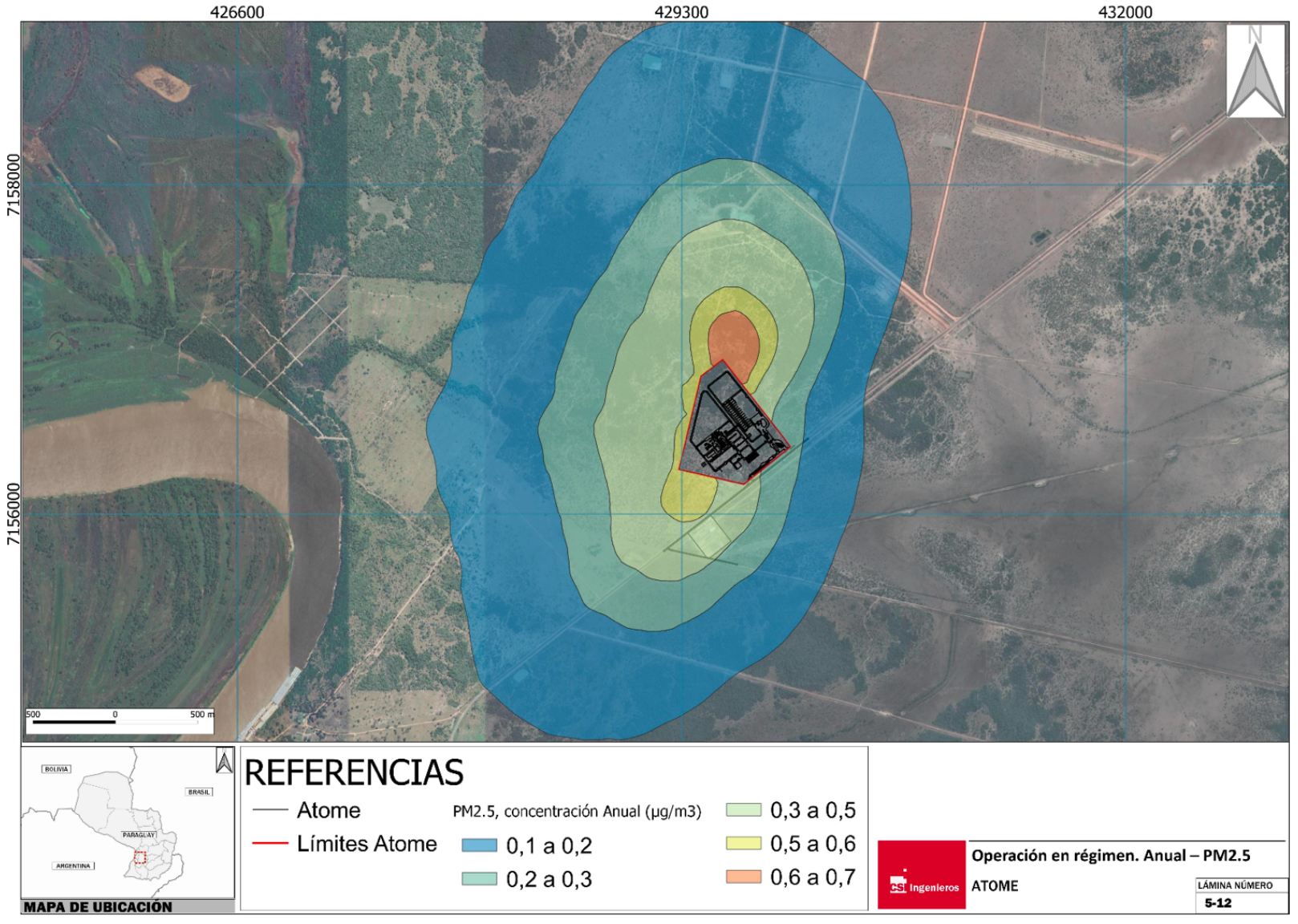
Map 5-10 Isoconcentration curves. Operation in regime. 24 hours – $PM_{2.5}$



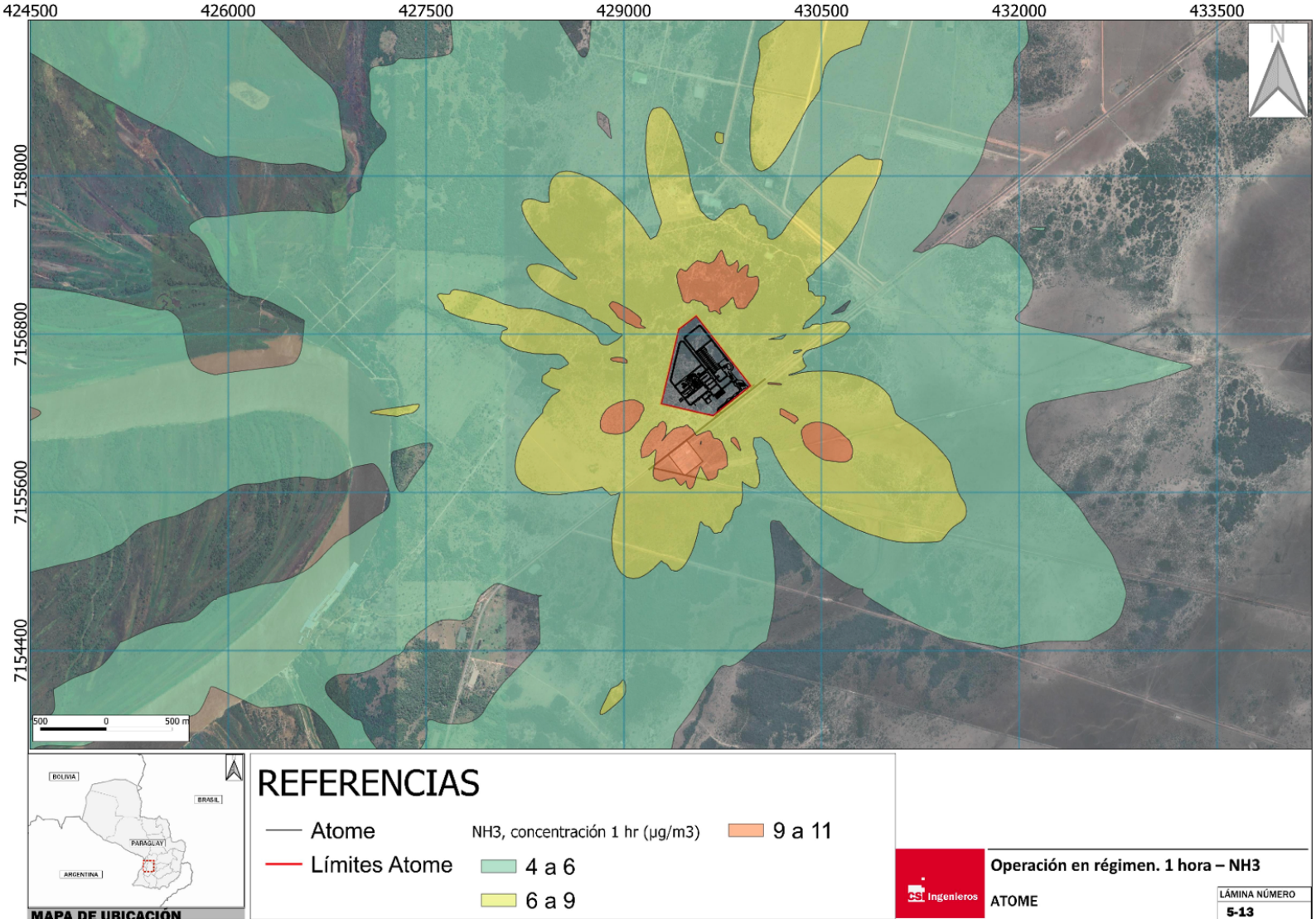
Map 5-11 Isoconcentration curves. Operation in regime. 24 hours (99th percentile, 4^{To} maximum) – PM2.5



Map 5-12 Isoconcentration curves. Operation in regime. Annual – $PM_{2.5}$



Map 5-13 Isoconcentration curves. Operation in regime. 1 hour – NH_3



6. Conclusions

An evaluation was carried out of the potential impact on air quality resulting from the operation of the ATOME green hydrogen, ammonia, and fertiliser production plant under normal operating conditions. Compliance with the objective quality values included in national legislation, Argentine legislation to analyse transboundary impacts, and international guidelines were examined. A mathematical simulation of the dispersion of pollutants CO, NO2, PM10, PM2.5 and NH3 was carried out using the AERMOD model, and ATOME provided the characterisation of the baseline. It included the survey of the parameters PTS, PM10, PM2.5, SO2, CO, CO2, O3 and NO2.

The results obtained during normal operation in regime (continuous operation) foresee that the future air quality (project in regime + baseline) will comply with all the objective quality values stipulated in the national, Argentine, and IFC guidelines for all parameters and all short-term integration periods considered. Although the baseline characterisation for annual periods is lacking, it is expected with reasonable certainty that the annual target quality values will not be exceeded. However, the characterisation of the current situation (baseline) is recommended to be strengthened mainly for the annual period to reinforce the conclusions reached.

About the NH3 parameter, the target quality value considered is not expected to be exceeded (Ontario, Canadian regulations).

ANNEX I
BASELINE RESULTS

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Aër Gestão Ambiental	**ENVIRONMENTAL DIAGNOSIS AIR QUALITY MONITORING** **ATOME PROJECT - PARAGUAY** **JGP CONSULTANCY** **JUNE / 2023**	acoem Creating environments of possibility

INTERNAL NO.	REVIEW	PAGE	TYPE OF AUDITS:	
			A- Data processing	**B** - Elaboration
AER-RTAMB-001/23	00	1/1	**C** - Revision/Formatting	**D** - Meteorology
			E - Approval	**F** - Validation

REVIEW	TYPE OF AUDIT	DESCRIPTION	BY	DATE
00	**A**	Data processing	Jurandir R. Brito	03/06/2023
00	**B**	Elaboration	Jurandir R. Brito	04/06/2023
00	**C**	Proofreading / Formatting	Jurandir R. Brito	05/06/2023
00	**D**	Meteorology	Silvio de Oliveira	05/06/2023
00	**E**	Approval	Jurandir R. Brito	05/06/2023
00	**F**	Validation	Nicolas Isnard	05/06/2023

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ATOME

Environmental Diagnosis / Physical Environment Air Quality Monitoring PROJECT ATOME / PARAGUAY

June 2023

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*1 - Parameter legislated in Paraguay - Resolution Nº259/15

1. SYNOPSIS

The synopsis presents a diagnosis of the meteorological conditions and air quality in the area where ATOME's Green Hydrogen production unit will be located.

In addition, the aim is to explain the complex interrelationship between emissions, the behaviour of atmospheric variables and the possible effects of the synergy of these factors on the air quality of the area assessed.

Meteorology and Air Pollutant Dispersion

Meteorological conditions affect a given location and result in various processes that act on different scales, influenced by atmospheric variables, which interact directly with the circulation, transport and dilution of pollutants in the atmosphere. The key variables for environmental monitoring are wind direction and speed, as well as topography and the presence of bodies of water.

During the monitoring period, the predominant winds were between the East-Northeast (ENE) and East-Southeast (ESE) quadrants, with the greatest predominance in the East (E) and East-Northeast (ENE) directions, between 25 and 30% in each direction, which together totalled approximately 60% of the predominant wind. The average wind speed was 0.51m/s, with the highest wind speed, 4.49m/s, occurring on 22 May 2023. The average temperature was 20.30ºC and the maximum was 31.27ºC, the average humidity was 81.25% and the average pressure was 758mmHg.

The air quality index remained at **"Good"** quality throughout the monitoring period. The environmental levels of the atmospheric pollutants monitored, in accordance with the air quality standards established by Resolution Nº259/2015 of the Paraguay Environment Secretariat and the WHO 2021 Global Air Quality Guidelines, were always below the standards.

This corroborates the fundamental aspect of this report: identifying background concentrations in the area of the future Green Hydrogen plant.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

2. OBJECTIVES / LOCATION

The general aim of this report is to present the results obtained from monitoring air quality at the sampling point defined by JGP Consultoria, located in Villeta, 35 kilometres from the capital Asunción, Paraguay. This point is located approximately 3.5 kilometres from the Puerto Sara industrial complex.

The specific objective of this report is to assess the levels of background values, which are representative values of pre-anthropogenic environmental quality, i.e. before the implementation of the project, in this case the Green Hydrogen production unit to be implemented in Villeta, Paraguay by ATOME, a project subject to an Environmental Impact Assessment (EIA).

The minimum sampling period established was 18 continuous and uninterrupted days.

Table 1 - Location of the sampling point

Description	**Coordinates in decimal degrees**
Point located on the Ruta Viilleta-Alberdi (Vila Alberdi Route) in front of the Subestacion Buey Rodeo (Buey Rodeo Sub-station). In the area where ATOME's future Green Hydrogen Plant will be installed.	Latitude - **-25.709654º** Longitude **-57.702060º**
Equipment installation date	**Demobilisation of equipment**
11 May 2023 at 17:00 hs.	03 June 2023.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

Image 1- Location of the development



Photos



Figure 1 - View of KUNAK from the north



Figure 2 - View of KUNAK from the south



Figure 3 - View of KUNAK in an easterly



directionFigure 4 - View of KUNAK in a westerly direction

*1 - Parameter legislated in Paraguay - Resolution Nº259/15

3. LIST OF ABBREVIATIONS AND ACRONYMS

- AQG - Global Air Quality Guidelines
- NH_3 - Ammonia
- CO - Carbon Monoxide
- CO_2 - Carbon Dioxide
- ENE - East-Northeast
- EPA - Environmental Protection - Agency
- ESE - East-southeast
- H_2 - Hydrogen
- IQAR - Air Quality Index
- E - East
- PM - Particulate Matter
- N - North
- NE - North-East
- NNE - North-Northeast
- NNO - North-north-west
- NO - North-West
- NO_2 - Nitrogen Dioxide
- O - West
- O_3 - Ozone
- WHO - World Health Organisation
- ONO - west-north-west
- OSO - west-south-west
- PM_{10} - Inhalable material with an equivalent diameter of 10µm
- $PM_{2.5}$ - Inhalable material with an equivalent diameter of 2.5µm
- PTS - Total Suspended Particles with an equivalent diameter of 100µm
- S - South
- SE - South East
- SEAM - Secretariat of the Environment of Paraguay
- SO - South-west
- SO_2 - Sulphur dioxide
- SSE - south-southeast
- SSO - south-south-west
- WHO - World Health Organisation

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

4. WEATHER CONDITIONS

Villeta is geographically located at a latitude where rainfall is most intense from January to April and least intense from June to August, according to the document: The climate of Villeta (Paraguay), https://es.wikipedia.org/wiki /Villeta (Paraguay). The climate in the Villeta region is moderate and humid. The maximum temperature in summer is 40°C, which is sometimes exceeded. The minimum in winter is 0°C and the average is 30°C.

The climate of the Villeta region as a whole is divided into three types of climate:

a) Humid subtropical in the southern part of the eastern region;
b) Tropical savannah in the west and north of the east;
c) Hot semi-arid climate in the north-west of the Chaco.

According to the Köppen climate classification. The average annual temperature in the region fluctuates between 20 ºC and 25 ºC. Although rainfall is common throughout most of the territory, the amount of 1,400mm varies depending on the region in question, although summer is the season with the highest frequency of rainfall.

During the monitoring period, the predominant winds were between the East-Northeast (ENE) and East-Southeast (ESE) quadrants, with the greatest predominance in the East (E) and East-Northeast (ENE) directions, between 25 and 30 per cent in each direction, which together total approximately 60 per cent of the predominant wind.

The average wind speed was 0.51m/s, with the highest wind speed being 4.49m/s on 22 May 2023, and periods of calm always occurred at night and in the early hours of the morning. The average temperature was 20.3ºC and the maximum was 31.27ºC, the average relative humidity was 81.25% and the average atmospheric pressure was 758mmHg. Annex 12.10 - "Meteorological Parameters" shows instantaneous graphs of the parameters measured.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

5. PARAMETERS SAMPLED / METHODOLOGY USED

The parameters defined for monitoring by JGP Consultoria were:

- ✓ Particulate Material
  - Total Particles (PTS)
  - Inhalable particles (PM_{10})
  - Inhalable particles ($PM_{2.5}$)
- ✓ Sulphur dioxide (SO_2);
- ✓ Carbon monoxide (CO);
- ✓ Carbon dioxide (CO_2);
- ✓ Ozone (O_3);
- ✓ Nitrogen dioxide (NO_2).

A **"KUNAK AIR PRO"** Air Quality Monitoring Station was installed to monitor the requested parameters.

This methodology is being widely used in Europe and has been applied in Latin America (Brazil and Paraguay) - *https://kunakair.com/case-studies/*

The "**KUNAK AIR PRO**" monitoring system has the following features:

- ❖ Autonomous pollutant monitoring station and meteorological parameters integrated in the same equipment;
- ❖ Electrochemical sensors for measuring gaseous compounds: Nitrogen Dioxide (NO_2); Ozone (O_3); Sulphur Dioxide (SO_2) and Carbon Monoxide (CO);
- ❖ Integrated non-dispersive infrared sensor (NDIR) to measure the gaseous parameter Carbon Dioxide (CO_2)
- ❖ Optical particle counter for measuring Particulate Matter ($PM_{2.5}$, PM_{10} and PTS)
- ❖ Integrated meteorological sensors: ambient temperature, relative humidity, atmospheric pressure, as well as wind speed and direction;
- ❖ Cloud data storage and management;
- ❖ Power supply via solar panel;
- ❖ Communication via 3G/4G, using a conventional data chip.
- ❖ Management platform for advanced statistical analysis and calculation of the Air Quality Index.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

Photo of the Air Quality Monitoring Station - **KUNAK AIR PRO**



Figure 5 - View of the gaseous



cartridgesFigure 6 - Front view - OPC

5.1. PRINCIPLES OF MEASUREMENT

5.1.1. Particulate Material

For monitoring Particulate Matter this equipment uses the "laser scattering" measurement principle, which consists of an Optical Particle Counter (OPC) capable of measuring particles from 0.3 µm up to 40 µm. where the particles PTS, PM1, PM2.5 PM4 and PM10 are measured and calculated assuming a particle density profile.

5.1.2. Pollutants gaseous

To monitor the gaseous parameters, this equipment uses cartridges mostly with electrochemical sensors, using nano technology and algorithms to correct interferents, and improve the precision and selectivity of the equipment.

- ✓ For the SO_2 parameter - A built-in electrochemical sensor (cartridge) is used which has high cross-sensitivities with O_3 and NO_2. When used in conjunction with the NO_2 and O_3 cartridges, the Kunak algorithm is able to correct these cross-sensitivities, improving the accuracy of the measurements.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

- ✓ For the CO parameter - It uses a cartridge with an integrated electrochemical sensor with noise electronics allowing concentrations to be read in two measurement ranges: Type A - Very low concentrations (ppb) down to several ppm, and Type B - Higher range concentrations that can measure up to 500 ppm. This cartridge is very stable over time with a service life that can go beyond what is specified.
- ✓ For the CO_2 parameter - Uses a cartridge with an integrated non-dispersive infrared sensor (NDIR) ideal for measuring low to high concentrations that can be found in the atmosphere. In addition, it includes an automatic baseline calibration to maintain long-term stability now with the effect of humidity, temperature and pressure, which are corrected in the algorithm.
- ✓ For the O_3 parameter - The ozone cartridge has an integrated electrochemical sensor that detects NO_2 and O_3 concentrations. That's why, in order to accurately measure the O_3 concentration, it needs to be installed in conjunction with the NO_2 cartridge. Thus, thanks to the Kunak algorithm, it is possible to provide accurate ozone measurements, without the influence of NO_2, even at high temperatures which are related to the higher concentration of O_3 due to solar radiation.
- ✓ For the NO_2 parameter - The cartridge has an integrated electrochemical sensor, with an inbuilt ozone filter, to correct for interference from this pollutant (ozone), making the cartridge ideal for measuring concentrations found in the atmosphere, from very low levels in clean environments to high concentrations in polluted areas of cities or industries.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

✓

Table 2 - KUNAK AIR PRO technical specifications

KUNAK AIR PRO				
Parameters	**Measurement unit**	**Measuring Range**	**Resolution**	**Limit of Detection**
CO	µg/m³. ppb	0-12,000 ppb(A) 0-500 ppm(B)	1 ppb(A) 0.1 ppm(B)	10 ppb
CO_2	µg/m³. ppm	0-5,000 ppm	1 ppm	
NO_2	µg/m³. ppb	0-5,000 ppb	1 ppb	2 ppb
O_3	µg/m³. ppb	0-2,000 ppb	1 ppb	2 ppb
SO_2	µg/m³. ppb	0-10,000 ppb	1 ppb	5 ppb
PTS	µg/m³	0 - 15,000 µg/m³	1 µg/m³	-
$PM2_{.5}$	µg/m³	0 - 1,500 µg/m³	1 µg/m³	
PM_{10}	µg/m³	0 - 2,000 µg/m³	1 µg/m³	

5.2. OTHER PARAMETERS MEASURED

In addition to the parameters defined for monitoring by JGP Consultoria, the following parameters were also measured:

- ✓ Air Quality Index (IQA) - Dimensional
- ✓ Condensation Point - ºC
- ✓ Humidity - %
- ✓ Inhalable Particle PM1 - µg/m³
- ✓ Inhalable Particle PM4 - µg/m³
- ✓ Atmospheric Pressure - hPa
- ✓ External Temperature - ºC
- ✓ Wind Speed - Average - m/s
- ✓ Wind Speed - Maximum - m/s
- ✓ Wind Direction - Deg

6. AIR POLLUTION / EMISSION SOURCES / HEALTH EFFECTS

Air pollution is associated with atmospheric emissions in urban areas with heavy traffic, industrial areas, areas of agricultural and livestock activities, and areas of

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

mining, but also related to natural phenomena such as forest fires and volcanoes

The main effects on human health are

- Particulate Matter (PM) - PM is a common indicator of air pollution. There is strong evidence of the negative health impacts associated with exposure to this pollutant. The main components of PM are sulphates, nitrates, ammonia, sodium chloride, black coal, mineral dust and water.
- Carbon monoxide (CO) - Carbon monoxide is a colourless, odourless and tasteless toxic gas produced by the incomplete combustion of carbon fuels such as wood, petrol, charcoal, natural gas and paraffin.
- Ozone (O_3) - Ground-level ozone, not to be confused with the ozone layer in the upper atmosphere, is one of the main constituents of photochemical smog and is formed by the reaction with gases in the presence of sunlight.
- Nitrogen dioxide (NO_2) - NO_2 is a gas commonly released from the combustion of fuels in the transport and industrial sectors.
- Sulphur dioxide (SO_2) - SO_2 is a colourless gas with a strong odour. It is produced by burning fossil fuels (coal and oil) and smelting sulphur-containing ores.

7. APPLIED LEGISLATION

The values obtained for the requested parameters were compared to the air quality standards established by Resolution Nº259/2015 of the Secretariat of the Environment of Paraguay (SEAM). They were also compared with the WHO Global air quality guidelines (AQG), as last updated in 2021.

The WHO's global air quality guidelines (AQG) provide global guidance on thresholds and limits for the main air pollutants that pose health risks. These guidelines are of high methodological quality and are developed through a transparent, evidence-based decision-making process.

In addition to reference values, the WHO's global air quality guidelines provide interim targets to promote a gradual shift from high to low concentrations. These guidelines are not legally binding standards; however, they provide countries with an evidence-based tool that can be used to inform and support the definition of air quality policies and the development of standards, clean air policies and other tools for air quality management.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

POLUENTE	TEMPO MÉDIO	PARAGUAY Resolución Nº259/2015 03/07/15 (µg/m³)	WHO 2021 µg/m³
$PM_{2.5}$	24 horas	30	15
PM_{10}	24 horas	150	45
O_3	8 horas	120	100
NO_2	24 horas	-	25
	1 hora	200	-
SO_2	24 horas	20	40
CO	24 horas	-	4.000
	8 horas	10.000	-

Table 1 - Comparative table of standards from Resolution Nº259/15 and WHO Global air quality guidelines/2021

Air Quality Index (AQI) - This index is a dimensionless numerical value that has been widely used by the US Environmental Agency (EPA) since the early 1980s, created with the aim of easily presenting information about the air quality of a given location to the population.

This index is a daily report in which air quality is classified based on the concentrations of pollutants recorded during the period into five different levels, ranging from good to very bad, and which portray the risks and adverse effects on health that the population is exposed to.

In Paraguay, this index has been used according to EPA standards since 2019.

The KUNAKCLOUD platform automatically calculates the IQA, the IQA calculations for all the legislated parameters presented in this report have been configured for AQI USEPA LAYER.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

EPA - Environmental Pr Agency	IQA	CONTENTS	POLLUTANTS							
			MP_{10} (µg/m³) 24 hours	$MP2_{.5}$ (µg/m³) 24 hours	O_3 (µg/m³) 1 hour	O_3 (µg/m³) 8 hours	CO (ppm) 8 hours	NO_2 (µg/m³) 1 hour	SO_2 (µg/m³) 1 hour	SO_2 (µg/m³) 24 hours
	Good	0 - 50	0 - 54	0 - 12	-	0 - 108	0 - 5038	0 - 99,6	0 - 91,7	-
	Moderate	51 - 100	55 - 154	12 - 35	-	109 - 140	5039 - 10763	99 - 188	91 - 196	-
	Unhealthy for Sensitive Groups	100 - 150	155 - 254	36 - 55	250 - 328	140 - 210	10764 - 14198	189 - 676	197 - 484	-
	Unhealthy	150 - 200	255 - 354	56 - 150	329 - 408	211 - 400	14199 - 17633	677 - 1220	485 - 796	-
	Very Unhealthy	201 300	355 - 424	151 - 250	409 - 808	-	17633 - 34808	1221 - 2348	-	799 - 1582
	Hazardous	301 500	425 - 604	251 - 500	809 - 1208	-	34809 - 57708	2349 - 3852	-	1583 - 2631

Table 2 - USEPA IQA

8. ANALYSING RESULTS

The results obtained from the air quality monitoring campaign, background values, carried out in the area of the future Green Hydrogen production unit in Villeta, Paraguay, from 12 May 2023 to 2 June 2023, are presented in the form of dynamic graphs, pollution rose and AQI calendar graph, attached to this document.

The air quality index remained **"Good"** throughout the monitoring period, with dimensionless values between 0 and 50, see appendix 12.9 - Calendar Graph - Air Quality Index (AQI).

This value indicates that all the environmental levels of the air pollutants monitored were always below the air quality standards established by the USEPA, since the index was calculated for this institution.

And as can be seen in Annexes 12.1 to 12.8, the environmental levels of monitored and legislated air pollutants were always below the air quality standards established by Resolution Nº259/2015 of the Paraguayan Environment Secretariat and the WHO 2021 Global Air Quality Guidelines.

This corroborates the fundamental aspect of this report: identifying background concentrations in the area of the future Green Hydrogen plant.

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

Table 3 shows the average, maximum and minimum values of the **instantaneous results** obtained during the monitoring campaign

Table 3 - Instantaneous pollutant values

Resultados "Instantâneos" do Monitoramento da Qualidade do Ar do periodo monitorado						Padrões de Qualidade do Ar			
Poluentes	Unidade	Valor Máximo *2	Valor Médio *1	Valor Mínimo	Desvio Padrão	SEAM (2015)	Tempo Médio	WHO (2021)	Tempo Médio
$PM_{2.5}$	µg/m³	94,54	5,06	0,32	6,30	30	24 hs	15	24 hs
PM_{10}	µg/m³	135,58	8,82	0,60	9,16	150	24 hs	45	24 hs
PTS	µg/m³	280,96	12,27	0,61	14,62	-	-	-	-
SO_2	ppb	17,53	0,11	0,00	0,89	7,6	24 hs	15,3	24 hs
O_3	ppb	49,74	11,69	0,00	11,30	61	8 hs	51	8 hs
NO_2	ppb	14,27	0,46	0,00	1,47	106	1 h	13,3	24 hs
CO	ppm	0,67	0,24	0,03	76,18	8,7	8 hs	3,5	24 hs
CO_2	ppm	616,49	478,76	414,38	37,97	-	-	-	-

*1 - Valor Médio de todo periodo de amostragem (18 dias)

*2 - Valor Máximo - Pico, amostragens de 10 em 10 minutos

8.1. Dynamic graphics

a) PM2.5 - 24-hour average*1
b) PM10 - 24-hour average*1
c) PTS - 24-hour average
d) O3 - Average of 8 hours*1
e) NO2 - 1 hour average*1
f) NO2 - 24-hour average
g) SO2 - 24-hour average*1
h) CO - Average of 8 hours*1
i) CO - 24-hour average
j) CO2 - 24-hour average

8.2. Rosa from Pollution

The Pollution Rose shows the values obtained for the monitored pollutant and the prevailing wind direction at the time of monitoring.

a) PM 2.5 - 24-hour average*1
b) PM 10 - 24-hour average*1
c) PTS - 24-hour average

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

d) O_3 - Average of 8 hours*1
e) NO_2 - Average of 1 hour*1
f) SO_2 - 24-hour average*1
g) CO - Average of 8 hours*1

8.3. Calendar graphic AQI

The AQI calendar graph shows the values obtained for the Air Quality Index (USEPA) during the campaign for the legislated pollutants.

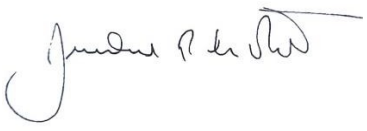
9. CONCLUSION

The results obtained in the campaign carried out in the area of ATOME's future Green Hydrogen plant were aimed at characterising the presence of pollutants and their dispersion in the area analysed. As can be seen, throughout the monitoring period, the index (IQA) widely used to easily present information on air quality, indicated **"Air Quality - GOOD"**, and the environmental levels of the atmospheric pollutants monitored were always below the air quality standards established by Resolution Nº259/2015 of the Paraguay Environment Secretariat and the WHO 2021 Global Air Quality Guidelines.

10. TEAM TECHNICAL

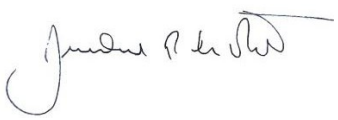
Data processing

✓ Jurandir R. Brito - Senior Consultant, Air Quality Specialist - CREA/BA 47634



Drafting / Proofreading / Formatting/Validation

✓ Jurandir R. Brito - Senior Consultant, Air Quality Specialist - CREA/BA 47634



***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

Preparation / Review / Formatting of meteorological data

✓ Meteorologist Silvio de Oliveira - MSc. CREA-SP Nº0600948501



11. BASE OF DATA

- KunakCloud
- World Health Organisation (2021). WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organisation. https://apps.who.int/iris/handle/10665/345329. Licence: CC BY-NC-SA 3.0 IGO
- Environmental, Health, and Safety Guidelines - General EHS Guidelines: Environmental - Air Emissions and Ambient Air Quality - IFC (International Finance Corporation)
- Guidelines for Ensuring and Maximising the Quality, Objectivity, Utility and Integrity of Information Disseminated by the EPA (Environmental Protection Agency).
- Resolution Nº259/2015 - Secretariat of the Environment - Paraguay.
- https://kunakair.com/case-studies/
- *Diagnosis of air pollution by nitrogen oxides in the city of Asunción Nuestra Señora de la Asunción Catholic University* https://www.researchgate.net/publication/289994180_Diagnostico_de_la_contaminacion_del_aire_por_oxidos_de_nitrogeno_en_la_ciudad_de_Asuncion

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

12. ANNEXES

12.1. $PM_{2.5}$ - Dynamic charts, Pollution Rose and Calendar chart.

12.2. PM_{10} - Dynamic charts, Pollution Rose and Calendar chart.

12.3. PTS - Dynamic Charts, Pollution Rose and Calendar Chart.

12.4. O_3 - Dynamic charts, Pollution Rose and Calendar chart.

12.5. NO_2 - Dynamic Charts, Pollution Rose and Calendar Chart.

12.6. SO_2 - Dynamic charts, Pollution Rose and Calendar chart.

12.7. CO - Dynamic Charts, Pollution Rose and Calendar Chart.

12.8. CO_2 - Dynamic charts, Pollution Rose and Calendar chart.

12.9. Calendar Chart - Air Quality Index (AQI).

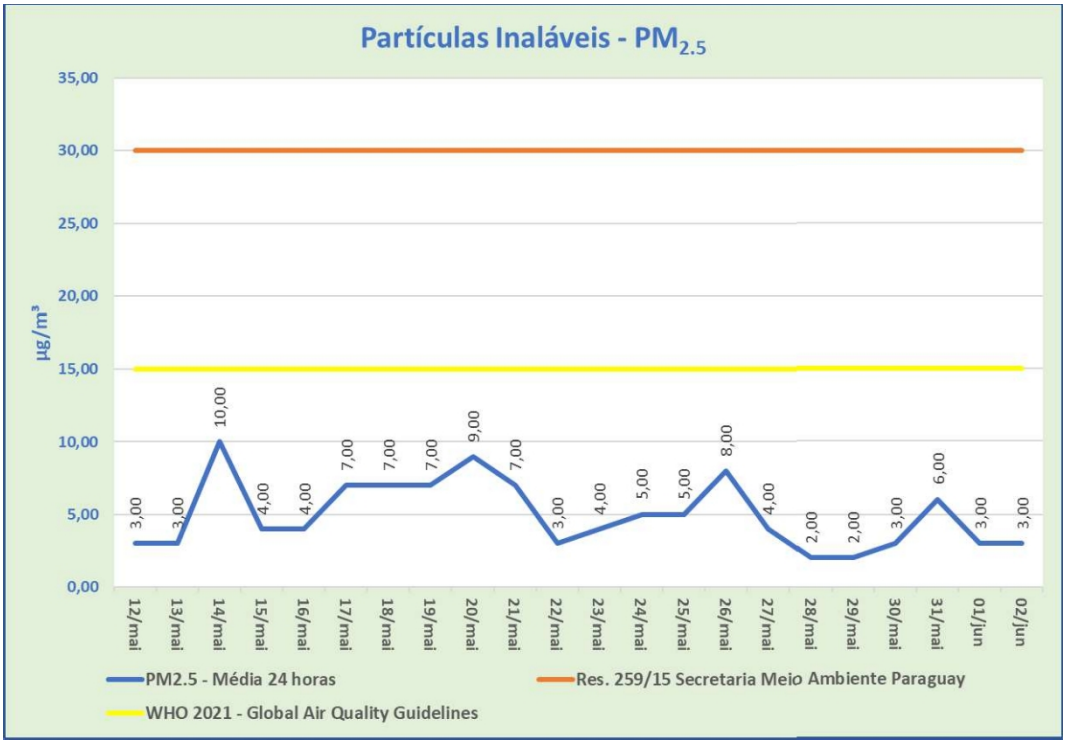
12.10. Meteorological parameters (WS, Humidity, Pressure and Temperature)

12.11. Sensor calibration certificates.

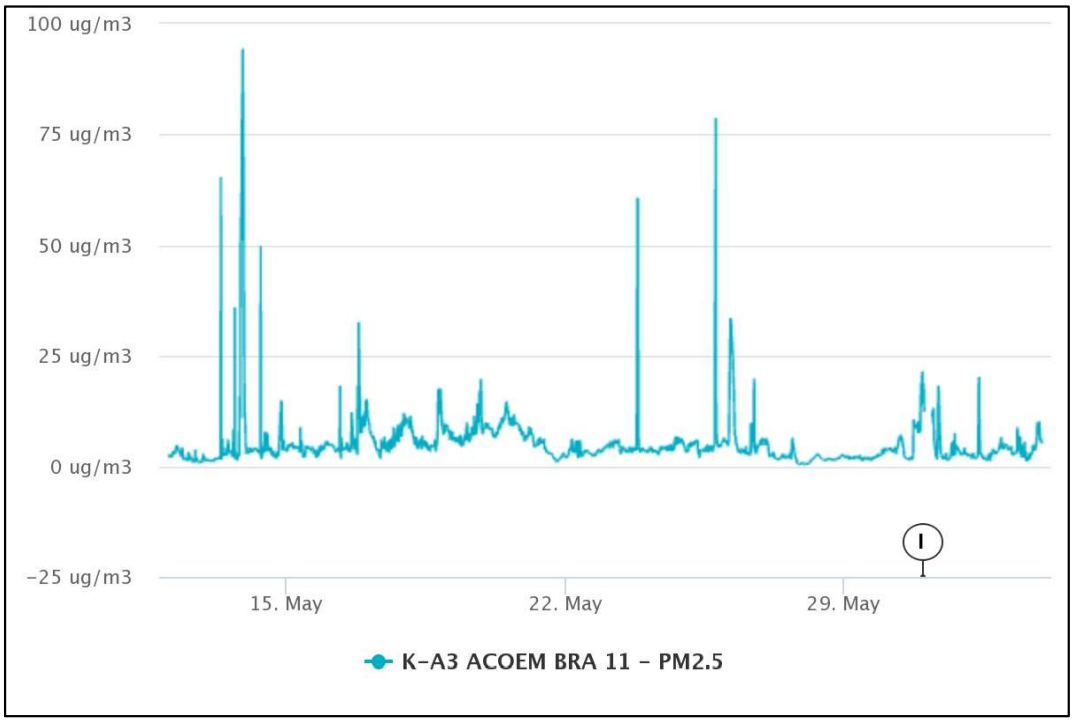
12.12. Technical Responsibility Certificate - ART

***1 - Parameter legislated in Paraguay - Resolution Nº259/15**

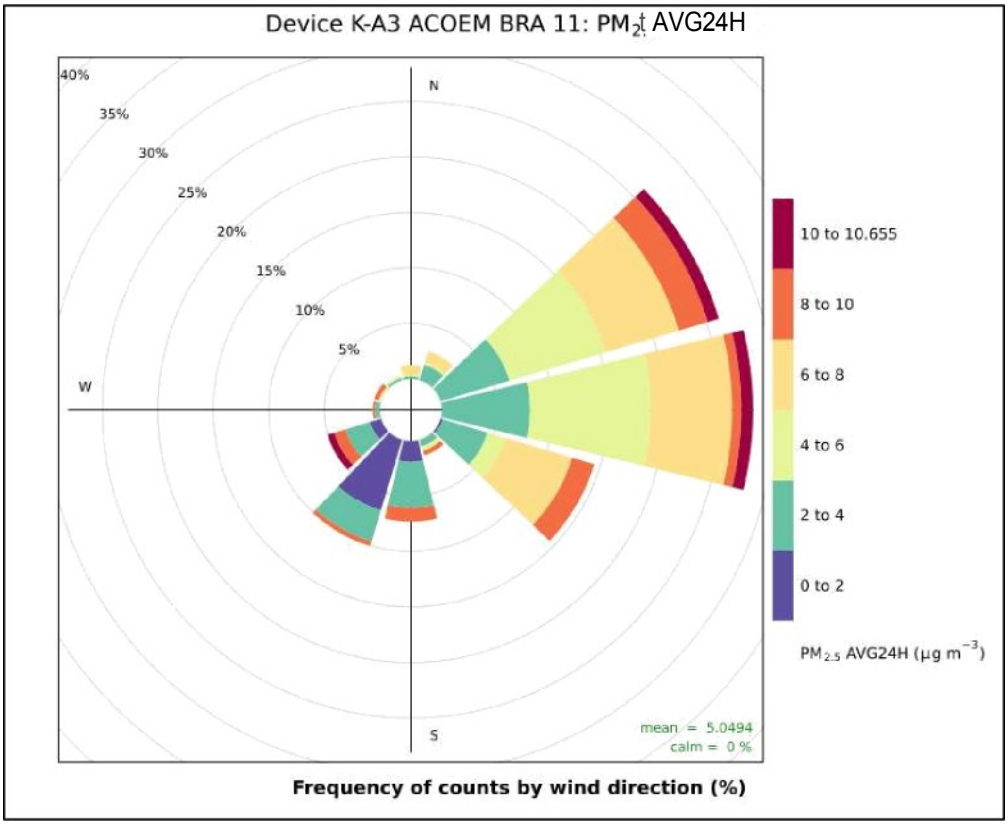
ANNEX 12.1 - $PM_{2.5}$– Dynamic graphs and Pollution Rose.



12.1.1 – Partícula Inalável $PM_{2.5}$ – Média 24 horas (µg/m³)

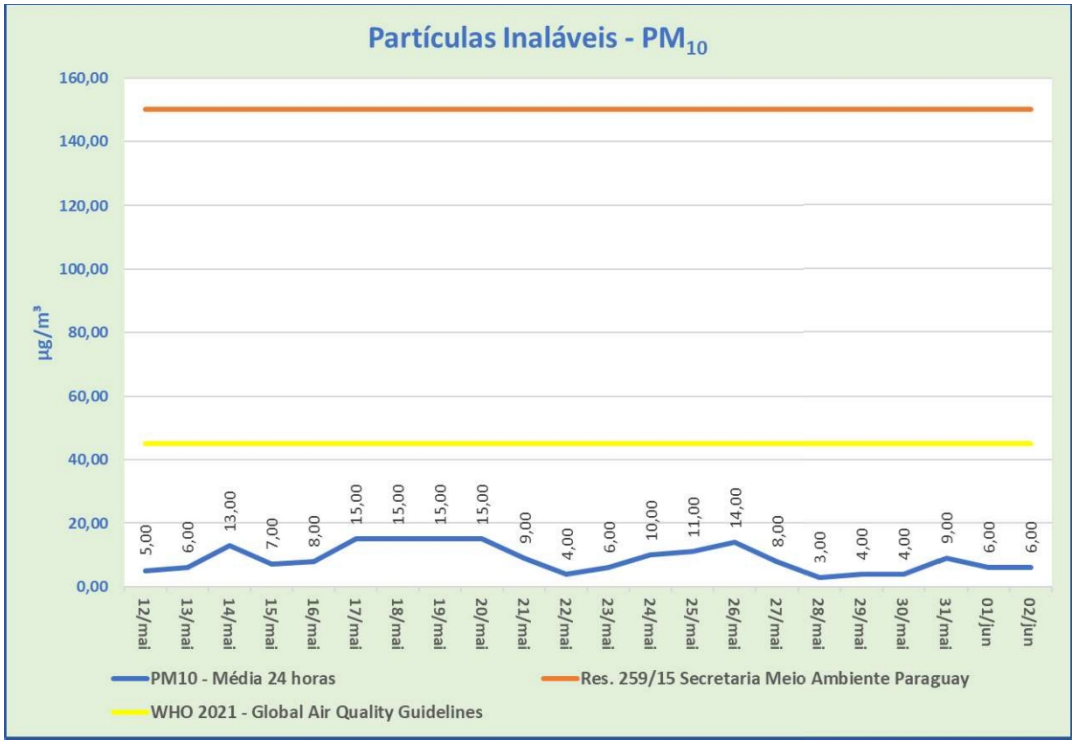


12.1.2 - Partícula Inalável $PM_{2.5}$ – Amostragem Instantânea (µg/m³)

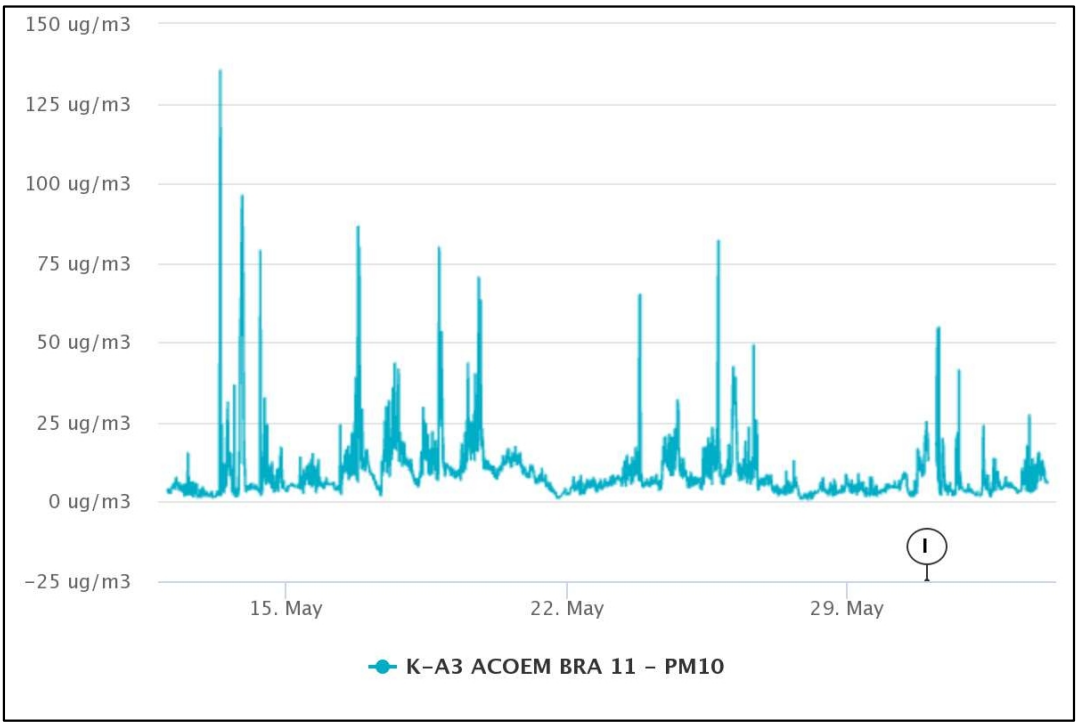


12.1.3 - Inhalable particle PME.s - 24 h average - Pollution Rose (pg/m°)

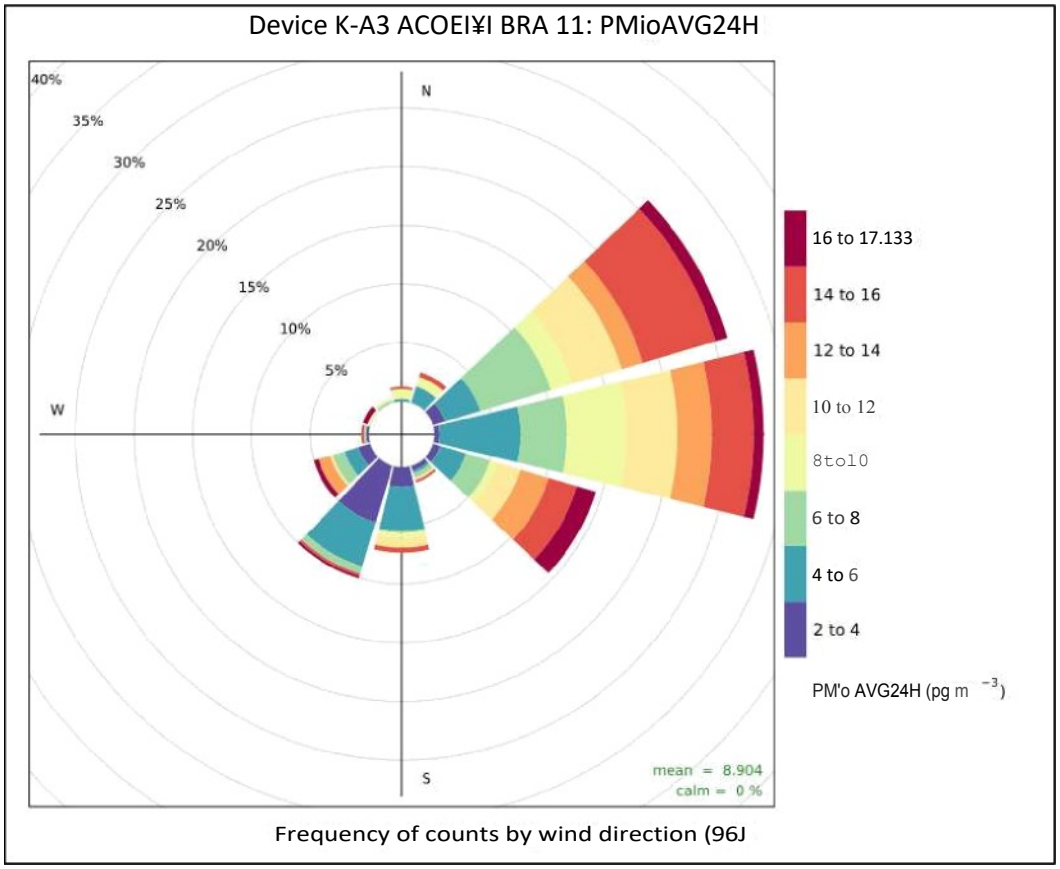
ANNEX 12.2– PM_{10}– Dynamic graphs and Pollution Rose.



12.2.1 – Partícula Inalável PM_{10} – Média 24 horas (µg/m³)

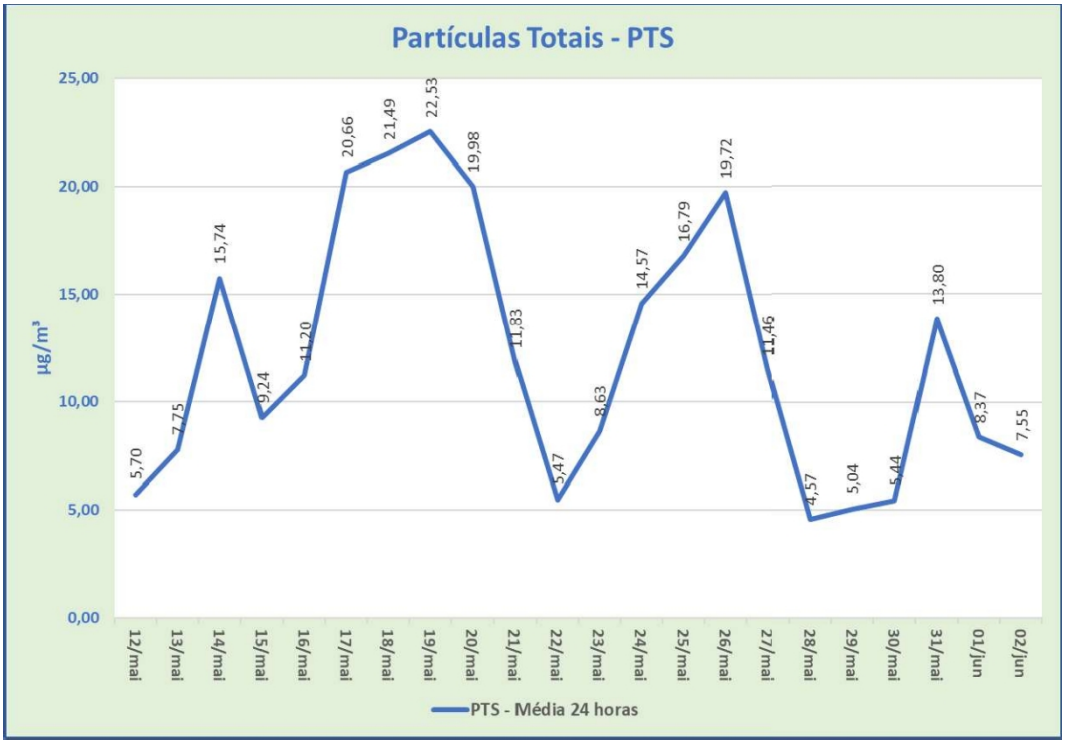


12.2.2 - Partícula Inalável PM_{10} – Amostragem Instantânea (µg/m³)

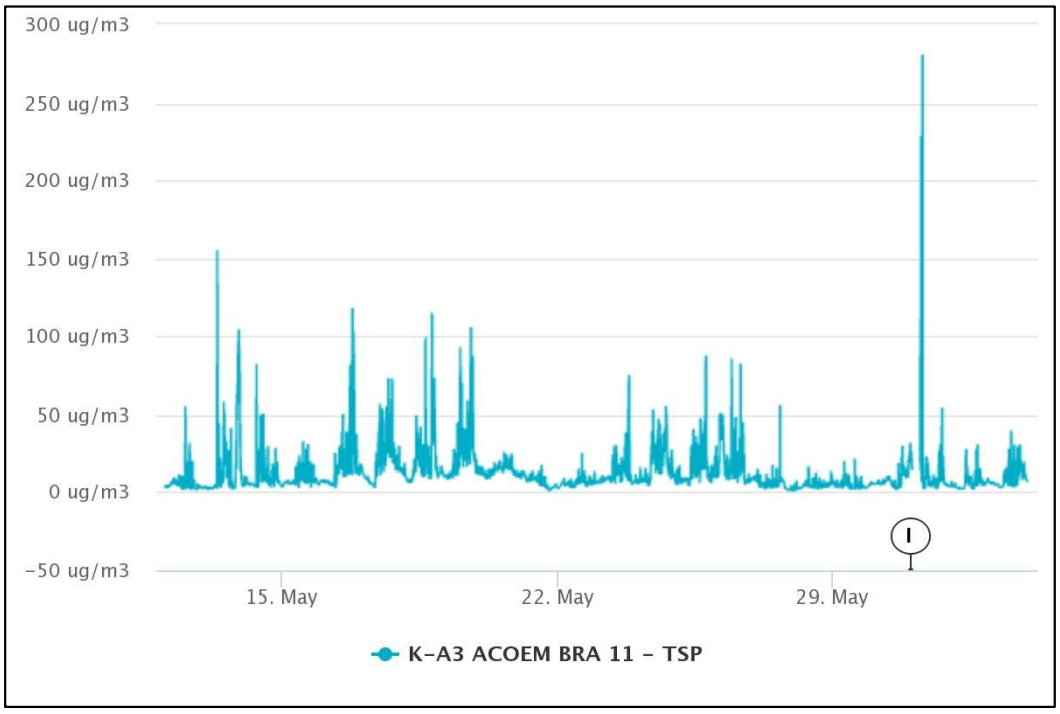


12.2.3 - Inhalable Particle PM10 - 24 h Average - Pollution Rose (pg/m)ª

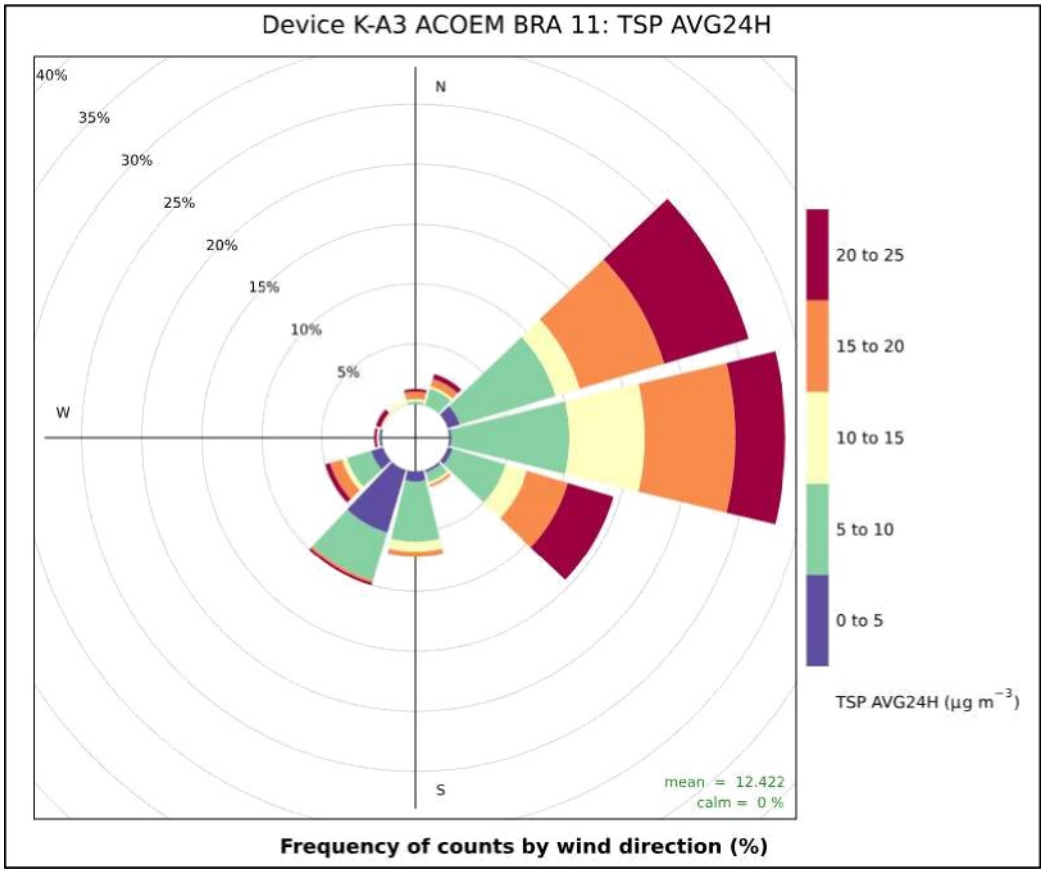
ANNEX 12.3– PTS– Dynamic graphics and Pollution Rose.



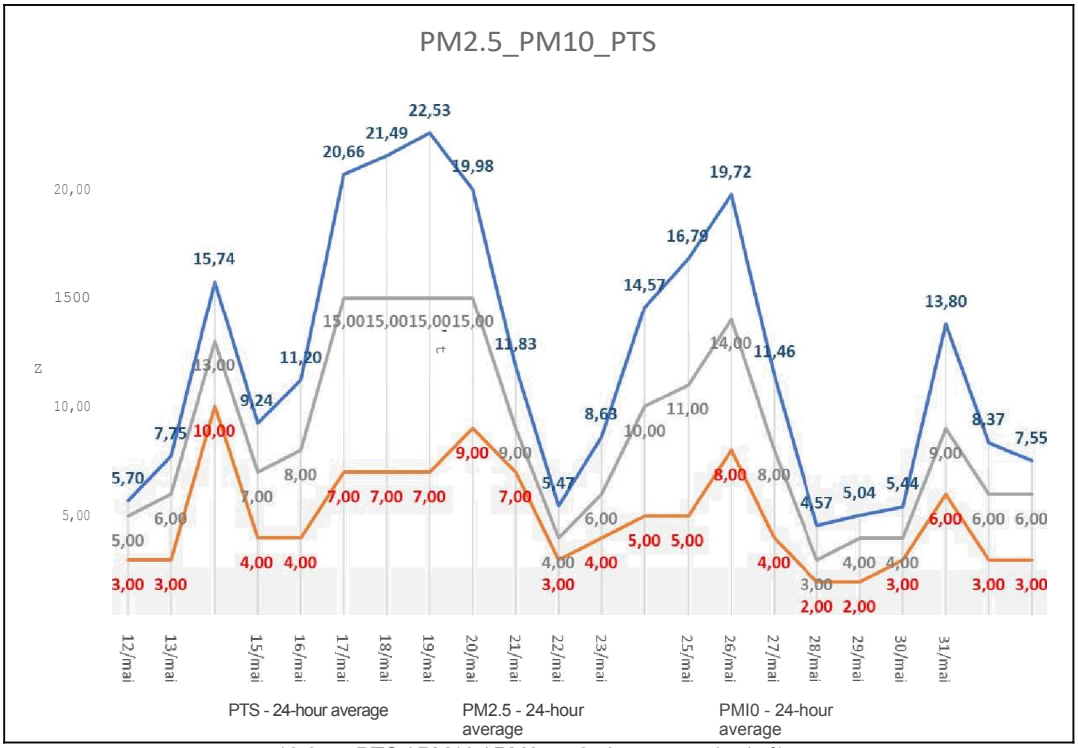
12.3.1 – Partículas Totais PTS – Média 24 horas (µg/m³)



12.3.2 – Partículas Totais PTS – Amostragem Instantânea (µg/m³)

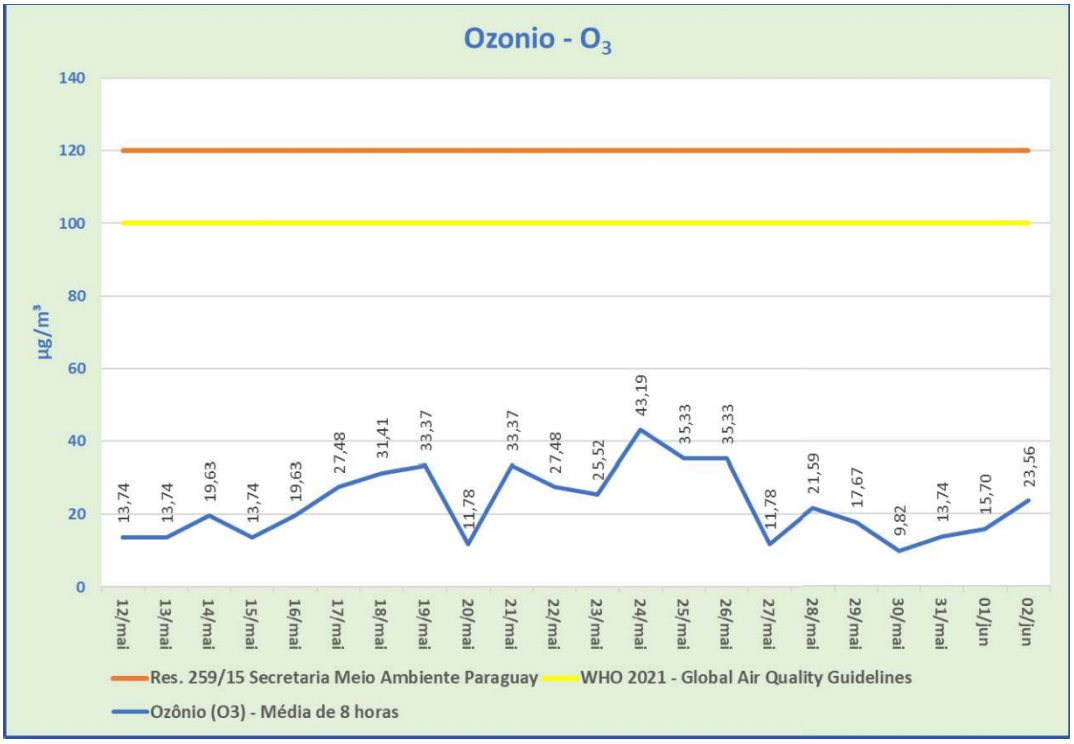


12.3.3 - Total Particles PTS - 24 h Average - Pollution Rose (pg/m°)

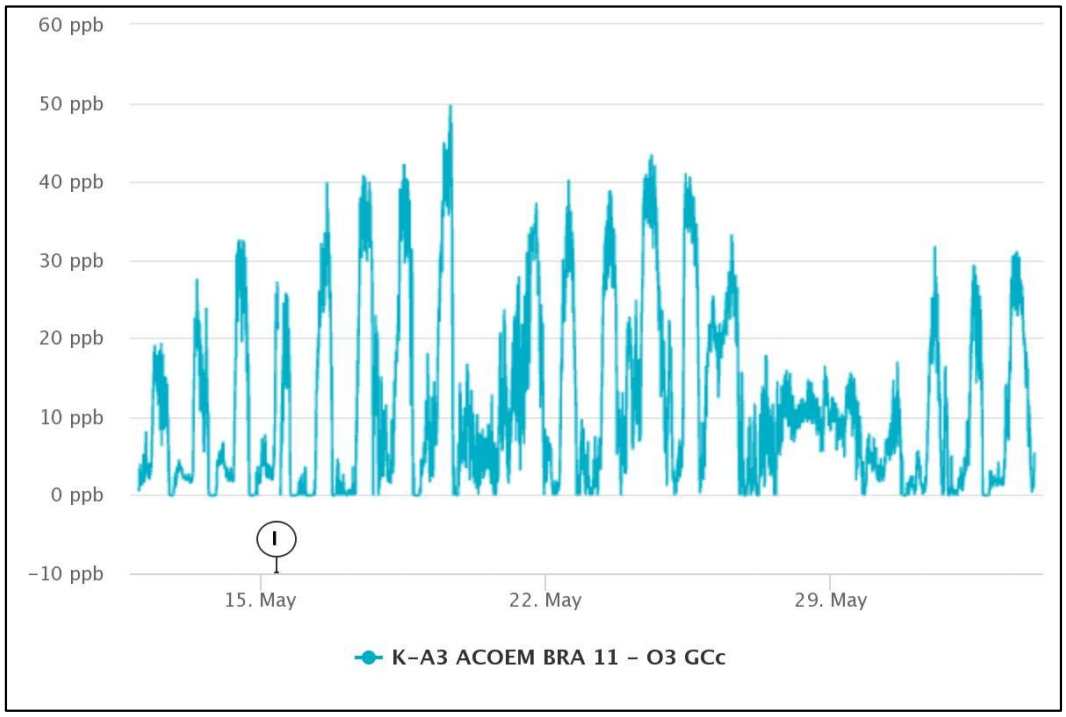


12.3.4 - PTS / PM10 / PM2.5 - 24 h average (pg/m°)

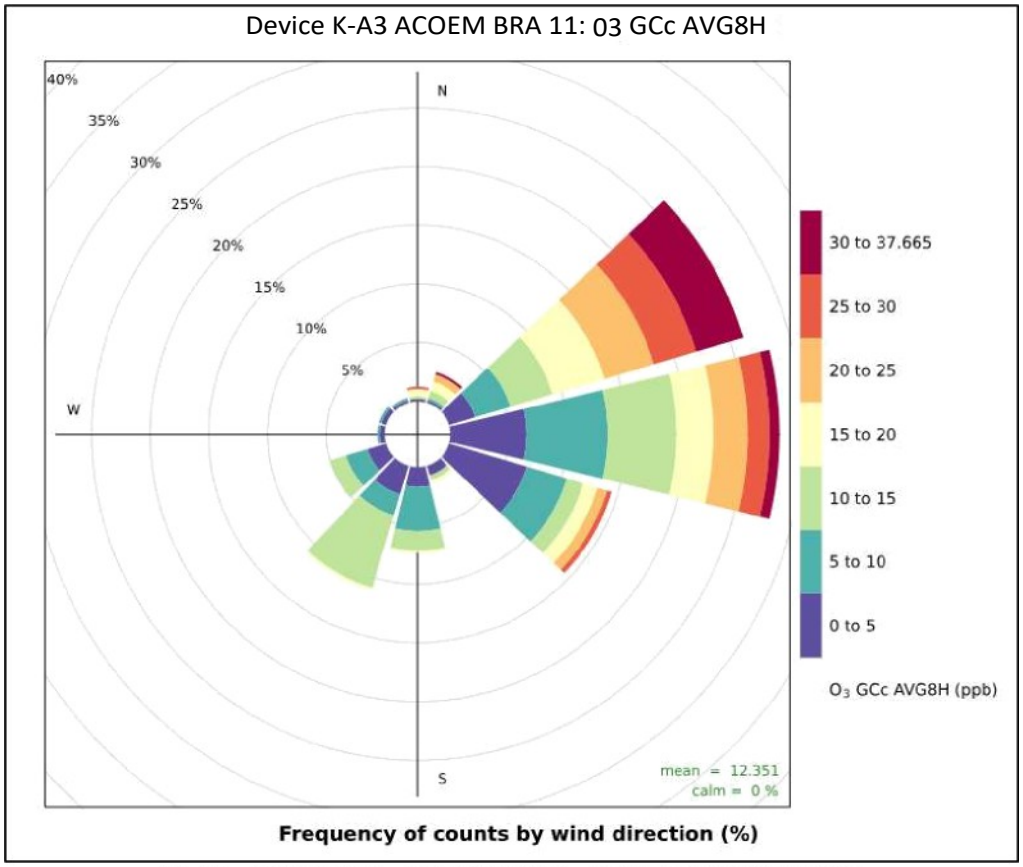
ANNEX 12.4– O_3– Dynamic graphics and Pollution Rose.



12.4.1 – Ozônio (0_3) – Média 8 horas (µg/m³)

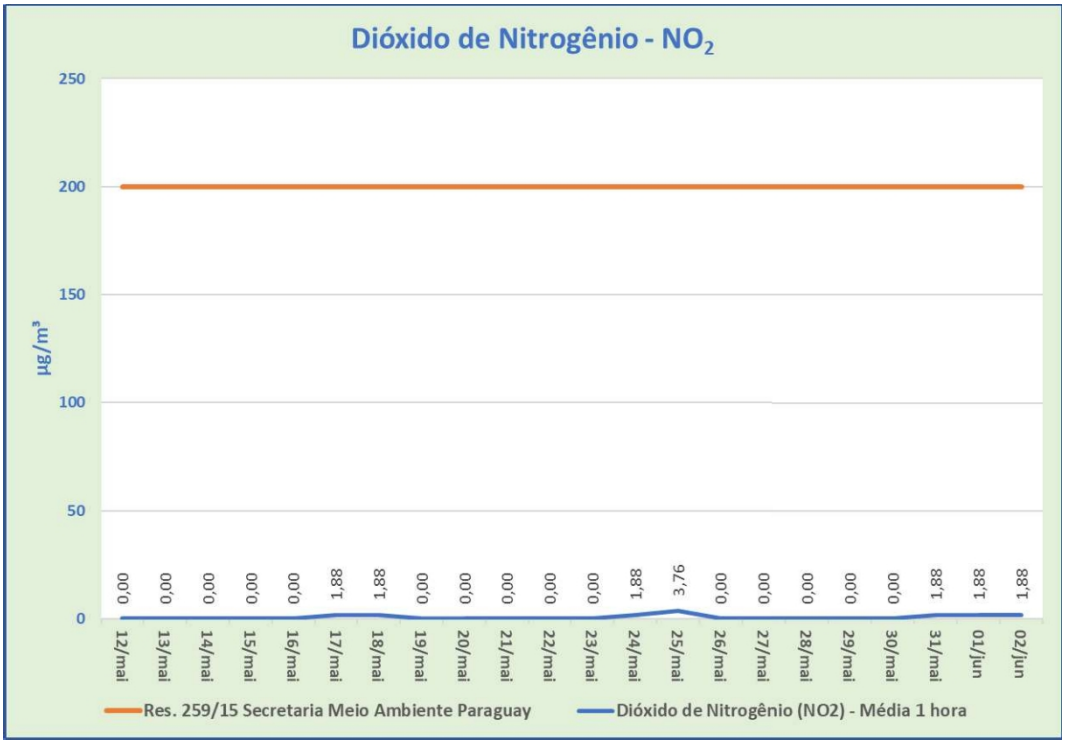


12.4.2 – Ozônio (0_3) – Amostragem Instantânea (ppb)

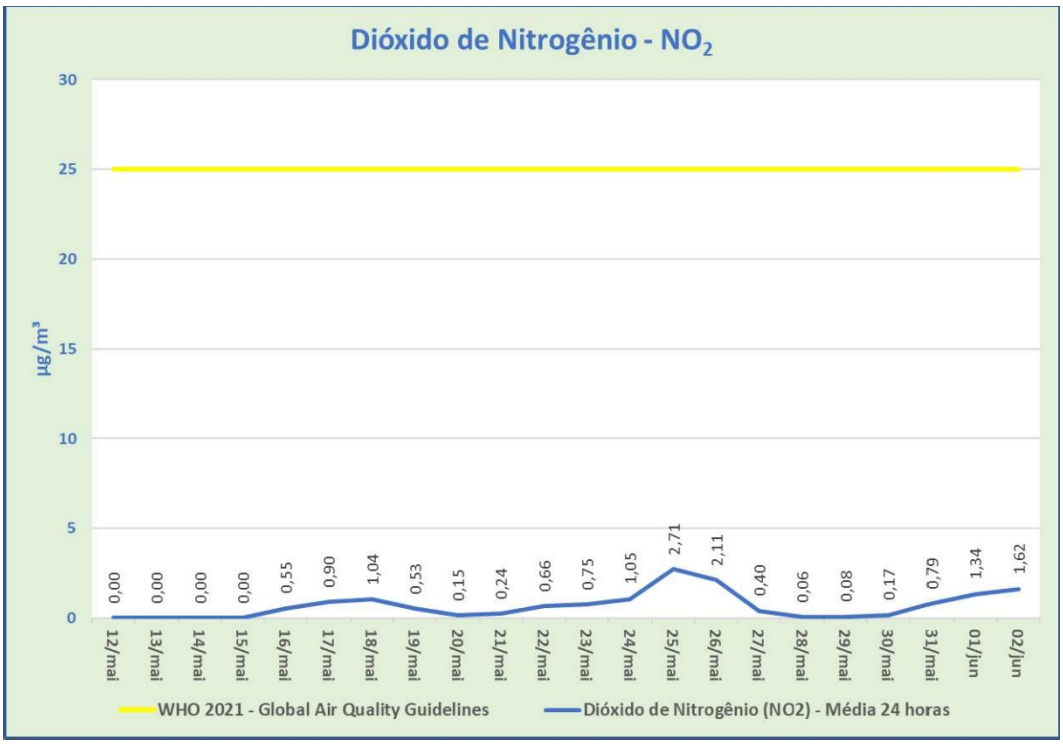


12.4.3 – Ozônio (0_3) – Média 8 horas – Rosa de Poluição (ppb)

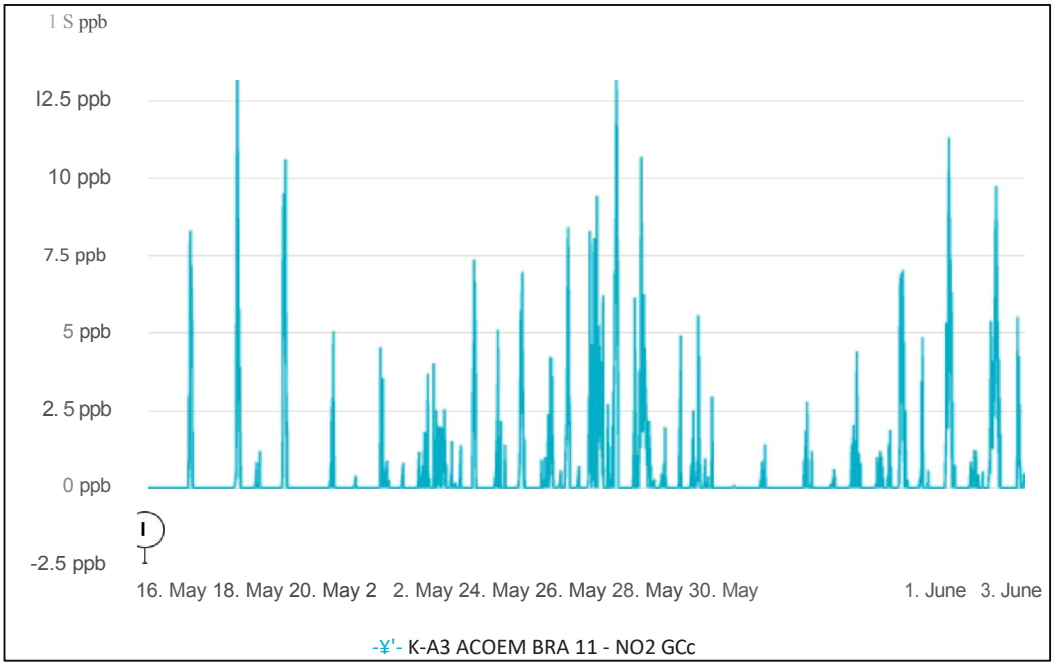
ANNEX 12.5– NO_2– Dynamic graphs and Pollution Rose.



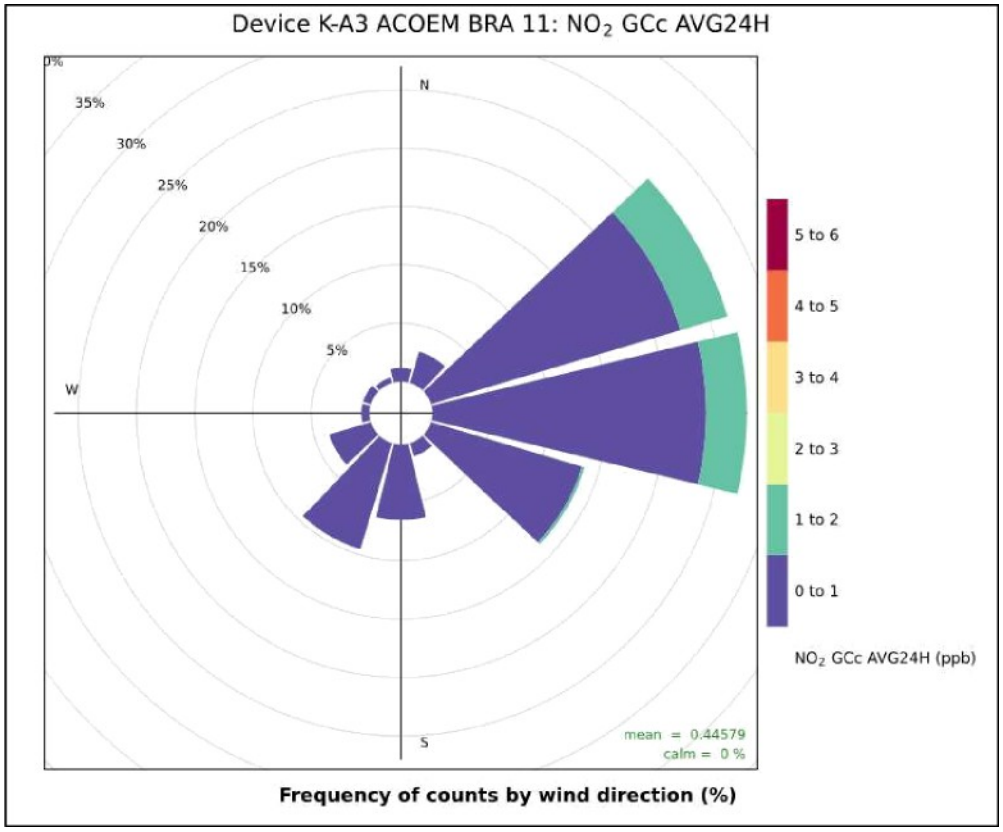
12.5.1 – Dióxido de Nitrogênio NO_2 – Média 1 hora (µg/m³)



12.5.2 – Dióxido de Nitrogênio NO_2 – Média 24 horas (µg/m³)

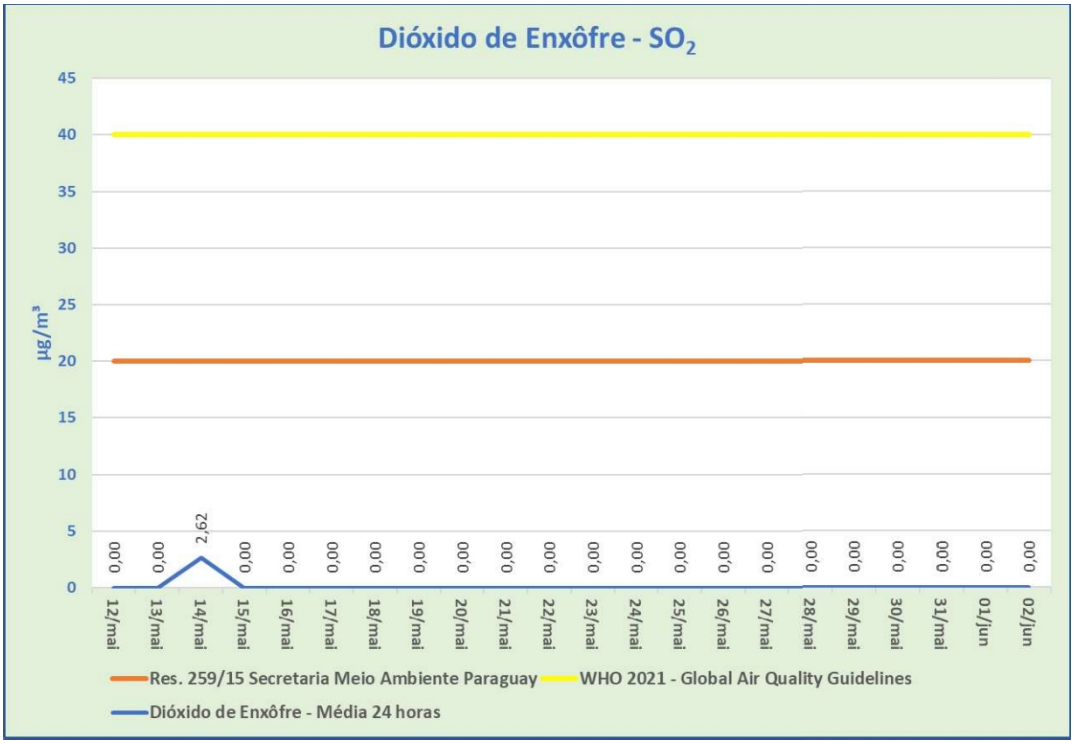


12.5.3 - Nitrogen Dioxide NO2 - Instantaneous Sampling (ppb)

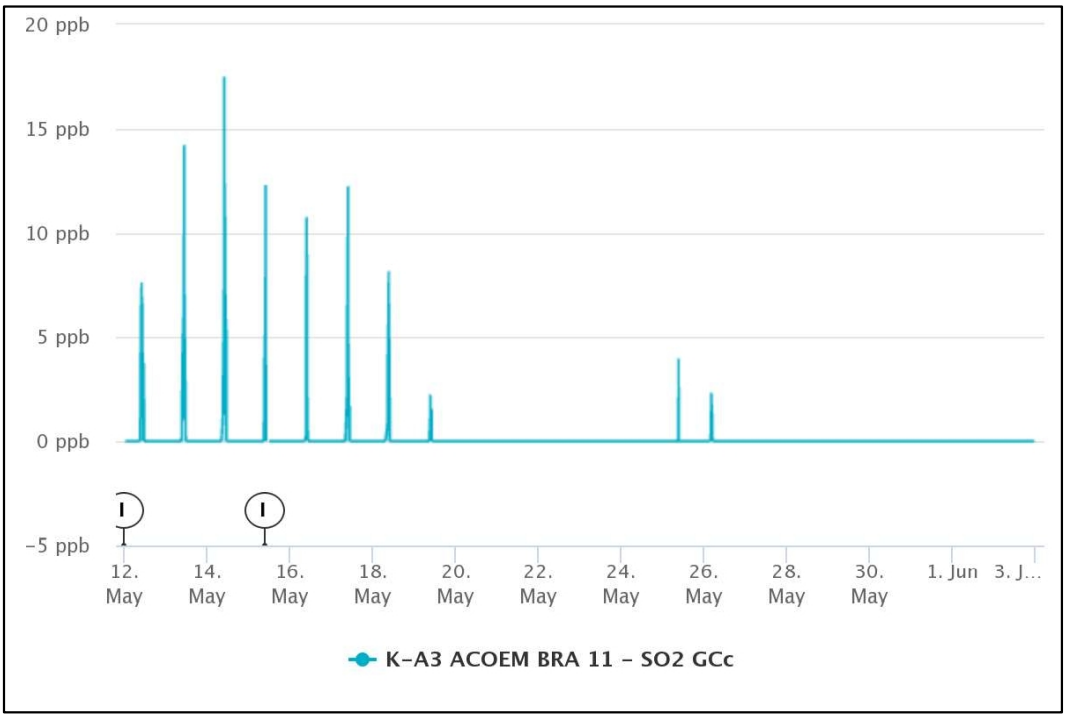


12.5.4 - Nitrogen Dioxide NO2 - 24 hour average - Pollution Rose (ppb)

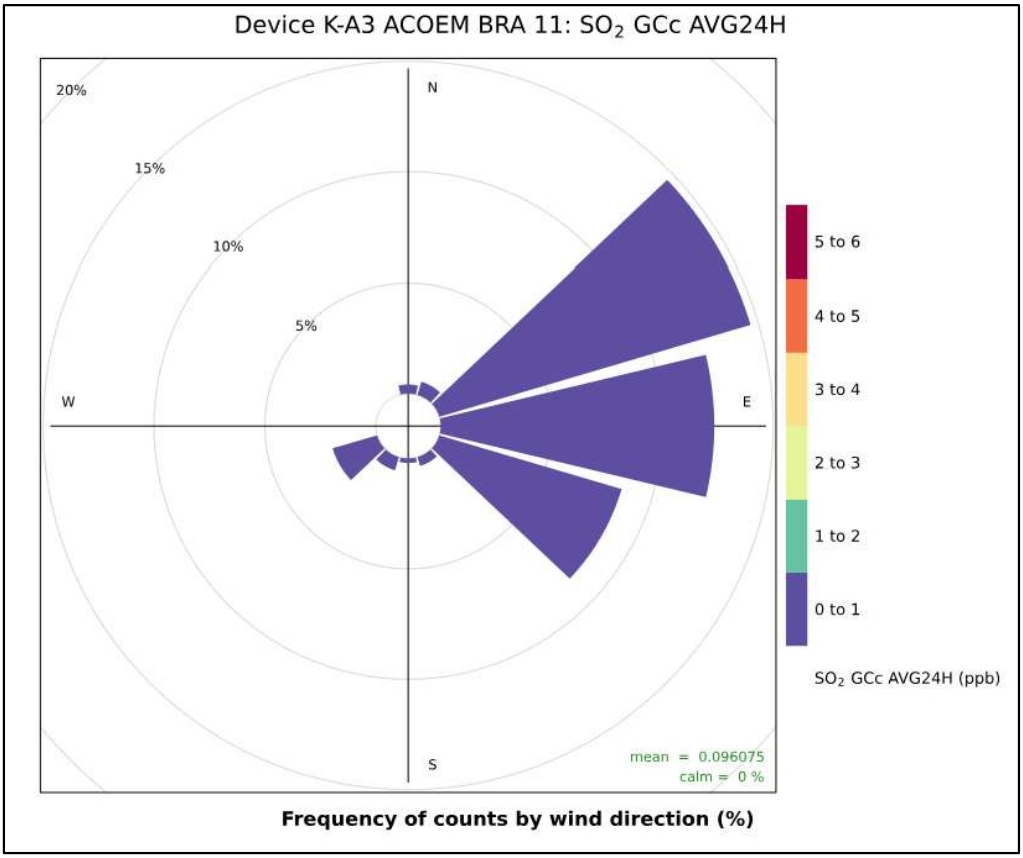
ANNEX 12.6– SO_2– Dynamic graphs and Pollution Rose.



12.6.1 – Dióxido de Enxofre SO_2 – Média 24 horas (µg/m³)

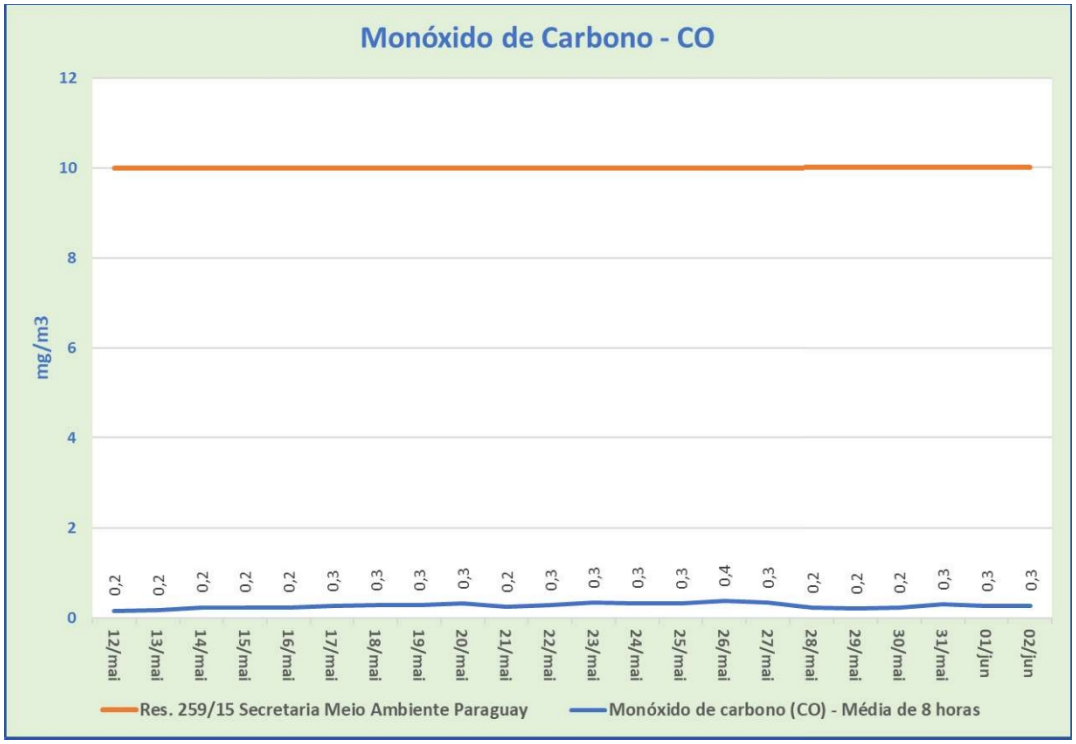


12.6.2 – Dióxido de Enxofre SO_2 – Amostragem Instantânea (ppb)

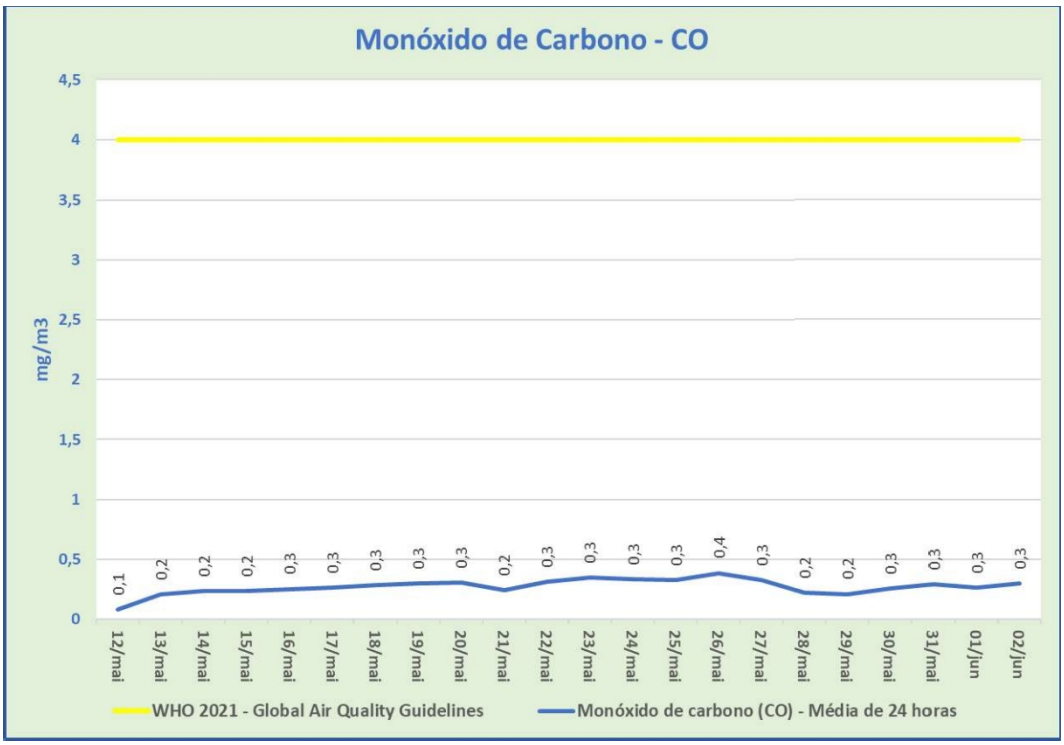


12.6.3 – Dióxido de Enxofre SO_2 – Média 24 horas – Rosa de Poluição (ppb)

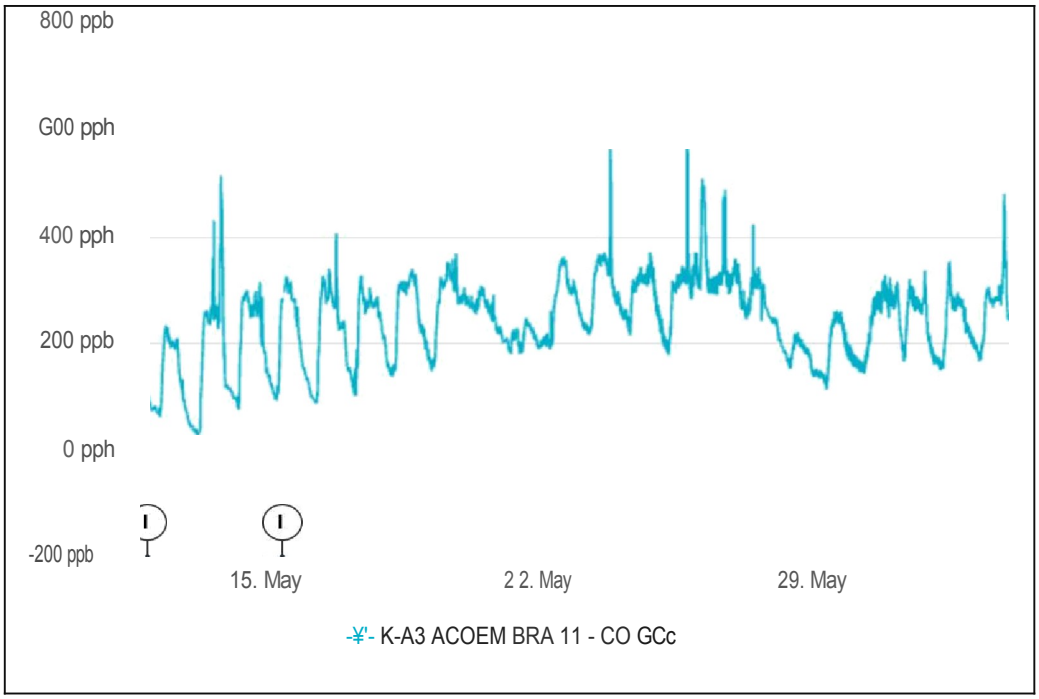
ANNEX 12.7– CO– Dynamic graphics and Pollution Rose.



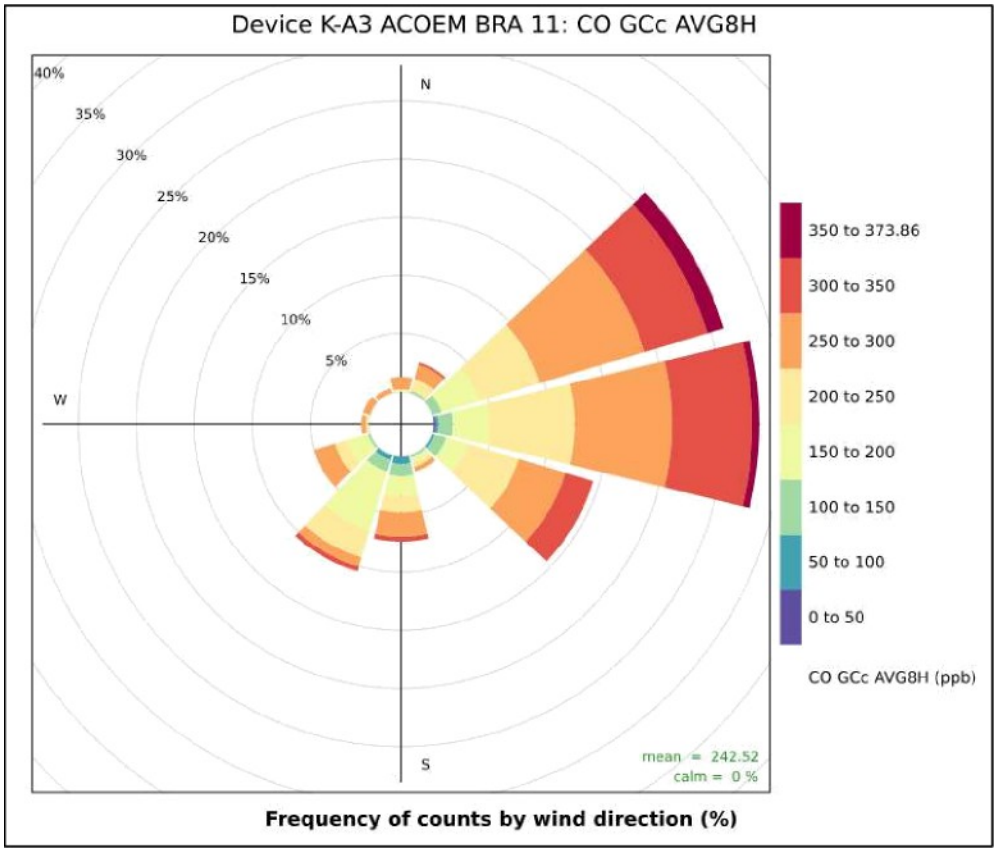
12.7.1 – Monóxido de Carbono CO– Média 8 horas (mg/m³)



12.7.2 – Monóxido de Carbono CO– Média 24 horas (mg/m³)

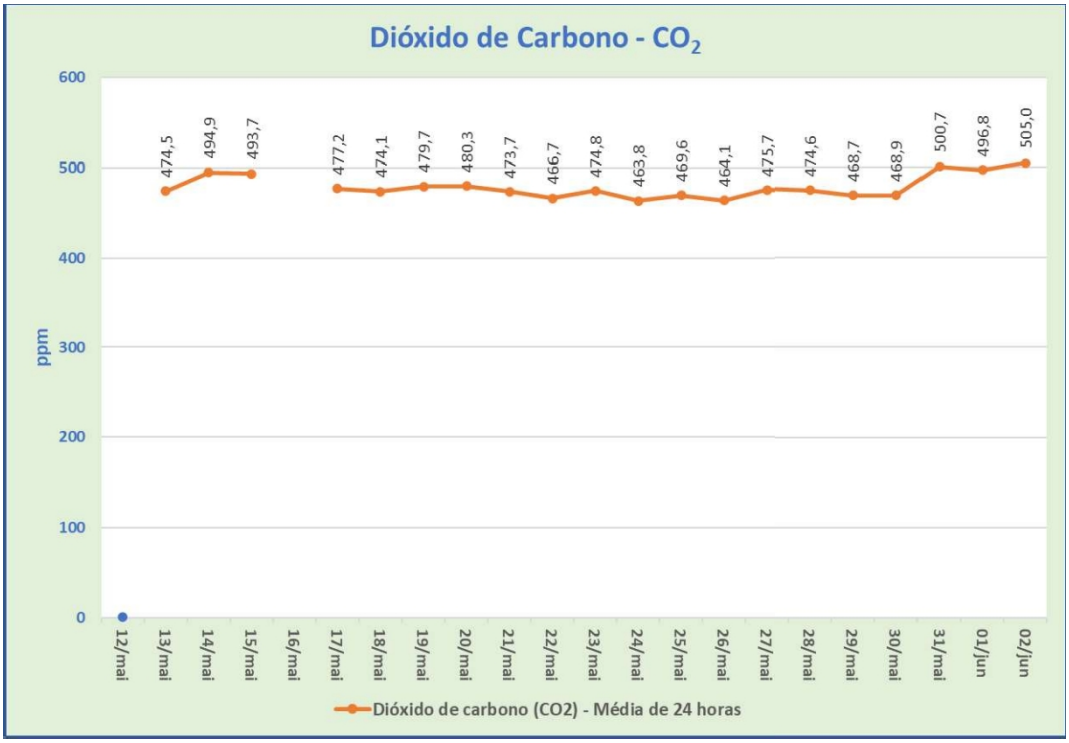


12.7.3 - Carbon Monoxide CO - Instant Sampling (ppb)

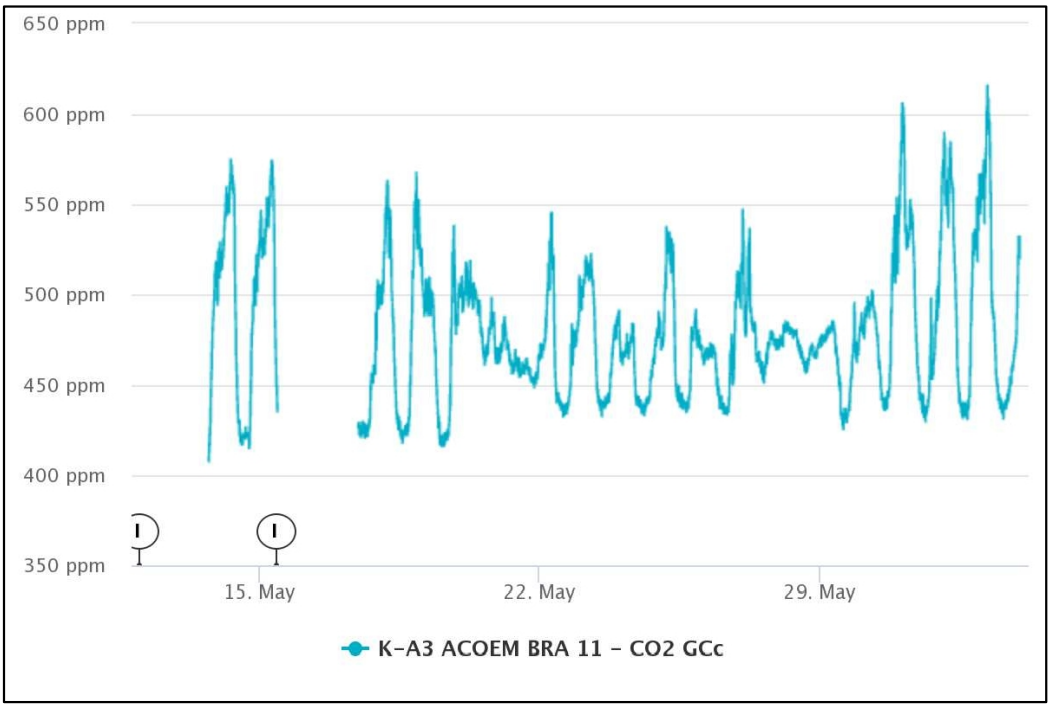


12.7.4 - Carbon Monoxide CO - 24 hour average - Pollution Rose (ppb)

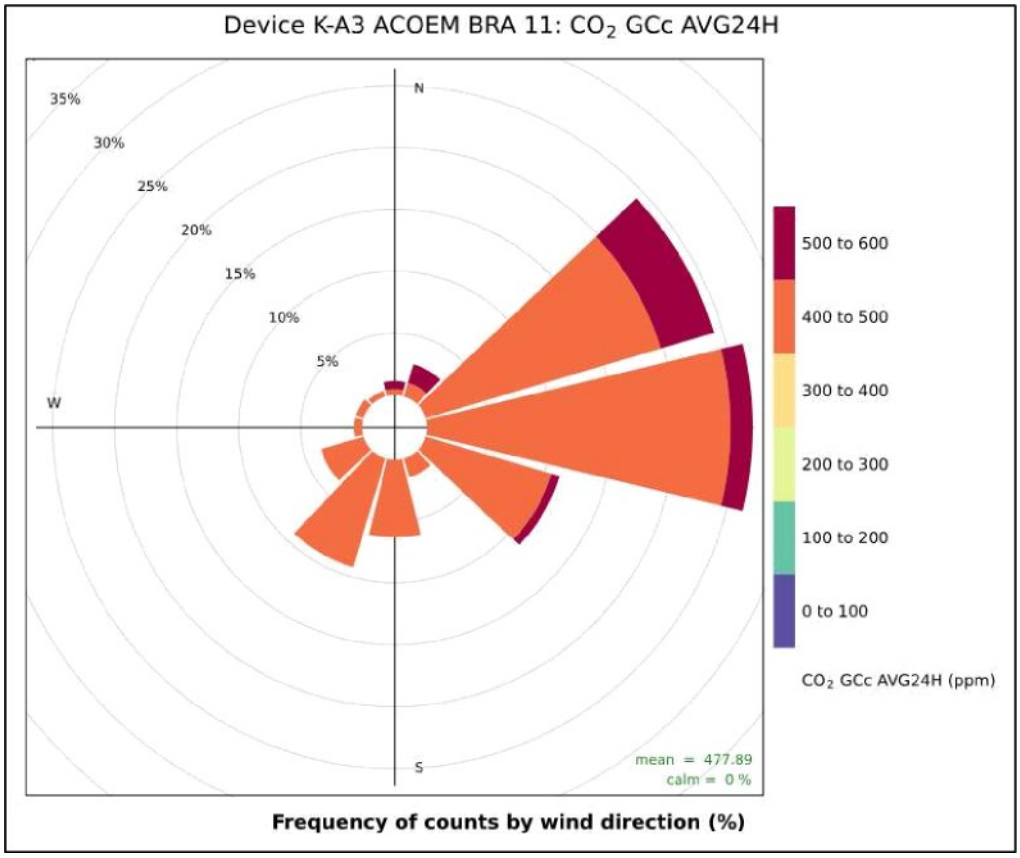
ANNEX 12.8– CO_2– Dynamic graphs and Pollution Rose.



12.8.1 – Dióxido de Carbono CO_2 – Média 24 horas (ppm)

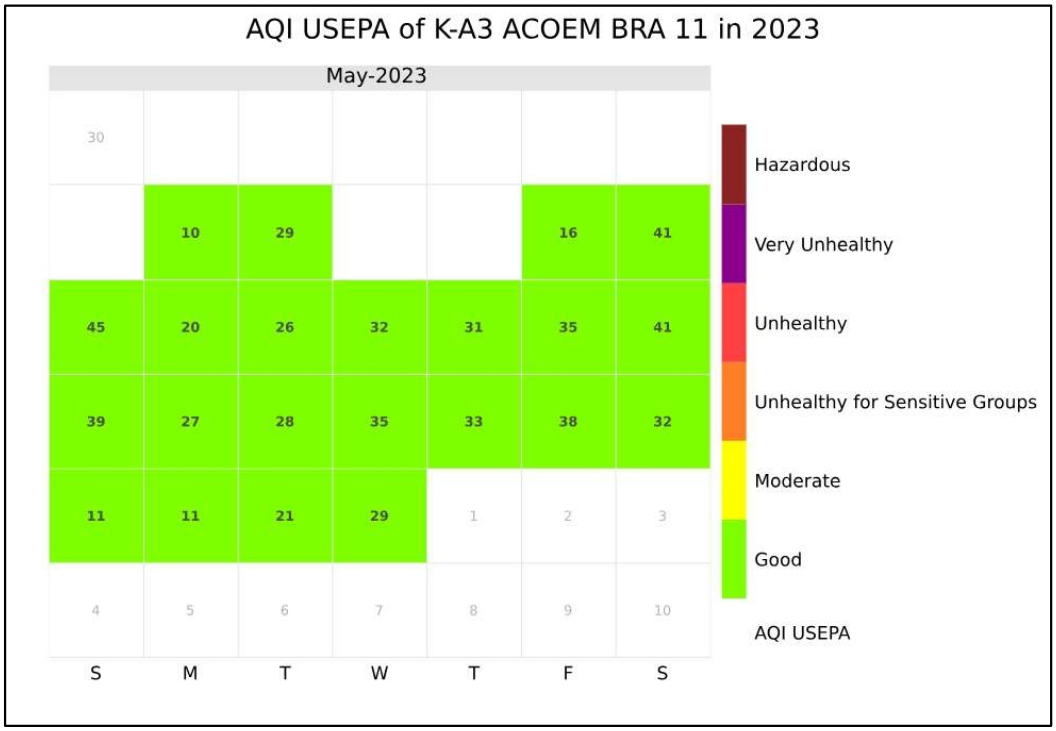


12.8.2 – Dióxido de Carbono CO_2 – Amostragem Instantânea (ppm)

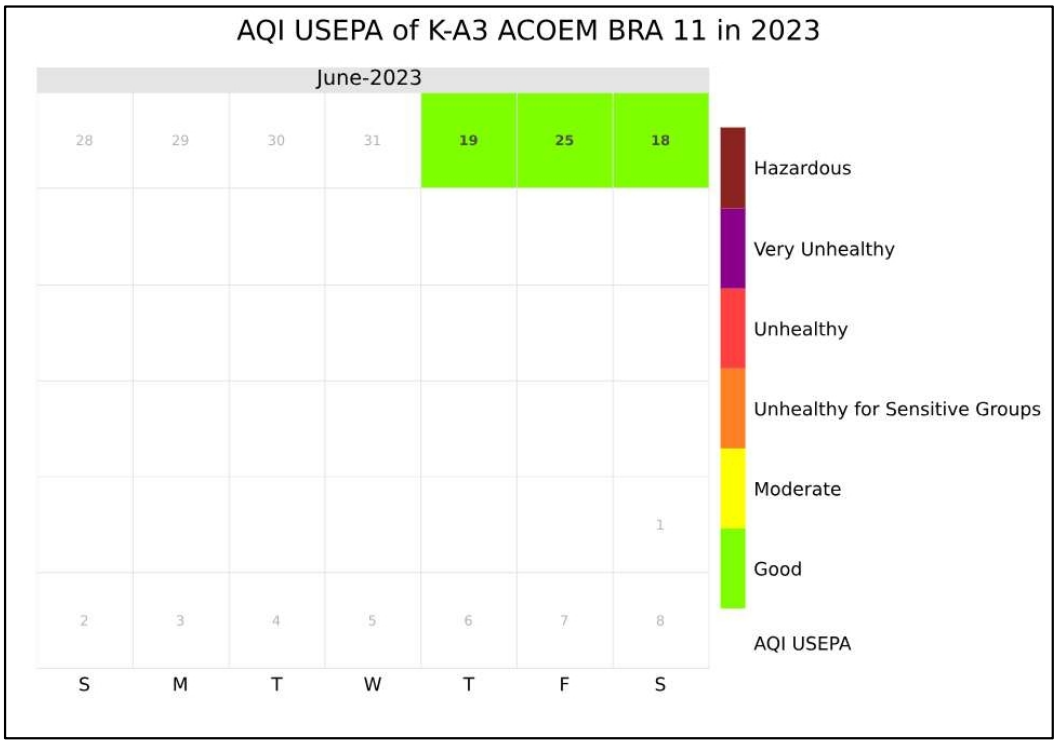


12.8.3 - COM Carbon Dioxide - 24 hour average - Pollution Rose (ppm)

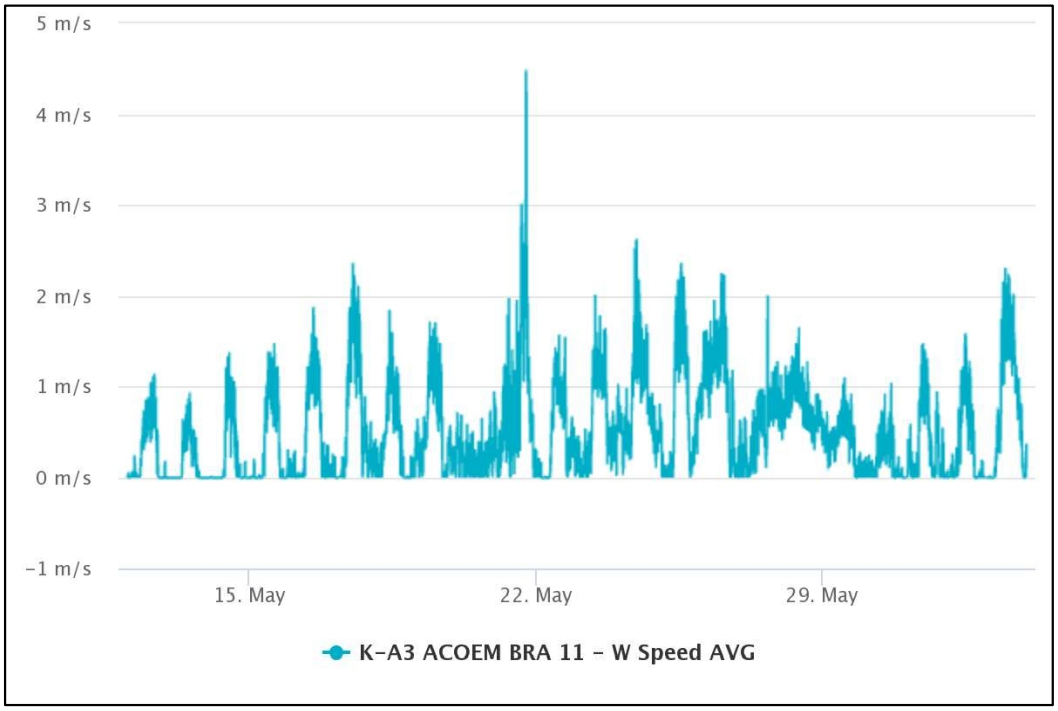
ANNEX 12.9– Calendar Chart– Air Quality Index (AQI).



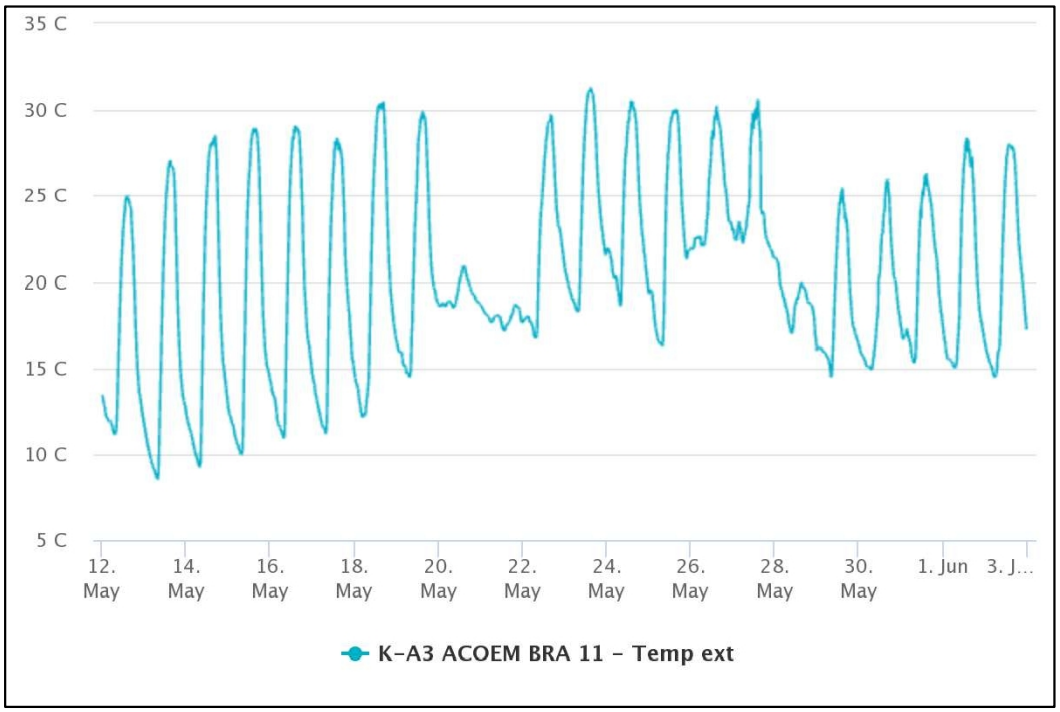
12.9.1 – Indice de Qualidade do Ar – Mês de Maio/2023 – Valores de 0 a 50 – AQI - Good



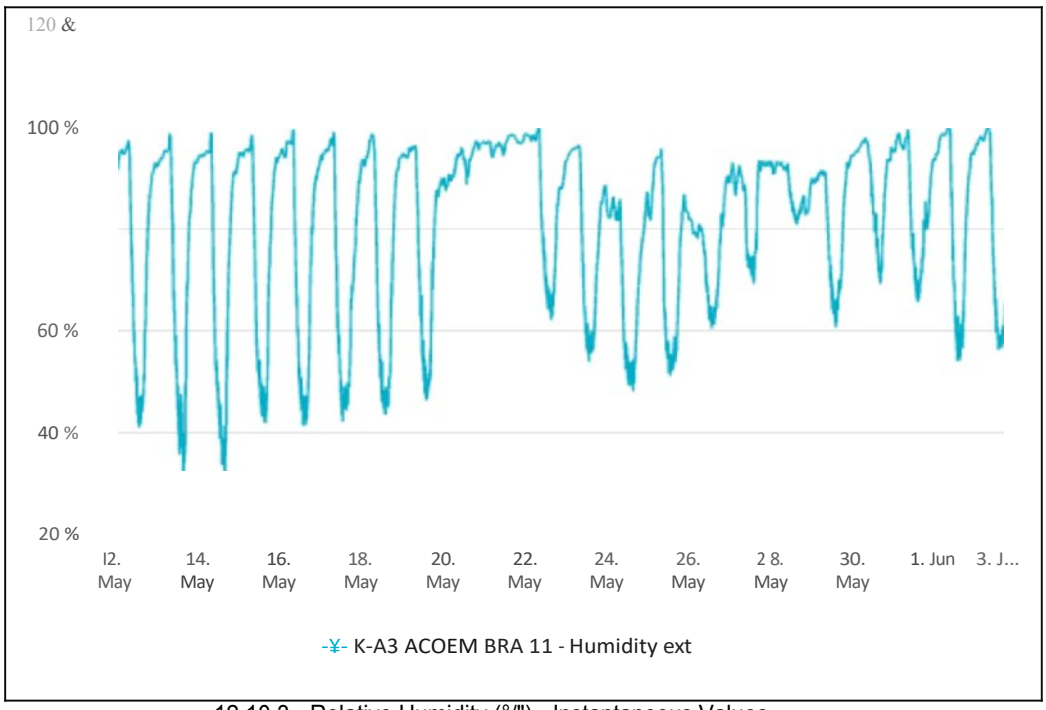
12.9.2 – Indice de Qualidade do Ar – Mês de Junho/2023 – Valores de 0 a 50 – AQI - Good



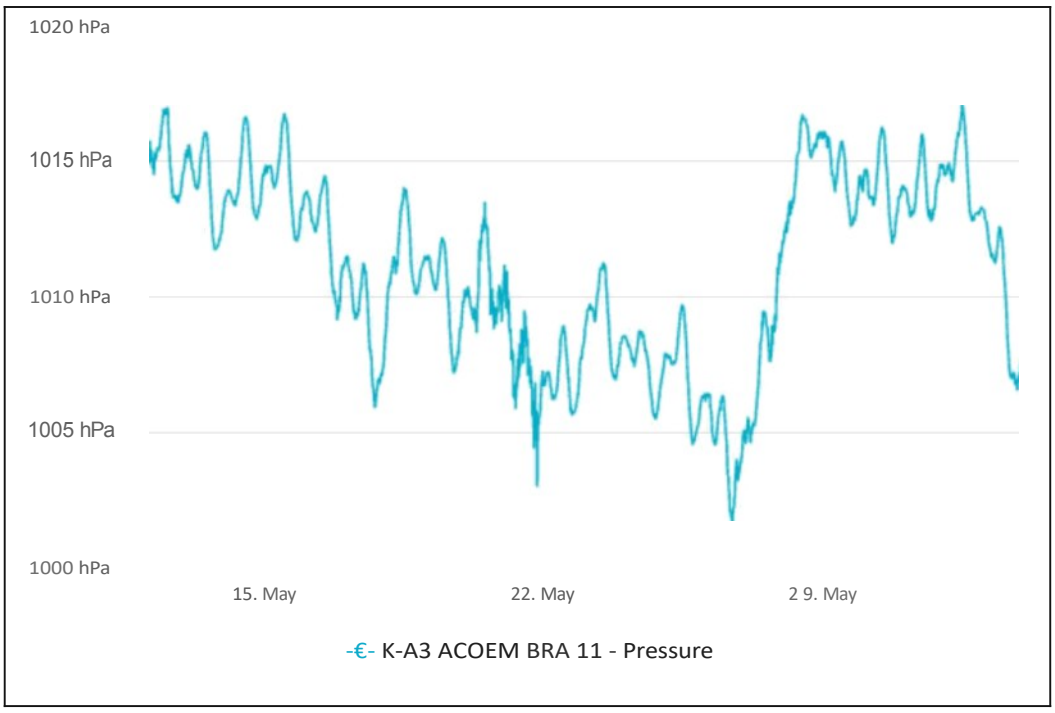
12.10.1 – Velocidade do Vento (m/s) – Valores Instantâneos



12.10.2 – Temperatura Ambiente (ºC) – Valores Instantâneos



12.10.3 - Relative Humidity (°/") - Instantaneous Values



12.10.4 - Atmospheric Pressure (hPa) - Instantaneous Values

ANNEX 12.11– Gas Sensor Calibration Certificates.

CHARACTERISATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type:	Carbon monoxide (CO)	**Manufacture Date:**	2021-05-07
P/N:	K-CO-A-01	**Expiry Date:**	2023-05-07
Y/N:	3021180025		

TEST 1: ENVIRONMENTAL CHARACTERISATION TEST

Environmetal characterisation test - not required for Carbon monoxide (CO) cartridges.

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Detection limit:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3021180025	< 30 s	< 360 s	PASS
Limit of Detection	3021180025	< 10 ppb	< 150 ppb	PASS
Repeatability	3021180025	< 20 ppb	< 50 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterisation and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

CHARACTERISATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type:	Carbon dioxide (CO2)	**Manufacture Date:**	2023-03-22
P/N:	K-CO2-B-01	**Expiry Date:**	2025-06-21
Y/N:	3723120005		

TEST 1: ENVIRONMENTAL CHARACTERISATION TEST

Environmetal characterisation test - not required for Carbon dioxide (CO2) cartridges.

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Detection limit:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	STATUS
Response Time	3723120005	< 180 s	PASS
Limit of Detection	3723120005	< 150 ppb	PASS
Repeatability	3723120005	< 0 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterisation and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

kunak®
SENSING ANYWHERE

CHARACTERISATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type:	Nitrogen dioxide (NO2)	**Manufacture Date:**	2021-03-18
P/N:	K-NO2-A-01	**Expiry Date:**	2023-03-18
Y/N:	3221110014		

TEST 1: ENVIRONMENTAL CHARACTERISATION TEST

Typical baseline error in the whole temperature (<40ºC) and humidity range.

Test	Cartridge S/N	Test results	Kunak requirement	STATUS
Environmetal characterisation	3221110014	5.56 ppb	< 16 ppb	NO PASS

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Detection limit:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3221110014	< 120 s	< 360 s	PASS
Limit of Detection	3221110014	< 3 ppb	< 10 ppb	PASS
Repeatability	3221110014	< 4 ppb	< 4 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterisation and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

CHARACTERISATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type: Ozone (O3) **Manufacture Date:** 2021-05-05
P/N: K-O3-A-01 **Expiry Date:** 2023-05-05
Y/N: 3321180032

TEST 1: ENVIRONMENTAL CHARACTERISATION TEST

Typical baseline error in the whole temperature (<40ºC) and humidity range.

Test	Cartridge S/N	Kunak requirement	STATUS
Environmetal characterisation	3321180032	< 7.5 ppb	NO PASS

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Detection limit:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3321180032	< 120 s	< 360 s	PASS
Limit of Detection	3321180032	< 3 ppb	< 10 ppb	PASS
Repeatability	3321180032	< 4 ppb	< 4 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterisation and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

kunak®
SENSING ANYWHERE

CHARACTERISATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type: Sulphur dioxide (SO2)
P/N: K-SO2-A-01
Y/N: 3521180016
Manufacture Date: 2021-05-05
Expiry Date: 2023-05-05

TEST 1: ENVIRONMENTAL CHARACTERISATION TEST

Typical baseline error in the whole temperature (<40ºC) and humidity range.

Test	Cartridge S/N	Kunak requirement	STATUS
Environmetal characterisation	3521180016	< 15 ppb	NO PASS

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Detection limit:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3521180016	< 120 s	< 360 s	PASS
Limit of Detection	3521180016	< 3 ppb	< 10 ppb	PASS
Repeatability	3521180016	< 4 ppb	< 4 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterisation and laboratory tests and described in this certificate.

Signature:

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Annex 5 – Sound Pressure Level Monitoring Report (Baseline)

TECNOAMBIENTAL
•INGENIERÍA Y CONSULTORÍA•

SOUND PRESSURE LEVEL MONITORING RESULTS REPORT

PROJECT:
PLANTA INDUSTRIAL ATOME S.A.

CUSTOMER:	ATOME S.A.
DISTRICT:	VILLETA
DEPARTAMENTO:	CENTRAL
CONSULTANT:	TECNOAMBIENTAL S.R.L
CTCA CODE:	E-133

October 2023

1. INTRODUCTION

ATOME Paraguay S.A., hereinafter *"The Company"*, is developing an industrial project to be installed on a 30-hectare property in the district of Villeta. The industry will be the first dedicated to the production of hydrogen, ammonia and green fertilizers.

The company contracted Tecnoambiental S.R.L. to carry out the environmental noise survey with the aim of collecting data on current noise levels, evaluating and comparing with the maximum permissible limits established in national legislation and the General Guidelines on the Environment, Health and Safety (MASS) of the International Finance Corporation (IFC)/World Bank.

The survey was carried out on September 30 and October 9, 2023, in places defined jointly with *The Company*. These were established within the property; specifically considering the location of future major sources of noise emission, and off-property; taking into account the presence of critical receptors.

The regulatory framework, methodology and results of the noise measurement campaign are described below.

2. REGULATORY FRAMEWORK

2.1 National

2.1.1 Law No. 6390/20 Regulating Noise Emission

The purpose of this law is to regulate the emission of noise capable of affecting the well-being or damaging the health of people or living beings, in order to ensure the due protection of the population, the environment and property affected by exposure to noise.

According to Article 4, the municipalities shall be the authority for the application of this Law. They are responsible for exercising the duties and powers established in this Law.

Among the main duties of municipalities are:

1. Determine the standards, categories and permitted emission sources, which must be established according to the characteristics of the noise emitter and the receiving medium.

2. Establish the permitted and prohibited noise levels by regulation.

3. Establish reference techniques for sampling, measurements, analysis, evaluation of noise pollution, and for the verification and calibration of measuring instruments.

The city of Villeta does not have up-to-date regulations to the aforementioned Law, therefore, the average values specified in Law No. 1100/97 "On the Prevention of Noise Pollution" are used as a reference.

2.1.2 Law No. 1100/97 on the Prevention of Noise Pollution

The purpose of this law is to prevent noise pollution on public roads, squares, parks, promenades, performance halls, meeting centres, sports and social clubs and in all public and private activities that produce noise pollution.

According to Article No. 9, noise and annoying sounds are considered to be those that exceed the average levels specified in Table 1.

Table 1. Maximum permissible sound levels per area

Area	**Night** 8:00 p.m. to 7:00 a.m.	**Day** 07:00 to 20:00	**Day (Occasional Peak)** 07:00 to 12:00 14:00 to 19:00
	Measured in decibels "A"		
Residential areas for specific use, public spaces: recreational areas, parks, squares and public roads.	45	60	80
Mixed Areas, Transition Zones, Urban Centres, Specific Programmes, Service Areas and Public Buildings	55	70	85
Industrial area	60	75	90

Source: Paraguay (1997).

To compare the Leq results in dBA obtained with Law No. 1100/97, the maximum permitted values defined for the Industrial Area, highlighted in gray, were used.

Taking into account the presence of a dwelling where Point 3 of measurement was located, for the contrast of the Leq results in dBA at this point, the maximum permitted values defined for the Area corresponding to residential areas of specific use, public spaces: recreational areas, parks, squares and public roads highlighted in light blue were used.

2.1.3 Ordinance No. 25/2017 amending and updating Ordinance No. 2/94 regulating the advertising and noise nuisance system within the district of Villeta

In the district of Villeta, Law No. 1100/97 is regulated by Ordinance No. 25/2017, which amends and updates Ordinance No. 2/94, which regulates the system of advertising and nuisance noise within the district of Villeta, in accordance with the provisions of this Law.

Article 1 of this Ordinance establishes the prohibition throughout the district of Villeta of causing annoying sounds, as well as vibrations when, due to time, place or intensity, they affect the tranquility, rest, health and material goods of the population.

As for industrial installations that, located in residential areas, that make hammers or produce annoying noises, will operate within the hours of 06:00 to 12:00 and from 14:00 to 20:00 hours. Likewise, they must adopt the required devices to reduce the noise produced.

2.2 International

2.2.1 IFC/World Bank General Guidelines on Environment, Health and Safety

The IFC/World Bank MASS Guides are technical reference documents containing general and specific examples of International Good Practice for Industry. These guides contain the levels and performance indicators that can generally be achieved in new installations, with existing technology and at reasonable costs.

The guidelines state that noise impacts may not exceed the levels set out in the following Table of Noise Level Guidelines.

Table 2. Noise Level Guides

Receptor	One hour LAeq (dBA)	
	Day 07:00 – 22:00	Night 22:00 – 07:00
Residential, Institutional, Educational	55	45
Industrial, Commercial	70	70

Source: IFC (2007).

It should be noted that the IFC also states that the maximum increase in background noise levels can be up to 3 dB at the nearest receiver.

To contrast the Leq results in dBA obtained with the General Guidelines on Environment, Health and Safety of the International Finance Corporation, the noise level guide values defined for the Industrial Receiver highlighted in gray were used.

Taking into account the presence of a house where Point 3 of measurement was located, for the contrast of the Leq results in dBA at this point, the noise level guide values defined for the Residential, Institutional, Educational Receiver highlighted in light blue were used.

Noise monitoring shall be carried out for the purpose of establishing existing ambient noise levels in the area of proposed and existing installations, or for the purpose of checking noise levels in the operational phase.

3. MATERIALS AND METHODS

3.1 Measuring Points

The selection of the measurement points was based on the methodology proposed by Segués (2008), of directed selection of measurement points based on land uses and noise sources, which consists of previously analyzing the dynamics of the activity, land uses and establishing a zoning of the study area. On the other hand, the main sources of noise, roads, industries, sensitive areas, etc., must be analyzed.

This methodology is in accordance with the recommended method for the measurement of environmental noise in the ISO 1996-2:2017 Standard, which measures the equivalent continuous level in frequency weighting A dB(A), where they also indicate that the selection of points should be established according to the generating source.

Considering the above, Table 3 mentions the four (4) selected measurement points and their description.

Table 3. Description of Measurement Points

Point N°	Geographic Coordinates	Description of Measurement Points
1 - Main access to the property	25°42'33.6"S 57°41'56.6"W	Point of circulation of mobile emission sources, such as machinery and heavy trucks and other types of vehicles of different sizes linked to the construction and operation/maintenance stage of the project. In addition, it is a strategic point for measuring noise levels, due to its proximity to the Villeta-Alberdi Route.
2 - ATOME Property Boundary – Near Neighbor's Barn	25°42'36.7"S 57°42'09.6"W	Area close to the dwelling of the neighbors of the adjoining property, the main critical receivers of the noise levels that the industry would generate, due to the proximity of the installation of certain equipment and service areas, as well as continuous work during the construction and operation/maintenance stage, in general.
3 – Main access to the Neighbor's home	25°42'37.9"S 57°42'06.6"W	Registration point located at the main access to the neighbors' homes, they would be direct receivers of the noise levels that could occur in the different stages of the industry, which could affect their health and alter their quality of life.
4 – Future area of fixed noise sources	25°42'31.8"S 57°42'06.8"W	It corresponds to a sector of industry where emission sources such as machinery and equipment of continuous operation (mainly compressors) would be found, which could generate high noise levels, which could affect occupational and housing levels.

Figure 1 shows the location of each of the 4 selected points.

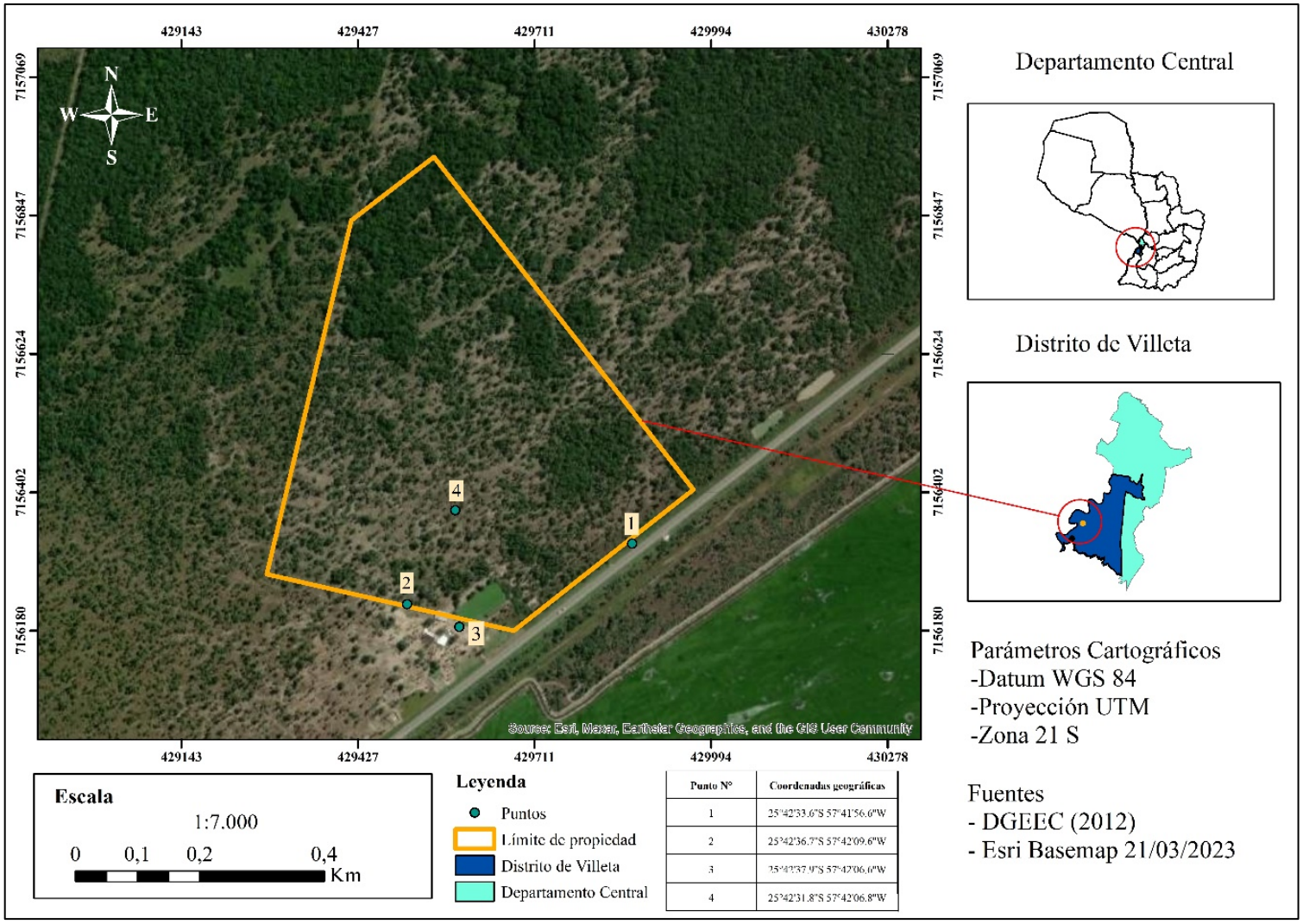

Figura 1. Localización de los puntos de medición de niveles sonoros.

3.2 Equipment

Sound level monitoring was performed with two Class 2 sound level meters that comply with IEC 61672-1 and IEC PUB 651 standards, the **PCE-322A sound level meter** and the **Minipa MSL-1355B sound level meter,** respectively**.**

Both are high-performance instruments, suitable for measuring sounds in the industrial, health, safety and environmental sectors. Both sound level meters comply with the provisions of the International Finance Corporation's General Guidelines on Environment, Health and Safety (2007): they are Type 2, frequency weighting A was used and comply with the applicable IEC standards.

The technical specifications of sound level meters are presented in Annex 8.1. Likewise, Annex 8.3 and 8.4 include the calibration certificates issued by LABSOL S.A., a calibration service provider company accredited by the National Accreditation Body (ONA), as a calibration laboratory, in accordance with the NP-ISO/IEC 17025:2018 Standard, equivalent to the ISO/IEC 17025:2017 Standard "General requirements for the competence of testing and calibration laboratories" and the requirements established in the regulations, ONA criteria and policies applicable to calibration laboratories in their current version.

3.3 Data collection

Data collection was carried out for 20 continuous hours at the 4 measurement points. The sound level meters were programmed to measure with frequency weighting A, in a range of 30 to 130 dB. The sound level meters were placed on a tripod to be placed at a distance of approximately 1.5 meters above the ground, and it was also taken into account that they are no closer than 3 meters from any reflective surface (walls, structures, obstacles), as specified in the IFC/World Bank MASS Guidelines.

According to the IFC General Guidelines on Environment, Health and Safety (2007), the usual monitoring periods should be sufficient for the statistical study and can last 48 hours with the use of noise monitoring devices that should have the ability to record data continuously during this period of time. or hourly or more frequently as deemed appropriate (or otherwise covering periods of time within multiple days, including weekdays on weekdays or over the weekend).

Due to the capacity of the Minipa MSL-1355B Sound Level Meter **Datalogger** and in order to have the largest number of records during the total measurement time, the equipment was configured in a measurement time interval of 1 data every 16 seconds, thus obtaining 4,502 records in 20 hours of measurement. As for the **PCE-322A sound level meter,** whose *Datalogger* has a larger data storage memory, yielding 1 data per second, 72,000 records were obtained in the 20 hours of measurement.

At the same time, the atmospheric variables in the weather forecast of the Directorate of Meteorology and Hydrology (DMH) were verified daily, considering the impact that climatic conditions may have on the sound measurements. A cap was used to protect the equipment from the wind and on rainy days the measurements were suspended and re-planned.

Table 4 below shows the details of the measurement schedules at each of the measurement points.

Table 4. Measurement schedules at each of the registration points.

Point N°	Measurement Start Time	End Time Measurements	Total Measurement Time
1	04:31:00	00:31:16	20 hours, 16 seconds
2	05:35:00	01:35:16	20 hours, 16 seconds
3	05:33:12	01:33:28	20 hours, 16 seconds
4	05:51:00	01:51:16	20 hours, 16 seconds

3.4 Data Processing and Analysis

3.4.1 Data Pre-Processing

Considering the differences in measurement time interval of each sound level meter, the records were pre-processed in order to standardize the amount of data between the two devices for analysis in the 20 hours of measurement at each of the 4 points. To this end, the following was done:

1) First, the data from each sound level meter were pooled every 1 hour, for the Minipa sound level meter 225 records were obtained, and for the PCE sound level meter 3,600 records were obtained.

2) Next, a simple random sampling was carried out by means of Microsoft Excel, which consists of a technique in which all the elements of a population or universe can be selected for the sample of a research. This selection process is carried out randomly or randomly, without the intervention of the researcher. This was done to randomly collect 225 recordings from the 3,600 PCE sound level meter records every hour, and thus have the same amount of data between the two sound level meters.

3.4.1 Data Processing

The data obtained by the sound level meters were processed in Microsoft Excel in order to obtain a spreadsheet with the means for each point. Due to the logarithmic nature of the sound level values, the equivalent continuous sound level (Leq) was calculated using the following formula:

$$Leq = 10\log((\Sigma ti \cdot 10^{Li/10})/T)\ dBA$$

Where:

T: This is the total duration of the measurement
Ti: is the instantaneous observation time per second
Li: Instantaneous Sound Pressure

It is important to determine the Leq value, as it represents the constant total exposure to sound levels over a period of time of interest.

The results of the Leq value measurements were calculated by specifying the frequency weight that was used (dBA), and the desired measurement time duration. For this study, it was defined to represent the Leq data every 1 hour **(LAeq1hour),** thus having 20 data for the total measurement time of 20 hours at each point.

The results were analyzed and presented in figures and tables, in such a way that the sound levels in dBA and their behavior are visualized. In this way, the temporal variability for each of the selected points is made visible.

The figures show the data on instantaneous sound levels in dB and the cumulative Leq levels in dBA, with the corresponding contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the IFC/World Bank EHS Guidelines.

A sound map is also presented to achieve a graphical presentation of the behavior of sound levels in the study area.

4. RESULTS

4.1 Weather conditions

The climatic variables were obtained from the weather forecast of the Directorate of Meteorology and Hydrology (DMH). The following conditions were considered to develop the measurements:

1. Precipitation: dry weather.
2. Temperature: range above -10 °C and below 50°C.
3. Relative humidity: up to 90%.
4. Wind speed: up to 5 m/s (18 km/h). At higher wind speeds, the turbulent noise caused by the wind can mask the source of noise to be measured. However, measurements with wind speeds of up to 10 m/s (36 km/h) can be accepted. In general, wind noise peaks should be at least 10 dB below the noise source to be measured.

Table 5 shows the climatic conditions recorded every 2 hours in Villeta during the measurement days.

Table 5. Climatic conditions recorded in the city of Villeta during the measurement days.

Day	**Hour**	**Atmospheric Variables**				
		Temperature °C	*Relative humidity %*	*Velocity of the wind km/h*	*Wind Direction N, S, E, O*	*Rainfall mm*
30/09/2023	05:00	17	77	14	Sur Sur Oeste	-
	07:00	19	77	11	Sur Sur Oeste	-
	09:00	22	73	7	On	-
	11:00	25	69	5	On	-
	13:00	26	63	11	South West	-
	15:00	26	55	17	Sur Sur Oeste	-
	17:00	24	56	19	South West	-
	19:00	23	56	19	South West	-
	21:00	21	54	20	On	-
	23:00	20	63	18	On	-
	01:00	18	60	18	On	-
09/10/2023	05:00	17	85	3	South East	-
	07:00	18	80	3	South East	-
	09:00	22	68	4	On	-
	11:00	26	41	7	On	-
	13:00	29	31	9	On	-
	15:00	28	35	9	South East	-
	17:00	26	41	11	On	-
	19:00	26	41	13	South West	-
	21:00	22	40	13	On	-
	23:00	19	38	11	On	-
	01:00	18	38	11	On	-

Source: Directorate of Meteorology and Hydrology, DMH (daytime forecast).

The climatic conditions presented in the two days of measurement were suitable for recording the sound levels.

4.2 Results of LAeq1hour (dBA) sound levels in Point 1

Table 6 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 1 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the IFC MASS Guidelines.

The total compliance of the results obtained with the provisions of the IFC Guidelines is highlighted. With regard to compliance with Law No. 1100/97, it was also possible to verify full compliance with the schedule from 07:00 to 20:00; However, from 20:00 to 07:00 the levels were higher than what is allowed by law, except for the first time of measurement (04:31:00).

Table 6. Compliance with national and international regulations of the results of the sound levels LAeq1hour (dBA) in Point 1

Point	Timetable	Cumulative sound level LAeq1hour (dBA)	Compliance			
			Ley N° 1100/97		CFI Guides	
			07:00 to 20:00	8:00 p.m. to 7:00 a.m.	07:00 to 22:00	10:00 p.m. to 7:00 a.m.
			75 dBA	60 dBA	70 dBA	
1 – Main Access to the Property	04:31:00	57,1*		✓	✓	
	05:31:00	64,44431207		×	✓	
	06:31:00	63,0156269		×	✓	
	07:31:00	61,34709751	✓		✓	
	08:31:00	61,32018686	✓		✓	
	09:31:00	60,75769404	✓		✓	
	10:31:00	64,25489113	✓		✓	
	11:31:00	63,80845616	✓		✓	
	12:31:00	64,83809346	✓		✓	
	13:31:00	64,45128289	✓		✓	
	14:31:00	64,61098871	✓		✓	
	15:31:00	64,56975525	✓		✓	
	16:31:00	65,2993824	✓		✓	
	17:31:00	65,14630637	✓		✓	
	18:31:00	65,06028275	✓		✓	
	19:31:00	65,37374355*	✓		✓	
	20:31:00	65,33555629		×	✓	
	21:31:00	65,11980296		×	✓	
	22:31:00	64,93759659		×	✓	
	23:31:00	64,8339658		×	✓	
	00:31:16	64,71544284		×	✓	

*The maximum recorded value of LAeq1hour was 65.37 dBA; while the minimum value of LAeq1hour was 57.1 dBA.

4.2.1 Behaviour of sound levels in Point 1

Figure 2 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The highest value of instantaneous sound levels was 89.4 dB; It was produced and recorded at the exact moment that one of the tires of a medium-sized cargo truck that was traveling along the Villeta-Alberdi Route exploded. It is important to remember that Point 1 of measurement was located at the future main access of the Industrial Plant, therefore, it was very close to the aforementioned Route. This incident occurred approximately 30 meters away from where the sound level meter was located.

The other instantaneous sound levels recorded, which are in a range between 70 and 85 dB, were caused by the different mobile sources, mainly large trucks that traveled along the Route at high speeds. The circulation of heavy trucks was more frequent at night and early in the morning.

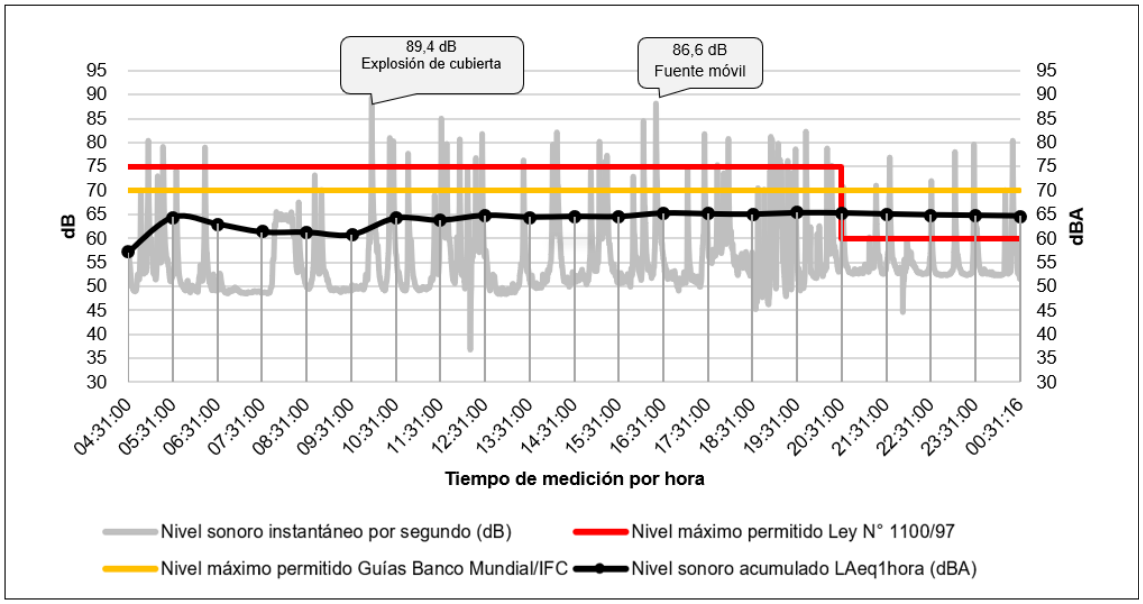

Figure 2. Behaviour of LAeq1hour (dBA) sound levels and their contrast with national and international standards in Point 1

The minimum instantaneous sound level recorded was 36.8 dB; and the average was 55.1 dB; which would be practically the levels that were maintained in the vicinity of the measurement point (in the absence of any external source, for example: mobile sources) produced by different types of insects, amphibians, birds.

LAeq1hour results remained in a range of 57.1 and 65.3 dBA during the 20 hours of measurement.

4.3 Results of sound levels LAeq1hour (dBA) in Point 2

Table 7 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 2 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's MASS Guidelines.

The results obtained have been fully complied with in accordance with the provisions of the IFC's MASS Guidelines and Law No. 1100/97 on the prevention of noise pollution.

Table 7. Compliance with national and international regulations of the results of the sound levels LAeq1hour (dBA) in Point 2

Point	Timetable	Cumulative sound level LAeq1hour (dBA)	Compliance			
			Ley N° 1100/97		CFI Guides	
			07:00 to 20:00	8:00 p.m. to 7:00 a.m.	07:00 to 22:00	10:00 p.m. to 7:00 a.m.
			75 dBA	60 dBA	70 dBA	
2 – ATOME Property Boundary – Near Neighbor's Barn	05:35:00	58,2		✓	✓	
	06:35:00	58,24211962		✓	✓	
	07:35:00	59,62836528	✓		✓	
	08:35:00	59,95574047*	✓		✓	
	09:35:00	58,74830527	✓		✓	
	10:35:00	58,09150913	✓		✓	
	11:35:00	57,32191866	✓		✓	
	12:35:00	57,22802704	✓		✓	
	13:35:00	57,78400861	✓		✓	
	14:35:00	57,80089311	✓		✓	
	15:35:00	57,76402453	✓		✓	
	16:35:00	58,11401744	✓		✓	
	17:35:00	57,838031	✓		✓	
	18:35:00	57,60459953	✓		✓	
	19:35:00	57,64053894	✓		✓	
	20:35:00	57,36483823		✓	✓	
	21:35:00	57,18615704		✓	✓	
	22:35:00	57,15483786		✓	✓	
	23:35:00	56,92197917		✓	✓	
	00:35:00	56,69516653		✓	✓	
	01:35:16	56,62094827*		✓	✓	

*The maximum recorded value of LAeq1hour was 59.9 dBA; while the minimum value of LAeq1hour was 56.62 dBA.

4.3.1 Behaviour of sound levels in Point 2

Figure 3 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC MASS Guidelines (orange line).

Point 2 of measurement was located on Atome's property but close to the home of the neighbors of the adjoining property, whose activity is characterized by the breeding of various types of farm animals. It is important to remember the dynamics of the environment of the measurement point, since the

highest value of instantaneous sound levels recorded was 83.6 dB; that they occurred at two times of the day, one of them in the early hours of the morning (07:17:08) which coincides exactly with the time when the horses were taken to graze, and the other in the afternoon (16:28:20) when the horses returned to the barn; The coming and going of the animals involved their passage through the vicinity of the measuring point (neighing and galloping), generating the aforementioned sound levels.

In addition, other values that exceed 70 dB could be attributed to the other animals on the farm, mainly birds such as chickens, ducks, turkeys, geese, roosters, etc., which at times also moved in the vicinity of the measurement point and that with their songs and clucks became sources of sound levels.

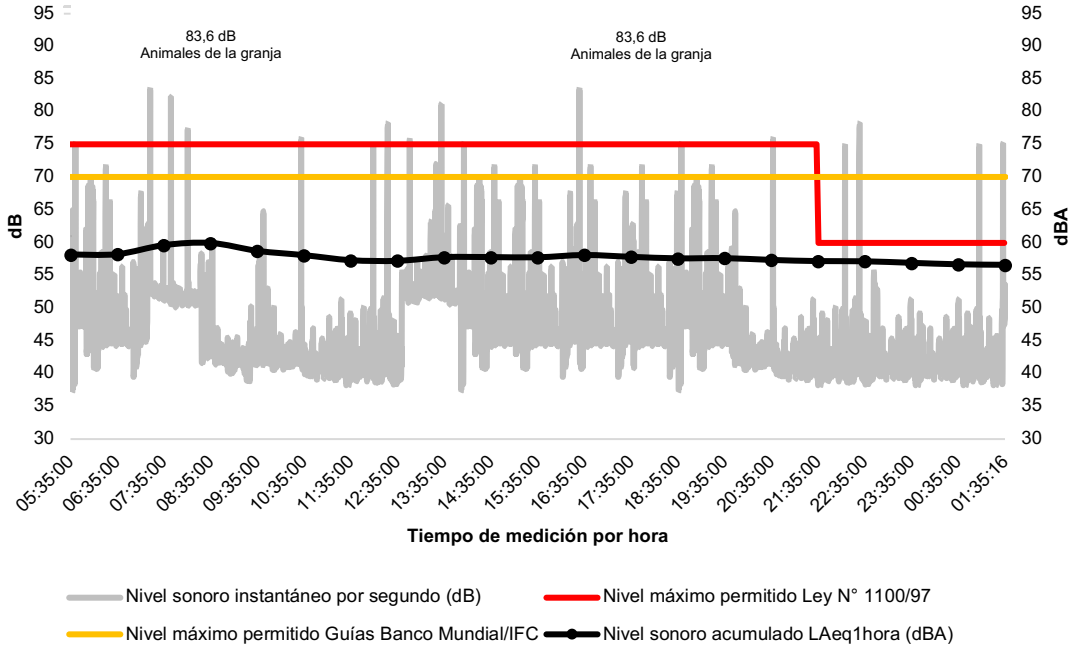

Figure 3. Behaviour of $LAeq_{1hora}$ (dBA) and its contrast with national and international regulations in Point 2

At night and early in the morning, when the farm animals were already sheltering in the barn or in the pens, the canines with their barking became sources of sound levels.

The minimum instantaneous sound level recorded was 37.4 dB; and the average yielded a value of 45.6 dB. In addition, the sounds generated by different types of insects, amphibians, and birds were a constant.

LAeq1hour results remained in a range of 56.6 and 59.9 dBA during the 20 hours of measurement.

4.3 Results of LAeq1hour (dBA) sound levels in Point 3 considering limits for Industrial Area

Table 8 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 3 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's General Guidelines on Environment, Health and Safety for the Industrial Area.

Regarding the contrast of the results obtained with the IFC's General Guidelines on the Environment, Health and Safety, it was possible to detect in the hours of 06:33:12 and 07:33:12 values that exceed what is allowed, in the rest of the schedules values below 70 dBA were presented.

With regard to compliance with Law No. 1100/97, total compliance was observed between 07:00 and 20:00; However, from 20:00 to 07:00 the levels were higher than what is allowed by law at all times.

Table 8. Compliance with national and international regulations of the results of the sound levels LAeq1hora (dBA) in Point 3 – Industrial Area

Point	Time	Cumulative sound level $LAeq_{1hora}$ (dBA)	Compliance			
			Law No. 1100/97 on the Prevention of Noise Pollution		IFC General Environmental, Health and Safety Guidelines	
			07:00 to 20:00	20:00 to 07:00	07:00 to 22:00	22:00 to 07:00
			75 dBA	60 dBA	70 dBA	
3 – Main access to the neighbours' house	05:33:12	61,2*		×	✓	
	06:33:12	73,14897839*		×	×	
	07:33:12	71,04904653	✓		×	
	08:33:12	70,17712384	✓		✓	
	09:33:12	69,80148867	✓		✓	
	10:33:12	69,65807204	✓		✓	
	11:33:12	69,61756739	✓		✓	
	12:33:12	69,12150994	✓		✓	
	13:33:12	68,66589614	✓		✓	
	14:33:12	68,37534767	✓		✓	
	15:33:12	68,11324953	✓		✓	
	16:33:12	67,74555474	✓		✓	
	17:33:12	67,38566265	✓		✓	
	18:33:12	67,0629521	✓		✓	
	19:33:12	66,80702657	✓		✓	
	20:33:12	66,51956989		×	✓	
	21:33:12	66,25814196		×	✓	
	22:33:12	66,01255585		×	✓	
	23:33:12	65,79616673		×	✓	
	00:33:12	65,57730409		×	✓	

Point	Time	Cumulative sound level $LAeq_{1hora}$ (dBA)	Compliance			
			Law No. 1100/97 on the Prevention of Noise Pollution		IFC General Environmental, Health and Safety Guidelines	
			07:00 to 20:00	20:00 to 07:00	07:00 to 22:00	22:00 to 07:00
			75 dBA	60 dBA	70 dBA	
	01:33:28	65,37485103		✗	✓	

*The maximum recorded value of LAeq1hour was 73.1 dBA; while the minimum value of LAeq1hour was 61.2 dBA.

4.3.1 Behaviour of sound levels in Point 3 considering limits for Industrial Area

Figure 4 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The highest noise levels were produced by the different activities related to the care and maintenance of the farm. In addition, another source that generated sound levels that was perceived from the measurement point were the mobile sources that traveled at high speeds along the Villeta-Alberdi Route.

According to the conditions in which the measurements were carried out, the possibility that a source generating sound levels from the property where the Industrial Plant would be installed could produce exposure levels that could affect the inhabitants of the house of the neighboring property is ruled out.

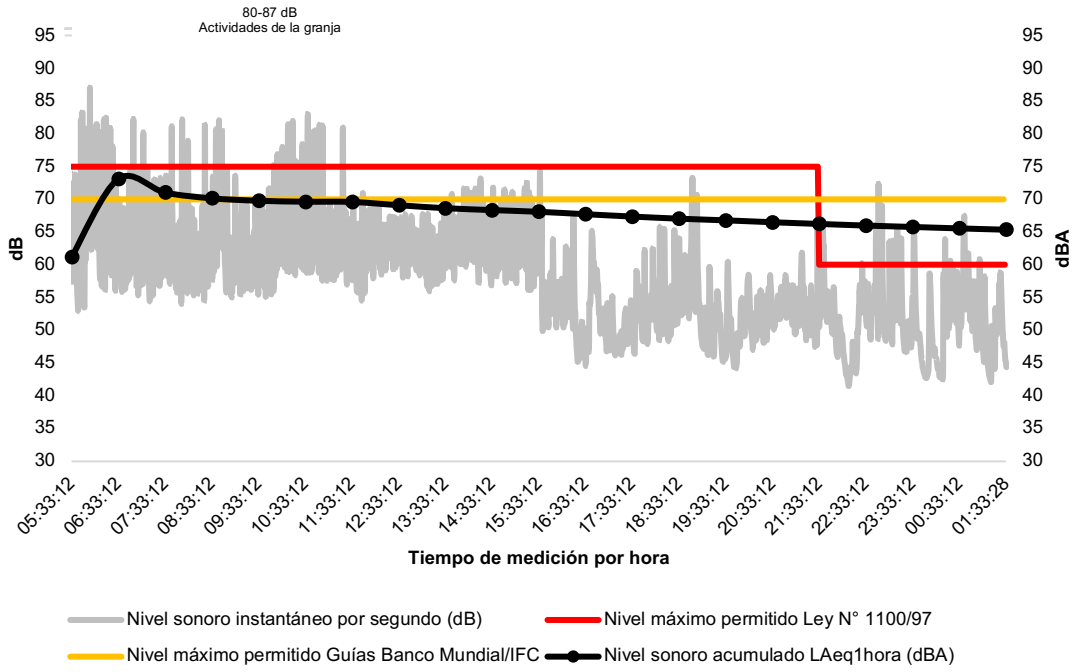

Figure 4. Behaviour of LAeq1hour (dBA) sound levels and their contrast with national and international regulations in Point 3 – Industrial Area.

The minimum instantaneous sound level recorded was 41.5 dB; and the average yielded a value of 57.7 dB.

LAeq1hour results remained in a range of 61.2 and 73.1 dBA during the 20 hours of measurement.

4.3 Results of LAeq1hour (dBA) sound levels in Point 3 considering limits for Residential Area

Table 9 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 3 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's General Guidelines on Environment, Health and Safety for the Residential Area.

In the contrast of the LAeq1hour results in dBA with both regulations, it was found that in all cases the maximum allowed in each of the schedules is exceeded.

Table 10. Compliance with national and international regulations of the results of the sound levels LAeq1hour (dBA) in Point 3 – Residential Area

Point	Time	Cumulative sound level $LAeq_{1hora}$ (dBA)	Compliance			
			Law No. 1100/97 on the Prevention of Noise Pollution		Guías Generales sobre Medio Ambiente, Salud y Seguridad de la IFC	
			07:00 to 20:00	20:00 a 07:00	07:00 a 22:00	22:00 a 07:00
			60 dBA	45 dBA	55 dBA	45 dBA
3 – Main access to the neighbours' home	05:33:12	61,2*		×		×
	06:33:12	73,14897839*		×		×
	07:33:12	71,04904653	×		×	
	08:33:12	70,17712384	×		×	
	09:33:12	69,80148867	×		×	
	10:33:12	69,65807204	×		×	
	11:33:12	69,61756739	×		×	
	12:33:12	69,12150994	×		×	
	13:33:12	68,66589614	×		×	
	14:33:12	68,37534767	×		×	
	15:33:12	68,11324953	×		×	
	16:33:12	67,74555474	×		×	
	17:33:12	67,38566265	×		×	
	18:33:12	67,0629521	×		×	
	19:33:12	66,80702657	×		×	
	20:33:12	66,51956989		×	×	
	21:33:12	66,25814196		×	×	
	22:33:12	66,01255585		×	×	
	23:33:12	65,79616673		×		×
	00:33:12	65,57730409		×		×
	01:33:28	65,37485103		×		×

*The maximum recorded value of LAeq1hour was 73.1 dBA; while the minimum value of LAeq1hour was 61.2 dBA.

4.3.1 Behavior of sound levels in Point 3 considering limits for Residential Area

Figure 5 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The highest noise level recorded was 87 dB, produced by the different activities of the inhabitants of the house, mainly related to the care and maintenance of the farm, such as the use of wheelbarrows to transport balance bags to feed the animals, the use of edgers and weeders to clear the land and the circulation of motorcycles to access the farm. Also in the morning, during the measurements, the farm managers were observed carrying out repair activities on the zinc-coated galvanized sheet metal roof of the barn, producing sound levels due to the succession of continuous blows with the hammer through the metal.

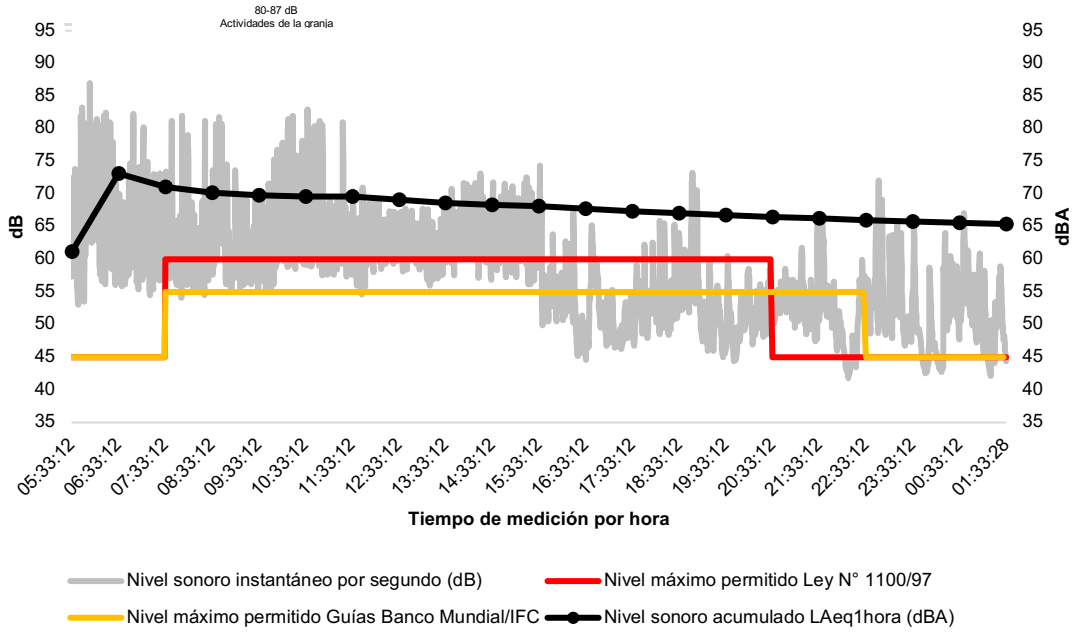

Figure 5. Behaviour of the LAeq1hour (dBA) sound levels and their contrast with national and international regulations in Point 3 – Residential Area.

Other main sources that contributed to high noise levels were the barking of the 4 canines on the farm. Other instantaneous sound level values are also related to the constant transit of different types of farm animals and their own characteristic sounds, becoming sound sources.

4.5 Results of sound levels LAeq1hour (dBA) in Point 4

Table 11 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 4 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's General Guidelines on the Environment, Health and Safety.

The total compliance of the results obtained with the provisions of the IFC's General Guidelines on Environment, Health and Safety is highlighted.

With regard to compliance with Law No. 1100/97, it was only possible to detect at 05:51:00 a value that exceeds that allowed by law.

Table 11. Compliance with national and international regulations of the sound levels results LAeq1hora (dBA) in Point 4.

Point	Time	Cumulative noise level $LAeq_{1hora}$ (dBA)	Compliance			
			Law N° 1100/97		IFC Guidelines	
			07:00 to 20:00	20:00 to 07:00	07:00 to 22:00	22:00 to 07:00
			75 dBA	60 dBA	70 dBA	
4 – Future area of fixed noise-emitting sources	05:51:00	63,2*		×	✓	
	06:51:00	55,01006306		✓	✓	
	07:51:00	54,87408975	✓		✓	
	08:51:00	53,5705438	✓		✓	
	09:51:00	55,17344041	✓		✓	
	10:51:00	54,46582421	✓		✓	
	11:51:00	53,79619023	✓		✓	
	12:51:00	53,27662597	✓		✓	
	13:51:00	52,93351851	✓		✓	
	14:51:00	52,9336212*	✓		✓	
	15:51:00	54,59271033	✓		✓	
	16:51:00	55,78908322	✓		✓	
	17:51:00	55,87865794	✓		✓	
	18:51:00	55,80355215	✓		✓	
	19:51:00	55,64230626	✓		✓	
	20:51:00	55,45257598		✓	✓	
	21:51:00	55,25446216		✓	✓	
	22:51:00	55,05381386		✓	✓	
	23:51:00	54,97782434		✓	✓	
	00:51:00	54,96970173		✓	✓	
	01:51:16	54,84299224		✓	✓	

*The maximum recorded value of LAeq1hour was 63.2 dBA; while the minimum value of LAeq1hour was 52.9 dBA.

4.5.1 Behaviour of sound levels in Point 4

Figure 6 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The value of 80.5 dB was the highest recorded, this could be presumed to be due to an isolated case, that according to the characteristics of the site where the sound level meter was located, flocks of parrots *(Tu'i karanda'y)* were observed that could have been perched by the equipment or with their song could have become sound sources. Also, during the measurements, the presence of a fox (*Aguara'i) could be observed*, an animal characterized by its cunning and curiosity, so it could also be presumed that at some point it could have approached the measuring equipment.

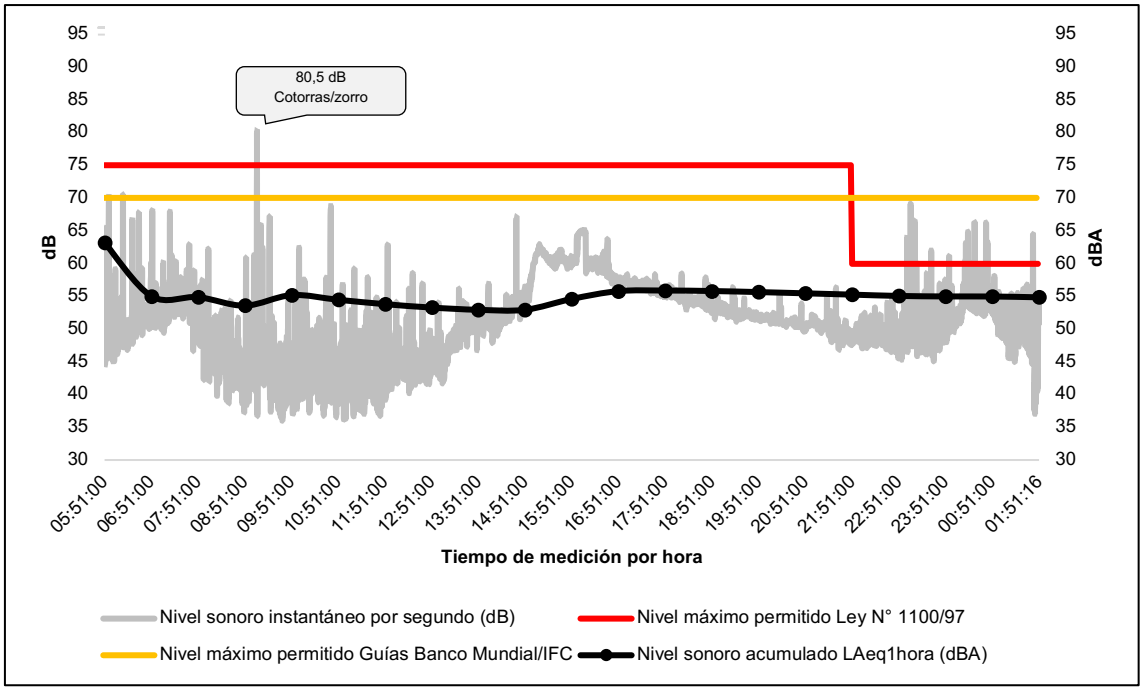

Figure 6. Behaviour of LAeq1hour (dBA) sound levels and their contrast with national and international regulations in Point 4.

The minimum instantaneous sound level recorded was 36 dB; and the average yielded a value of 50.8 dB; which would be practically the levels that were maintained in the vicinity of the measurement point (in the absence of any external source) produced by different types of insects, amphibians, birds.

The LAeq1hour results remained in a range of 52.9 and 63.2 dBA during the 20 hours of measurement.

Figure 7 shows the sound map of the behavior of the LAeq20 hours sound levels in the study area.

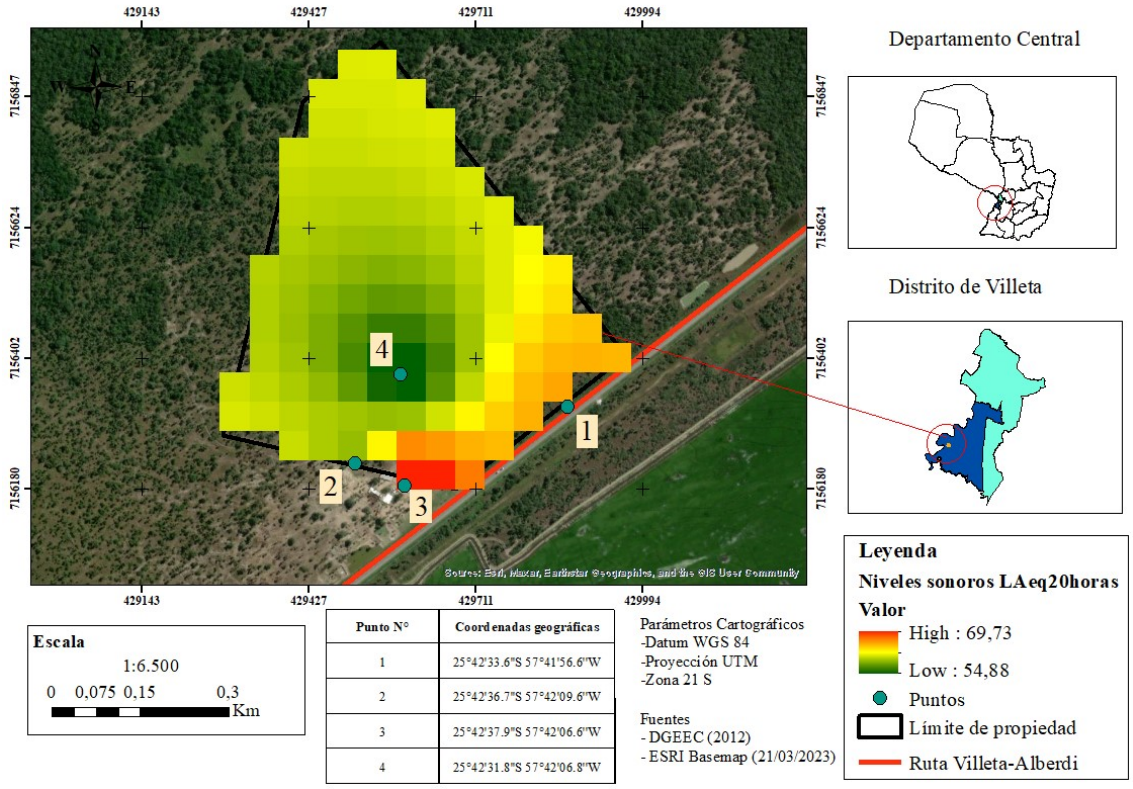

Figura 7. Sound map showing the behaviour of sound levels $LAeq_{20horas}$.

5. CONCLUSIONS

It was possible to monitor the sound levels in compliance with all the requirements established in the terms of reference provided for the consulting service.

All appropriate controls and procedures were applied to carry out the measurements of sound levels.

The peak instantaneous sound levels were maintained in a range of 80.5 and 89.4 dB between the 4 recording points during the 20 hours of measurement, which were produced by sources outside the property or by the activities of the farm adjacent to it.

Instantaneous sound levels were maintained in a range of 36 and 89.4 dB between the 4 recording points during the 20 hours of measurement

LAeq1hour levels were maintained in a range of 52.9 and 73.1 dBA between the 4 recording points during the 20 hours of measurement.

In Point 1, a level of compliance of 66.7% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 100% compliant.

In Point 2, a level of compliance of 100% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety also recorded 100% compliance.

For the analysis of Point 3 and its contrast as an Industrial Area, a level of compliance of 62% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 90% compliant.

Regarding the analysis of point 3 and its contrast as a Residential Area, a level of compliance of 0% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution and the IFC's General Guidelines on the Environment, Health and Safety.

In Point 4, a level of compliance of 95% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 100% compliant.

In general, at the 4 recording points during the 20 hours of measurement, there was a level of compliance of 81% for Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 98% compliant.

The results obtained will constitute a fundamental input to fulfill the purpose of the consultancy, which is to carry out the modeling of the propagation of sound levels.

6. TECHNICAL TEAM

Table 12. Technical Team

Nombre y Apellido	Función
Bruno Lovera	Environmental Technician coordinator of the measurements, field collaborator
Eng. Amb. César Fleitas Franco	Professional Technician registered by the Ministry of Labour, Employment and Social Security
Eng. Amb. Julio Bordón Gadea	Field collaborator for measurements, data processing and reporting
Osvaldo Avalos Jara	Trained field collaborator to perform the measurements

7. REFERENCES

International Finance Corporation. 2007. General Guidelines on Environment, Health and Safety. World Bank Group. 116 p

Kiely, G. 1999. Environmental Engineering: Fundamentals, Environment, Technology and Management Systems. Madrid, ES. 1331 p.

Municipality of Villeta. 2017. Ordinance No. 25/2017 amending and updating Ordinance No. 2/94 regulating the advertising and noise nuisance system within the district of Villeta in accordance with the provisions of Law No. 1100/97 on the Prevention of Sound Pollution. Villeta. PY. 3 p.

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Seguéz, F. 2008. Noise mapping strategy (online). Center for the Study and Experimentation of Public Works. Available in: http://www.imac.unavarra.es/web_imac/pages/investigacion/proyectos_investigacion/ForoVerde/disturbeco/documentos/Estrategia_elaboracion_mapa_ruido.pdf

8. ATTACHMENTS

8.1 Technical Specifications of Sound Level Meters

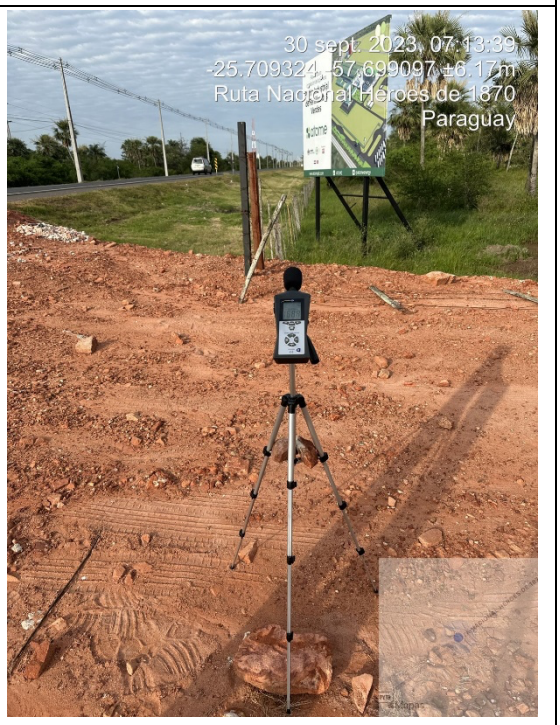
Table 13. Technical specifications of the PCE-322A sound level meter.

Technical Specifications		**Illustrative Image**
Measuring Ranges	Low: 30 a 80 dB	
	Medium: 50 a 100 dB	
	High: 80 a 130 dB	
	Auto: 30 a 130 dB	
Resolution	0,1 dB	
Precision	±1,4 dB	
Frequency	31,5 Hz a 8 kHz	
Memory	Approx. 32700 data + 32 GB memory card (accessory)	
Frequency Weighting	A - C	
Microphone Type	Electret Capacitor	
Functions	Values MIN, MAX, HOLD	
Operating Conditions	0 a 40 °C	
	< 90 % H.r.	
Power Source	Batery of 9 V	
Dimensions	280 x 95 x 45 mm	
Weight	Aprox. 350 g. (without batteries)	
Type	Class II	
Compliance with international standard	IEC61672-1	

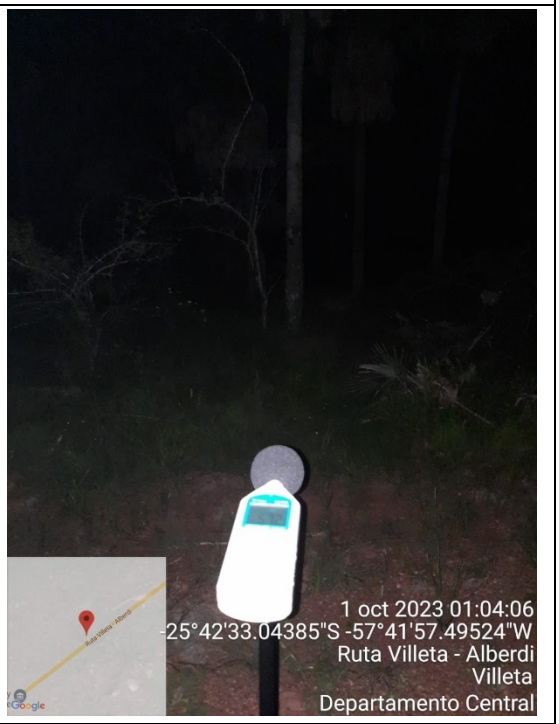
Tabla 14. Technical specifications of the Minipa MSL-1355B

Technical Specifications		**Illustrative Image**
Resolution	0,1 dB	
Frequency Weighting	A - C	
Response Time	Fast - Slow	
Datalogger (memoria)	Approx. 4422 data points	
Datalogger Time Interval	From 1 to 250 seconds	
Battery life	Approx. 20 hours of continuous use	
Operating Conditions	0°C – 40°C	
	HR ≤ 80%	
Dimensions	256 x 70 x 35 mm	
Weight	244 g (without batteries)	
Measuring Ranges	30 a 80 dB	
	30 a 130 dB	
	50 a 100 dB	
	60 a 110 dB	
	80 a 130 dB	
Precision	±1,5 dB	
Frequency	31,5 Hz a 8,5 kHz	
Type	Class II	
Compliance with international standard	IEC PUB 651	

8.2 Photographic record of measurements

<table>
<tr><th colspan="2">Point 1. Main access to the property</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photograph 1. Monitoring of Sound Levels in the morning hours</td><td>Photograph 2. Monitoring of Sound Levels in the morning hours</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photograph 3. Monitoring of Sound Levels at Point 1 at noon</td><td>Photograph 4. Monitoring of Sound Levels at Point 1 in the afternoon</td></tr>
</table>

<table>
<tr><th colspan="2">Point 1. Main access to the property</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photograph 5. Monitoring of Sound Levels at night</td><td>Photographs 5 and 6. Monitoring of Sound Levels at night</td></tr>
</table>

Point 2. ATOME Property Boundary – Near Neighbor's Barn	
	
Photograph 7. Monitoring of Sound Levels in the morning hours.	Photograph 8. Monitoring of Sound Levels in the morning hours.
	
Photograph 9. Monitoring of Sound Levels in the Afternoon	Photograph 10. Monitoring of Sound Levels at night

Point 3. Main access to the neighbours' house.



Photograph 11. Monitoring of Sound Levels in the morning hours



Photograph 12. Monitoring of Sound Levels in the morning hours.

Point 3. Main access to the neighbours' house.



Photographs 13 and 14. Monitoring of Sound Levels at night



Photograph 14. Monitoring of Sound Levels at night

Punto 4. Futura zona de fuentes fijas emisoras de ruido



Photograph 15. Monitoring of Sound Levels at Point 4 in the morning hours



Photograph 16. Monitoring of Sound Levels at Point 4 in the morning hours



Photograph 17. Monitoring of Sound Levels in the morning hours

8.3 PCE-322A Sound Level Meter Calibration Certificate

LABSOL

CERTIFICADO DE CALIBRACIÓN

SERVICIO ACREDITADO

Organismo Nacional de Acreditación
NP-ISO/IEC 17025:2018
LC009

Certificado N°:	LS20977-2023

1. SOLICITANTE:	JULIO BORDON
Dirección:	Lomas Valentinas c/ Campo Via – Fdo. de la Mora
RUC:	3183136-2

2. DATOS DEL EQUIPO CALIBRADO			
Instrumento:	SONOMETRO	N° de Serie:	180924367
Identificación:	SON-01	Intervalo:	(94 a 114) dB
Marca:	PCE	Resolución:	0,1 dB
Modelo:	322A	Tipo:	DIGITAL

3. PATRONES UTILIZADOS				
Identificación:	PCA-01	PCT-35	---	---
Descripción:	Calibrador acústico	Termohigrometro	---	---
Certificado:	122.855	LS19107-2023	---	---
Próx. Calibración:	2024-02	2024-06	---	---

4. DATOS DE CALIBRACIÓN	
Fecha de calibración:	2023-09-28
Lugar de calibración:	Laboratorio LABSOL
Temperatura:	22,6 °C
Humedad Relativa:	55 %
Procedimiento/s:	LS-PRO-C37 Rev.01

5. ABREVIATURAS	
IP:	Promedio de indicacion del patrón
IEC:	Promedio de indicacion del equipo calibrado
E:	Error de medición
U:	Incertidumbre de medición
k:	Factor de cobertura

Realizado por: Tomás Duarte

Código: ID2022LS028

Autorizado por: Andrea Fernandez

Código: ID2017LS008

6. OBSERVACIONES

La incertidumbre expandida de medida informada se expresa como la incertidumbre de medida estándar multiplicado por el factor de cobertura k con una probabilidad correspondiente a aproximadamente del 95%.
La incertidumbre típica combinada fue determinada en conformidad con el documento Guía para la Expresión de la incertidumbre en las mediciones (GUM).

Firmado digitalmente por ANDREA BEATRIZ FERNANDEZ BAEZ

Este documento ha sido firmado digitalmente y tiene validez legal de acuerdo a la Ley 4017/2010

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohibe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

LS-FOR-038 Rev.06
Vigencia: 2021-09-11

8.3 PCE-322A Sound Level Meter Calibration Certificate (Continued)

LABSOL

CERTIFICADO DE CALIBRACIÓN

SERVICIO ACREDITADO

Organismo Nacional de Acreditación
NP-ISO/IEC 17025:2018
LC009

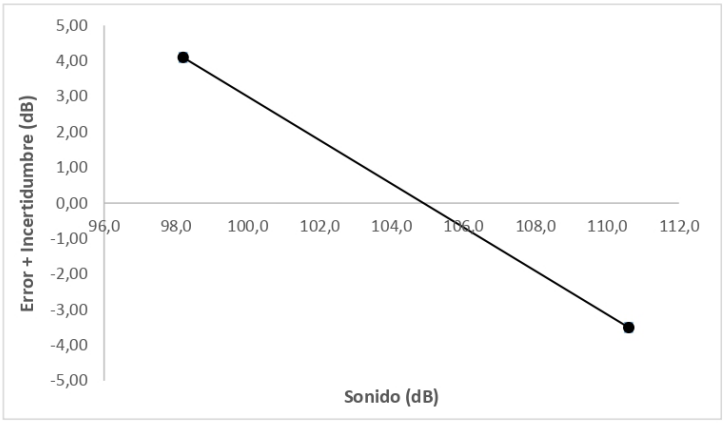
Certificado N°:	LS20977-2023

7. RESULTADOS

SONIDO (dB)

IP (dB)	IEC (dB)	E (dB)	U (dB)	k
94,1	98,2	4,10	0,12	2,00
114,1	110,6	-3,50	0,12	2,00

RESULTADO GRÁFICO DE LA CALIBRACIÓN



8. FECHA DE EMISIÓN DEL CERTIFICADO: 2023-10-02

--- FIN DEL CERTIFICADO ---

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohibe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

8.4 Minipa MSL-1355B Sound Level Meter Calibration Certificate

LABSOL

CERTIFICADO DE CALIBRACIÓN

SERVICIO ACREDITADO

Organismo Nacional de Acreditación NP-ISO/IEC 17025:2018 LC009

Certificado N°:	LS20702-2023

1. SOLICITANTE:	TECNOAMBIENTAL S.R.L.
Dirección:	Jose Viñuales - Fernando de La Mora
RUC:	80070966-7

2. DATOS DEL EQUIPO CALIBRADO			
Instrumento:	SONOMETRO	N° de Serie:	002182H
Identificación:	DB1	Intervalo:	(94 a 114) dB
Marca:	MINIPA	Resolución:	0,1 dB
Modelo:	MSL-1355B	Tipo:	DIGITAL

3. PATRONES UTILIZADOS				
Identificación:	PCA-01	PCT-35	---	---
Descripción:	Calibrador acústico	Termohigrometro	---	---
Certificado:	122.855	LS19107-2023	---	---
Próx. Calibración:	2024-02	2024-06	---	---

4. DATOS DE CALIBRACIÓN	
Fecha de calibración:	2023-09-08
Lugar de calibración:	Laboratorio LABSOL
Temperatura:	22,4 °C
Humedad Relativa:	83 %
Procedimiento/s:	LS-PRO-C37 Rev.00

5. ABREVIATURAS	
IP:	Promedio de indicacion del patrón
IEC:	Promedio de indicacion del equipo calibrado
E:	Error de medición
U:	Incertidumbre de medición
k:	Factor de cobertura

Realizado por: Juan Velázquez

Código: ID2023LS032

Autorizado por: Andrea Fernandez

Código: ID2017LS008

6. OBSERVACIONES

La incertidumbre expandida de medida informada se expresa como la incertidumbre de medida estándar multiplicado por el factor de cobertura k con una probabilidad correspondiente a aproximadamente del 95%.
La incertidumbre típica combinada fue determinada en conformidad con el documento Guía para la Expresión de la incertidumbre en las mediciones (GUM).

Firmado digitalmente por ANDREA BEATRIZ FERNANDEZ BAEZ

Este documento ha sido firmado digitalmente y tiene validez legal de acuerdo a la Ley 4017/2010

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohibe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

8.4 Minipa MSL-1355B Sound Level Meter Calibration Certificate (Continued)

LABSOL

CERTIFICADO DE CALIBRACIÓN

Certificado N°: LS20702-2023

SERVICIO ACREDITADO

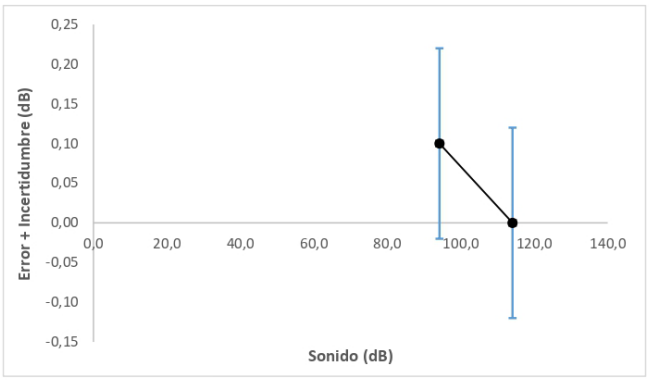
Organismo Nacional de Acreditación
NP-ISO/IEC 17025:2018
LC009

7. RESULTADOS

SONIDO (dB)

IP (dB)	IEC (dB)	E (dB)	U (dB)	k
94,1	94,2	0,10	0,12	2,00
114,1	114,1	0,00	0,12	2,00

RESULTADO GRÁFICO DE LA CALIBRACIÓN



8. FECHA DE EMISIÓN DEL CERTIFICADO: 2023-09-14

--- FIN DEL CERTIFICADO ---

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohíbe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

8.5 Technical professional register of the Ministry of Labour, Employment and Social Security of the technician in charge of the measurements

Ministerio de TRABAJO, EMPLEO Y SEGURIDAD SOCIAL

GOBIERNO NACIONAL

Paraguay de la gente

Registrado en:
Dirección de Salud y Seguridad Ocupacional
VICEMINISTERIO DE TRABAJO
Registro Profesional Técnico

Nombre Completo
CESAR AUGUSTO FLEITAS FRANCO

C.I. Nro.
2859882

Foto Carnet



Categoría
Reg. Profesional Renovación A

Fecha Registro
4/9/2023

Fecha Vencimiento
4/9/2025

Annex 6 – Noise Modeling Report

Assessment of the impact on the acoustic environment – Sound pressure level modelling

November 2023

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1. Introduction

An assessment was made of the acoustic impact that the environment could suffer because of the future operation of ATOME's hydrogen, ammonia, and fertilizer production plant, to be installed in the district of Villeta, in the Central Department of the Republic of Paraguay.

To this end, a sound pressure level modelling (hereinafter NPS) of the operating condition of the industrial plant was carried out, including the main sources of noise generated considered under conservative scenarios. The description and characterization of these sources was provided by URBAS Energy, a company contracted by ATOME, for the development of Engineering and Initial Design of the Plant (FEED).

The modelling carried out made it possible to characterise the future sound environment of the immediate surroundings by studying the propagation of the noise generated by the operation of the industrial plant under regime conditions and characterising the current situation of the area (baseline), determining the incremental contribution of the project and the degree of compliance with the objective acoustic quality values proposed by the regulations and reference guides.

For the analysis, two different scenarios were considered: Esc 1 and Esc 2. The first includes the contribution of the main sound sources foreseen by the project, and the second includes, in addition to the main sound sources, the noise abatement measures currently considered in the engineering design of the project.

The characterization of the current situation (baseline) was carried out by ATOME based on a monitoring campaign in the area. The relevant report is contained in Annex II.

This report is structured in six chapters, which detail the regulations and guidelines used as references, the modelling methodology used, and the characterization of the issues required for modelling, the characterization of the environment (baseline) and, finally, the results and conclusions are presented.

2. Regulations and reference guide

Law No. 6.390/020 of the Republic of Paraguay regulates the emission of noise capable of affecting the well-being or harming the health of persons or living beings, to ensure the due protection of the population, the environment and property affected by exposure to noise. It also regulates that the municipalities will be the authorities in charge of the application of this law and that it is within their duties to establish the regulations associated with emission sources and target acoustic quality levels.

Given that Villeta does not yet have local ordinances that include regulations on the permitted sound pressure levels or target quality as indicated in Law 6.390/020, Law No. 1.100/97 has been taken as a reference, which, despite having been repealed, still represents a starting point for noise regulation in the region. This previous law established objective noise quality values, both for day and night, considering the characterization of land use.

In addition, the noise guidelines established in the General Environmental, Health and Safety Guidelines of the International Finance Corporation (IFC) have also been considered for the assessment.

The following table summarises the acoustic quality objectives of the regulations and reference guidelines according to the land use and the period surveyed.

Table 2-1 Acoustic Quality Objectives (dBA)

Regulations	Period	Land Use		
		Residential Areas	Mixed Areas, Transition Zones	Industrial area
Law No. 1.100/97 Paraguay LAeq, T	Daytime (7 a.m. to 8 p.m.)	60	70	75
	Evening (8 p.m. to 7 a.m.)	45	55	60
IFC Guides LAeq,1h	Daytime (7 a.m. to 10 p.m.)	55	-	70
	Night (10 p.m. to 7 a.m.)	45	-	70

Source: Prepared by the authors based on Law No. 1.110/97 and IFC guidelines

As can be seen, Paraguayan regulations and the IFC guide define the day and night period differently, so explicit mention will be made of which period is being referred to throughout the evaluation carried out.

3. Methodology for calculating and characterizing the aspects required for modelling

The evaluation of the impact on acoustic quality because of the operation of the project was carried out considering two different scenarios at the request of ATOME. The first (Esc 1) corresponds to considering all the main sources of noise emission operating continuously and simultaneously (conservative assumption) without including noise abatement measures that could reduce the emission. The second scenario analysed (Esc 2) arises from considering the previous scenario and adding the noise abatement measures defined during the engineering design of the industrial plant, as additional instruments to mitigate the acoustic impact that the project could generate on the environment.

The description and characterization of noise sources and abatement measures were provided by ATOME.

3.1. Description of the calculation methodology

The CadnaA *software from* DataKustik GmbH *(2020 version) was used for NPS modelling.* This *software* is based on numerical NPS calculation tools through different mathematical models of noise propagation, and, in this particular study, the calculations were based on the ISO 9613 standard for the modeling of industrial complexes, an internationally recognized calculation methodology for NPS modeling of this type of projects.

The *calculation software* used allows the incorporation of georeferenced elements for the development of the terrain model, such as contour lines, forested areas, emitting and receiving sources with their respective heights, among others.

With respect to the propagation calculation, the model considers geometric divergence attenuations[1], atmospheric absorption attenuation[2], ground effect attenuation, attenuations due to the presence of barriers (including buildings, structures, and topography), weather corrections, and wave reflections. The criteria for the determination of attenuation factors were based on the recommendations of ISO 9613 standards.

As a result of the modelling, within the adopted calculation configuration, the *software* returns estimated NPS values at the individual receivers evaluated, as well as an isophone line map for the entire evaluation area (calculation grid).

Regarding the calculation parameters used in this case, a factor of G=1 was considered for the absorption of the land, since most of the propagation area corresponds to porous land, areas covered with grass, trees, or vegetation, taking into account that even within the industrial plant there are green areas. Buildings were considered in all cases as reflective surfaces (G=0). The general order of reflection of the modelling was set in 1st order.

[1] $ADiv = 20 \log(d/d)_0) + 11$ dB

[2] For the standard frequency of 500 Hz, the atmospheric absorption attenuation of Aatm = 0.002 dB/m was considered.

3.2. Characterization of emitting sources

The emission sources indicated in the Table 3-1 operating at its maximum emission, continuously and simultaneously, which corresponds to a conservative assumption. These were georeferenced and with their corresponding heights.

The operation of these sources with the characterization indicated in the Table 3-1 was analysed in Scenario 1 (Esc 1).

Table 3-1 Emission data from major sources

Point	Description	Height (m)	Emitted noise (dBA) *
R1a	Air Separation Unit Main Air Compressor (USA)	0,5	85
R1b	USA Air Compressor Reserve	0,5	85
R2	Cooling tower (5 cells)	10	85
R3	Turboset	1	95
R4a	Syngas Main Compressor	1	95
R4b	Syngas compressor reserve	1	95
R4c	NH3 Compressor	1	95
R5	NH3 Synthesis Unit Chiller (x3)	5	85
B2a	Turboset A Room Fans	1,5	84
B2C	Turboset B Room Fans	1,5	84
B4a	Compressor Building Fans A	1,5	84
B4B	Compressor Building Fans B	1,5	84
B4C	C Compressor Building Fans	1,5	84

* 1 m from the equipment (distance at floor level)

Source: Based on information provided by ATOME (URBAS Energy).

During the engineering design of the project, various noise abatement measures were defined, such as specific insulation in buildings or the incorporation of silencers, to act directly on the emission. The details of these are presented in the Table 3-2 and its application was included in the analysis of Scenario 2 (Esc 2). It should be noted that noise abatement measures were not considered in Scenario 1 (Esc 1).

Table 3-2 Characterization of the noise abatement measures considered in Scenario 2

Point	Description	Height (m)	Mitigation Level (dBA)
B1	Turboset encapsulation	1,5	15
B2a	Turboset A Room Fans	1,5	15
B2B	Turboset intake air filter	1,5	15
B2C	Turboset B Room Fans	1,5	15
B3	Compressor Building Encapsulation	1,5	15
B4a	Compressor Building Fans A	1,5	15
B4B	Compressor Building Fans B	1,5	15
B4C	C Compressor Building Fans	1,5	15

Source: Based on information provided by ATOME (URBAS Energy).

3.3. Characterization of the terrain model and calculation grid

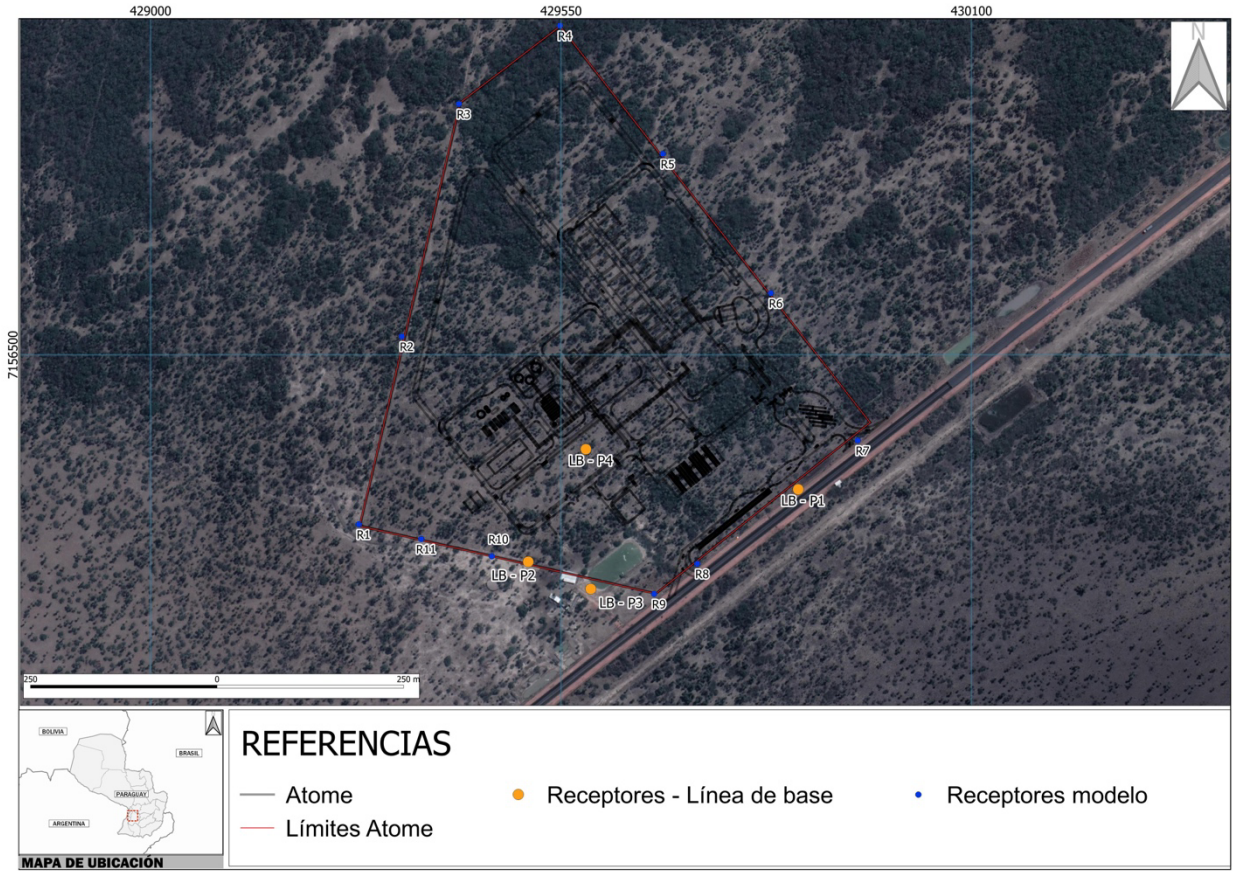
For the construction of the physical model, the general *layout* of the ATOME industrial plant was used (according to the plan "*VILLETA PLANT LAYOUT r05C*"), assigning names and heights to all the buildings, structures and tanks. Appendix I presents the details and characteristics of the buildings considered.

For the definition of the calculation grid, a grid size of 10 m x 10 m and a receiver height of 1.60 m were considered. In addition, particular individual receivers were defined to represent the perimeter of the industrial plant (property boundary) and other sites of particular interest.

Eleven point receptors were defined along the perimeter of the property and four additional receptors were incorporated corresponding to the monitoring sites where the NPS baseline measurements were performed. The LB-P3 receiver corresponds to the nearest inhabited dwelling. All recipients were assigned a height of 1.60 m, a value commonly defined as the average height of a person.

The following figure shows the location of all the point receptors considered.

Figure 3-1 Point Receivers Considered



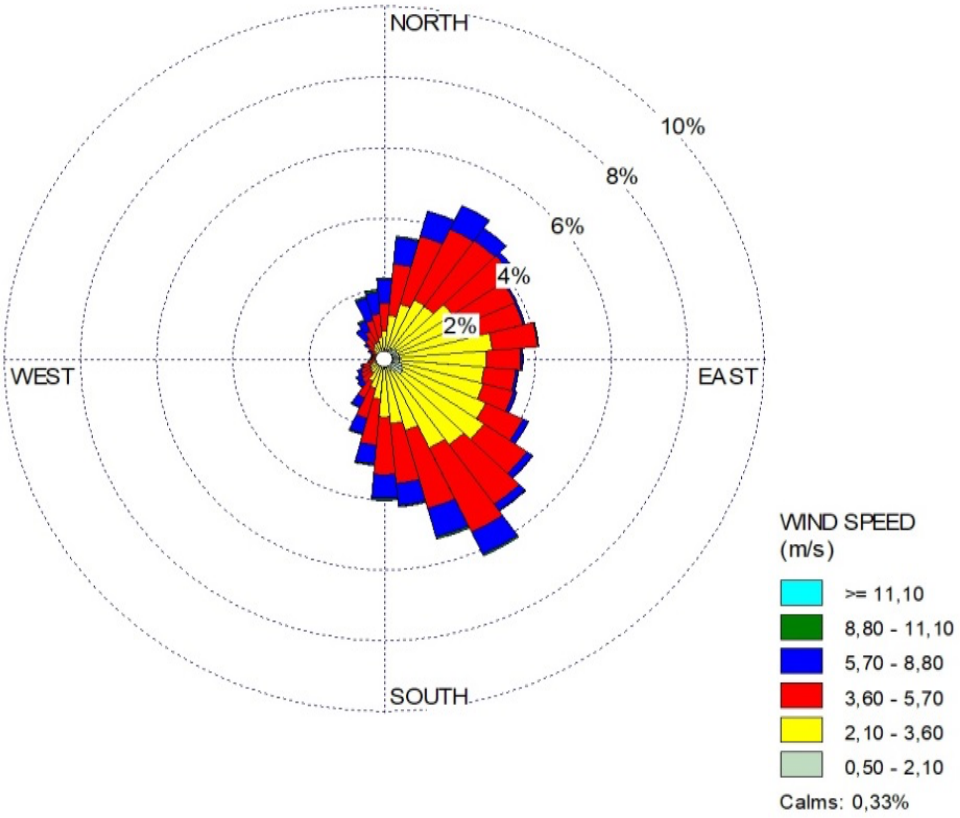
Source: Authors' own creation

3.4. Meteorological characterization

The characterization of the meteorological conditions and the correction required by the calculation method was carried out according to the compass rose presented in the Figure 3-2. This was obtained because of the WRF[3] mesoscale model in the industrial site, for the period of 2017-2021.

[3] The output of the WRF mesoscale model in the area of the industrial site for the period 2017-2021 was acquired from the company Lakes Environmental.

Figure 3-2 Compass Rose – 2017-2021



Source: Authors' elaboration based on the output of the WRF mesoscale model.

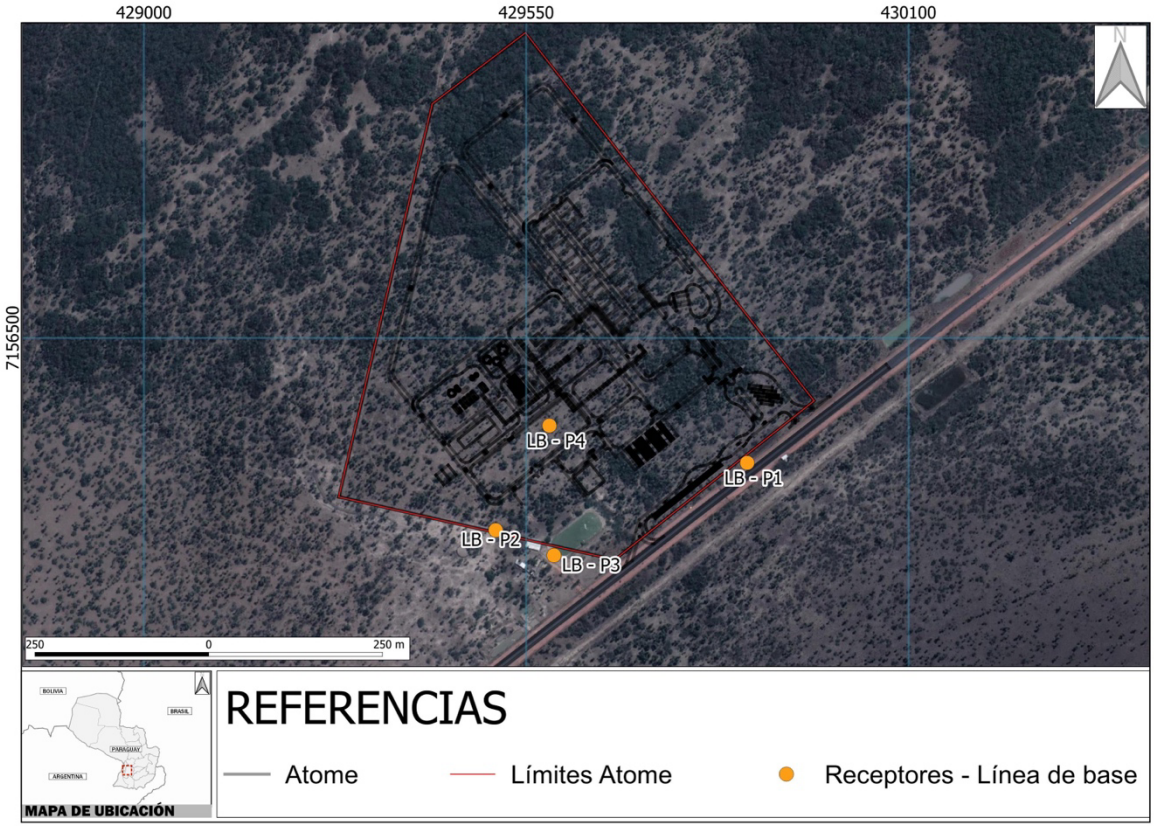
4. Baseline Characterization

The baseline characterization was provided by ATOME and is presented in Annex II.

An NPS measurement campaign was carried out between September 30 and October 10, 2023, during the day and at night, in four selected receivers located in the vicinity of the project, through a single continuous measurement of 20 hours per point.

In the Figure 4-1 You can see the location of the points surveyed and in the Table 4-1 Their coordinates are presented. The neighbouring property located to the south of the project corresponds to a rural productive establishment with animal husbandry (farm).

Figure 4-1 Points surveyed during baseline



Source: Authors' own elaboration based on data provided by ATOME

Table 4-1 Coordinates of monitoring points

Point	UTM Coordinates (21J)	
	East (m)	South (m)
LB - P1	429.867,79	7.156.319,41
LB - P2	429.506,01	7.156.222,12
LB - P3	429.589,81	7.156.185,65
LB - P4	429.583,24	7.156.373,27

Source: ATOME

In the Table 4-2 The values collected during the baseline characterization campaigns carried out by ATOME for the day and night periods are presented. It should be noted that Paraguayan regulations and IFC guidelines consider different periods such as day and night, so the results are expressed indicating the time range considered in each case.

For the purpose of characterizing the day and night periods by means of a single representative value of each period at each point surveyed, the LAeq of the entire measurement period within the time slot considered for each case was considered.[4] Plate 4-1 shows the spatial distribution of the results (obtained from Annex II).

Table 4-2 Baseline Results Surveyed by Period

Receptor	LAeq (dBA)			
	Daytime Paraguay 7 a.m. – 8 p.m.	IFC Daytime 7 a.m. – 10 p.m.	Nocturnal Paraguay 8 p.m. – 7 a.m.	IFC Night 10 p.m. – 7 a.m.
LB - P1	66	65	62	62
LB - P2	58	57	54	55
LB – P3	65	65	66	67
LB – P4	56	55	53	53

Source: Based on Annex II

The baseline characterization report (Annex II) presents observations on the environment and acoustic climate of each of the surveyed points. These observations are transcribed below to better understand the acoustic environment where the project will be inserted.

Point LB – P1 corresponds to the current access point to the project register. It is located very close to the Villeta-Alberdi route. The maximum instantaneous value recorded during the measurement (89 dBA) corresponds to the explosion of one of the tires of a medium-sized cargo truck that was traveling along the road, approximately 30 m from the sound level meter. During the entire measurement, the passage of vehicles, mainly of large size, that travelled along the route was recorded. The circulation of heavy trucks was more frequent at night and in the early morning.

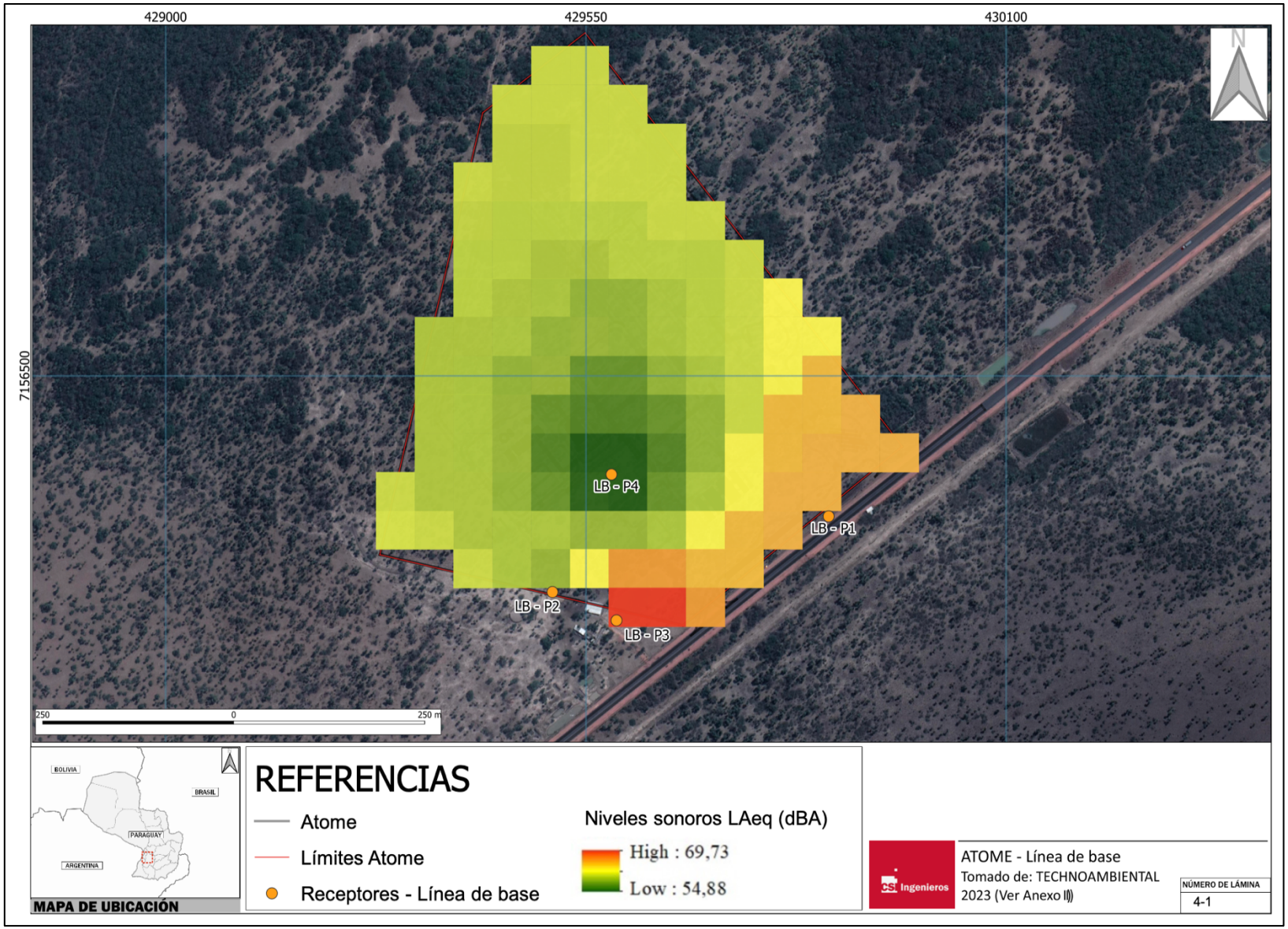
Point LB – P2 is located on the edge of the property, close to an existing stable on the neighbouring property. On this property, a productive rural farm for the breeding of farm animals is developed. The highest instantaneous values were recorded at the times when horses passed through the vicinity of the measurement point neighing and galloping, a situation that corresponded to the departure of these animals from the stable at around 7 am, and their subsequent return at around 4 pm. In addition, in the vicinity of the measurement point there were animals, mainly birds such as chickens, ducks, turkeys, geese and roosters, which roamed freely in the environment, approaching the sound level meter on several

[4] These values were obtained from the processing of data provided by ATOME (Annex II).

occasions. At night and early in the morning, when the farm animals were already sheltering in the barn or in the corrals, the barking of several dogs was identified.

Point LB – P3 corresponds to the dwelling of the rural productive establishment. During the measurement, the members of the house carried out various activities of care and maintenance of the farm, such as the use of wheelbarrows to transport bags of animal feed, the use of edgers and weeders to clear the land, and the circulation of motorcycles in the surroundings. Noise from traffic on the Villeta-Alberdi route was also perceptible during the measurement. During the morning, the execution of repair activities of a galvanized sheet roof was observed, with continuous hammer blows on it and, throughout the measurement, the constant transit of different types of farm animals was observed, emitting their characteristic sounds.

Point LB – P4 is located within the property away from both the Villeta-Alberdi route and the rural establishment located in the neighbouring property to the south. This point is located, approximately, where the infrastructure of the project will be built, which will contain the main sound sources. It is presumed that the maximum instantaneous values recorded (80 dBA) around 9 am correspond to the song of a flock of parrots located very close to the sound level meter.



Sound Pressure Level Modeling in Industrial Plant.

ATOME

November 2023.

CSI Ingenieros

5. Results

The results obtained for the two modelled scenarios, the isophone maps and the estimated immission values in the individual receivers evaluated, as well as their comparison with the standards and reference guidelines, are presented below. Immission values are represented as A-weighted equivalent continuous sound level, which is noted as LAeq.

In the Table 5-1 The estimated values of LAeq are presented for the contribution derived only from the operation of the industrial plant under the conditions described above for Scenario 1 (without considering abatement measures) and for Scenario 2 (considering abatement measures). As can be seen, no value foreseen by the operation of the project exceeds 41 dBA in the individual receivers considered.

Table 5-1 Modelled NPS – Industrial Plant Input

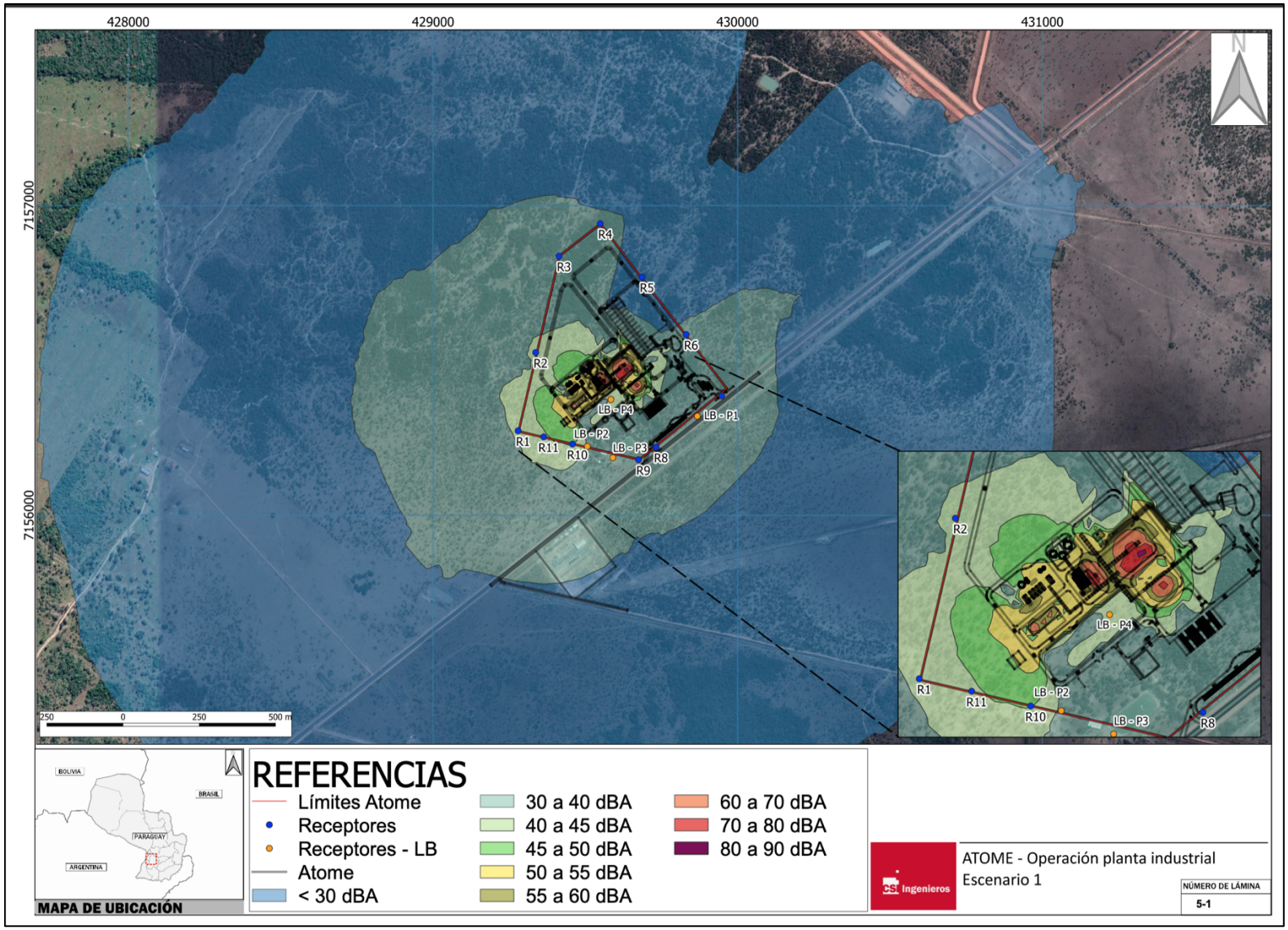
Receptor	Scenario 1 LAeq (dBA)	LAeq (dBA)
R1	41	41
R2	41	41
R3	34	33
R4	31	30
R5	25	19
R6	35	31
R7	33	30
R8	34	31
R9	33	31
R10	45	45
R11	44	44
LB - P1	34	31
LB - P2	40	39
LB - P3	32	31

Note: The LB-P4 receiver is not evaluated because it is located within the industrial site

The isophone maps generated by the operation of the industrial plant are presented as graphic figures, according to the following denomination:

- Slide 5–1 Noise Map. Industrial Plant Operation – Scenario 1.
- Slide 5–2 Noise Map. Industrial Plant Operation – Scenario 2.

It should be noted that in the maps presented, the baseline values (Plate 4-1) and the expected contribution from the project operation can be visualized independently in both scenarios (Plate 5-1 and 5-2 respectively). The analysis of the future situation (project + baseline) for each modelled scenario can be seen in the Table 5-2.



Sound Pressure Level Modeling in Industrial Plant.

ATOME

November 2023.

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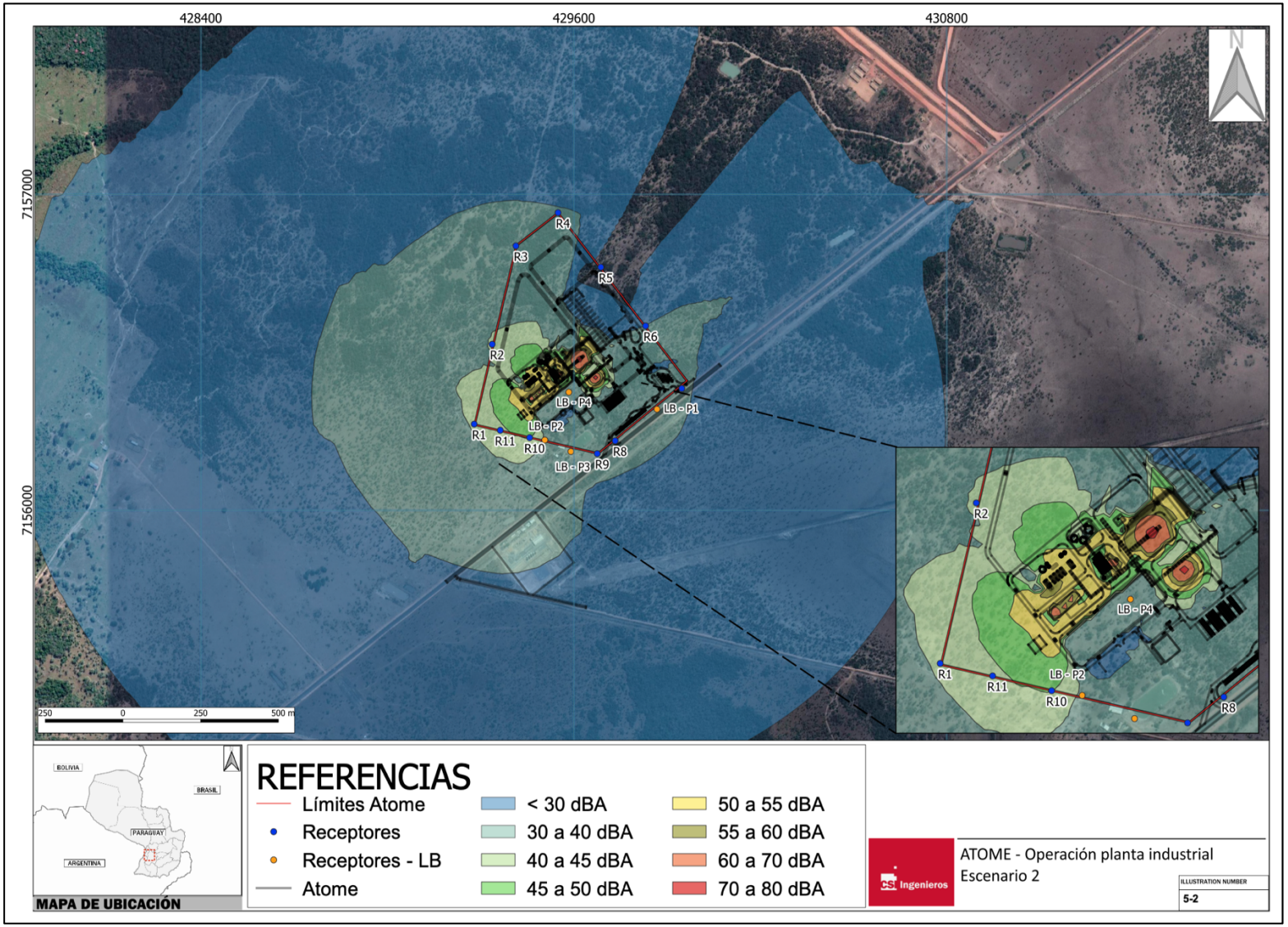
428400
429600
430800
7157000
7156000
N
R1
R2
R3
R4
R5
R6
R8
R9
R10
R11
LB - P1
LB - P2
LB - P3
LB - P4
250 0 250 500 m
BOLIVIA
BRASIL
PARAGUAY
ARGENTINA
MAPA DE UBICACIÓN
REFERENCIAS
Límites Atome
Receptores
Receptores - LB
Atome
< 30 dBA
30 a 40 dBA
40 a 45 dBA
45 a 50 dBA
50 a 55 dBA
55 a 60 dBA
60 a 70 dBA
70 a 80 dBA
Ingenieros
ATOME - Operación planta industrial
Escenario 2
ILLUSTRATION NUMBER
5-2

The predicted immission values for the future situation (project + baseline) are obtained by the logarithmic sum of the baseline values and of each scenario evaluated (Esc 1 and Esc 2), and are presented in the Table 5-2. In addition, this table presents the values of the current situation (baseline) for the day and night period, and compares the situation with the target acoustic quality values indicated in the reference regulations and guide. Green indicates the receivers that comply with Paraguayan regulations and IFC guidelines, and orange indicates those that do not comply with at least one.

Given that the Paraguayan regulations and the IFC guide consider different time slots for the day and night periods, the highest value revealed among the time slots defined by both standards for these periods is selected as representative of the baseline for the purposes of the comparison sought in each period considered (day and night).

As can be seen, the resulting NPS values in the future situation (project + baseline) are fully determined by the values of the current situation (baseline) since the expected contribution of the project to the evaluated recipients is, in all cases, lower than the current situation by more than 10 dBA. which implies that the operation of the project will not generate an increase in future NPS.

Regarding compliance with the acoustic quality values indicated by the regulations and reference guides, the presence of the project will not change the current level of compliance. It is for this reason that in recipients where the current situation already exceeds the target quality value, the future situation (project + baseline) will also do so in equal quantity. If Paraguayan regulations are considered, this situation occurs in the daytime period only in the LB-P3 receptor (nearest home) and in the nocturnal period in the R7, R8, R9, LB-P1 and LB-P3 receptors. However, if the objective quality value proposed by the IFC is considered, the only point surveyed where compliance is not given is in the PB-P3 receiver (nearest dwelling), where the guide value for residential use was considered. Notwithstanding the above, it should be remembered that the nearest dwelling (LB-P3 receiver) corresponds to a productive rural enterprise where farm activities are carried out and the current situation (baseline) already presents high values that exceed the target quality values to date.

Table 5-2 Predicted NPS values and comparison with regulations and reference guidelines

Receptor	Period	Project Contribution LAeq (dBA)		Baseline * (dBA)	Representative Baseline Point** (dBA)	Future Situation: Project + Baseline (dBA)		Law 1100/97 (dBA)	IFC Guide (dBA)
		Esc 1	Esc 2			Esc 1	Esc 2		
R1	Diurnal	41	41	56	LB-P4	56	56	75	70
	Noct.	41	41	53		53	53	60	70
R2	Diurnal	41	41	56	LB-P4	56	56	75	70
	Noct.	41	41	53		53	53	60	70
R3	Diurnal	34	33	56	LB-P4	56	56	75	70
	Noct.	34	33	53		53	53	60	70
R4	Diurnal	31	30	56	LB-P4	56	56	75	70
	Noct.	31	30	53		53	53	60	70
R5	Diurnal	25	19	56	LB-P4	56	56	75	70
	Noct.	25	19	53		53	53	60	70
R6	Diurnal	35	31	56	LB-P4	56	56	75	70
	Noct.	35	31	53		53	53	60	70
R7	Diurnal	33	30	66	LB-P1	66	66	75	70
	Noct.	33	30	62		62	62	60	70

Receptor	Period	Project Contribution LAeq (dBA)		Baseline * (dBA)	Representative Baseline Point** (dBA)	Future Situation: Project + Baseline (dBA)		Law 1100/97 (dBA)	IFC Guide (dBA)
		Esc 1	Esc 2			Esc 1	Esc 2		
R8	Diurnal	34	31	66	LB-P1	66	66	75	70
	Noct.	34	31	62		62	62	60	70
R9	Diurnal	33	31	65	LB-P3	65	65	75	70
	Noct.	33	31	67		67	67	60	70
R10	Diurnal	45	45	58	LB-P2	58	58	75	70
	Noct.	45	45	55		55	55	60	70
R11	Diurnal	44	44	58	LB-P2	58	58	75	70
	Noct.	44	44	55		55	55	60	70
LB - P1	Diurnal	34	31	66	LB-P1	66	66	75	70
	Noct.	34	31	62		62	62	60	70
LB – P2	Diurnal	40	39	58	LB-P2	58	58	75	70
	Noct.	40	39	55		55	55	60	70
LB – P3	Diurnal	32	31	65	LB-P3	65	65	60	55
	Noct.	32	31	67		67	67	45	45

6. Conclusions

An assessment of the acoustic impact that the immediate surroundings of the ATOME project implementation site could suffer was carried out through the modelling of the NPS of the operating condition of the industrial plant, including the main sources of noise generation under two different scenarios.

The evaluation carried out foresees that there will be no impact on future acoustic quality, given that the levels that the project will provide outside the limits of its property will be marginal compared to the current situation (lower by more than 10 dBA compared to the baseline). In other words, the future acoustic quality of the point receptors evaluated will be determined by the current situation and will not be modified by the presence of the project.

Regarding compliance with the objective quality values established in Paraguayan regulations and IFC guidelines in the future situation, it is not expected that there will be a modification of the current compliance in the recipients surveyed. In other words, those recipients where the current NPS exceeds the target quality values will continue to exceed them in the future and it is not expected that any point recipient evaluated will change its level of compliance when the project starts operating. If the IFC guideline is considered, the LB-P3 receiver is the only point receiver where the target quality value for day and night periods is not met and will not be met in the future situation. If Paraguayan regulations are considered, the same LB-P3 receiver does not and will not comply in the future with the target quality values for both periods, and the same happens for the R7, R8, R9 and LB-P1 receptors at night.

It should be noted that the LB-P3 receiver corresponds to the nearest and only dwelling in the evaluated area, so the land use for the application of Paraguayan regulations and IFC guidelines was considered there as residential only. Notwithstanding the above, it is recalled that this recipient corresponds to a productive rural enterprise where farm activities are carried out and that the current NPS values are among the highest surveyed during the characterization of the current situation (baseline).

ANNEX I
BUILDINGS & TANKS

CS Ingenieros

Annex Buildings and Tanks

October 2023

1. Introduction

As the first step of the modelling, the physical model of the plant must be assembled, for which the main buildings must be loaded into the model, considering both buildings and tanks.

This annex summarizes the data on heights and considerations taken with respect to these structures.

All tanks and buildings were considered reflective (silent façade/reflective screen), i.e. they have a α acoustic absorption coefficient of 0.21 depending on the model used.

All information on buildings, sources, location, and emission was provided by ATOME.

2. Building & Tank Data

2.1. Buildings

Table 2-1 Height and nomenclature of buildings

Name of the building	Relative height considered (m)
Milling	4
Bulk storage silo	23
Packaged storage building	15
Electrolysers building	13
Syngas compressors building	14
Workshop-warehouse building	7
Electrical building	5,7
Access/Customs Control	4
Granulation Plant	35
Cooling tower	8,7
Nitric Acid Plant	18
Office Buildings	5,5
ANS Plant	21

2.2. Tanks

Table 2-2 Height and nomenclature of tanks

Name of the tank	Radius (m)	Height (m)
FFS Water Tank & Services (x2)	8.81	12
NH3 Tank	5.88	13
NA Tanks x2	5.19	13
ANS Tanks	3.43	9.5
Demi Water Tanks	4.79	7

ANNEX II
NOISE BASELINE

Annex 5 – Sound Pressure Level Monitoring Report (Baseline)

TECNOAMBIENTAL
•INGENIERÍA Y CONSULTORÍA•

SOUND PRESSURE LEVEL MONITORING RESULTS REPORT

PROJECT:
PLANTA INDUSTRIAL ATOME S.A.

CUSTOMER:	ATOME S.A.
DISTRICT:	VILLETA
DEPARTAMENTO:	CENTRAL
CONSULTANT:	TECNOAMBIENTAL S.R.L
CTCA CODE:	E-133

October 2023

1. INTRODUCTION

ATOME Paraguay S.A., hereinafter *"The Company"*, is developing an industrial project to be installed on a 30-hectare property in the district of Villeta. The industry will be the first dedicated to the production of hydrogen, ammonia and green fertilizers.

The company contracted Tecnoambiental S.R.L. to carry out the environmental noise survey with the aim of collecting data on current noise levels, evaluating and comparing with the maximum permissible limits established in national legislation and the General Guidelines on the Environment, Health and Safety (MASS) of the International Finance Corporation (IFC)/World Bank.

The survey was carried out on September 30 and October 9, 2023, in places defined jointly with *The Company*. These were established within the property; specifically considering the location of future major sources of noise emission, and off-property; taking into account the presence of critical receptors.

The regulatory framework, methodology and results of the noise measurement campaign are described below.

2. REGULATORY FRAMEWORK

2.1 National

2.1.1 Law No. 6390/20 Regulating Noise Emission

The purpose of this law is to regulate the emission of noise capable of affecting the well-being or damaging the health of people or living beings, in order to ensure the due protection of the population, the environment and property affected by exposure to noise.

According to Article 4, the municipalities shall be the authority for the application of this Law. They are responsible for exercising the duties and powers established in this Law.

Among the main duties of municipalities are:

1. Determine the standards, categories and permitted emission sources, which must be established according to the characteristics of the noise emitter and the receiving medium.

2. Establish the permitted and prohibited noise levels by regulation.

3. Establish reference techniques for sampling, measurements, analysis, evaluation of noise pollution, and for the verification and calibration of measuring instruments.

The city of Villeta does not have up-to-date regulations to the aforementioned Law, therefore, the average values specified in Law No. 1100/97 "On the Prevention of Noise Pollution" are used as a reference.

2.1.2 Law No. 1100/97 on the Prevention of Noise Pollution

The purpose of this law is to prevent noise pollution on public roads, squares, parks, promenades, performance halls, meeting centres, sports and social clubs and in all public and private activities that produce noise pollution.

According to Article No. 9, noise and annoying sounds are considered to be those that exceed the average levels specified in Table 1.

Table 1. Maximum permissible sound levels per area

Area	**Night** 8:00 p.m. to 7:00 a.m.	**Day** 07:00 to 20:00	**Day (Occasional Peak)** 07:00 to 12:00 14:00 to 19:00
	Measured in decibels "A"		
Residential areas for specific use, public spaces: recreational areas, parks, squares and public roads.	45	60	80
Mixed Areas, Transition Zones, Urban Centres, Specific Programmes, Service Areas and Public Buildings	55	70	85
Industrial area	60	75	90

Source: Paraguay (1997).

To compare the Leq results in dBA obtained with Law No. 1100/97, the maximum permitted values defined for the Industrial Area, highlighted in gray, were used.

Taking into account the presence of a dwelling where Point 3 of measurement was located, for the contrast of the Leq results in dBA at this point, the maximum permitted values defined for the Area corresponding to residential areas of specific use, public spaces: recreational areas, parks, squares and public roads highlighted in light blue were used.

2.1.3 Ordinance No. 25/2017 amending and updating Ordinance No. 2/94 regulating the advertising and noise nuisance system within the district of Villeta

In the district of Villeta, Law No. 1100/97 is regulated by Ordinance No. 25/2017, which amends and updates Ordinance No. 2/94, which regulates the system of advertising and nuisance noise within the district of Villeta, in accordance with the provisions of this Law.

Article 1 of this Ordinance establishes the prohibition throughout the district of Villeta of causing annoying sounds, as well as vibrations when, due to time, place or intensity, they affect the tranquility, rest, health and material goods of the population.

As for industrial installations that, located in residential areas, that make hammers or produce annoying noises, will operate within the hours of 06:00 to 12:00 and from 14:00 to 20:00 hours. Likewise, they must adopt the required devices to reduce the noise produced.

2.2 International

2.2.1 IFC/World Bank General Guidelines on Environment, Health and Safety

The IFC/World Bank MASS Guides are technical reference documents containing general and specific examples of International Good Practice for Industry. These guides contain the levels and performance indicators that can generally be achieved in new installations, with existing technology and at reasonable costs.

The guidelines state that noise impacts may not exceed the levels set out in the following Table of Noise Level Guidelines.

Table 2. Noise Level Guides

Receptor	One hour LAeq (dBA)	
	Day 07:00 – 22:00	Night 22:00 – 07:00
Residential, Institutional, Educational	55	45
Industrial, Commercial	70	70

Source: IFC (2007).

It should be noted that the IFC also states that the maximum increase in background noise levels can be up to 3 dB at the nearest receiver.

To contrast the Leq results in dBA obtained with the General Guidelines on Environment, Health and Safety of the International Finance Corporation, the noise level guide values defined for the Industrial Receiver highlighted in gray were used.

Taking into account the presence of a house where Point 3 of measurement was located, for the contrast of the Leq results in dBA at this point, the noise level guide values defined for the Residential, Institutional, Educational Receiver highlighted in light blue were used.

Noise monitoring shall be carried out for the purpose of establishing existing ambient noise levels in the area of proposed and existing installations, or for the purpose of checking noise levels in the operational phase.

3. MATERIALS AND METHODS

3.1 Measuring Points

The selection of the measurement points was based on the methodology proposed by Segués (2008), of directed selection of measurement points based on land uses and noise sources, which consists of previously analyzing the dynamics of the activity, land uses and establishing a zoning of the study area. On the other hand, the main sources of noise, roads, industries, sensitive areas, etc., must be analyzed.

This methodology is in accordance with the recommended method for the measurement of environmental noise in the ISO 1996-2:2017 Standard, which measures the equivalent continuous level in frequency weighting A dB(A), where they also indicate that the selection of points should be established according to the generating source.

Considering the above, Table 3 mentions the four (4) selected measurement points and their description.

Table 3. Description of Measurement Points

Point N°	Geographic Coordinates	Description of Measurement Points
1 - Main access to the property	25°42'33.6"S 57°41'56.6"W	Point of circulation of mobile emission sources, such as machinery and heavy trucks and other types of vehicles of different sizes linked to the construction and operation/maintenance stage of the project. In addition, it is a strategic point for measuring noise levels, due to its proximity to the Villeta-Alberdi Route.
2 - ATOME Property Boundary – Near Neighbor's Barn	25°42'36.7"S 57°42'09.6"W	Area close to the dwelling of the neighbors of the adjoining property, the main critical receivers of the noise levels that the industry would generate, due to the proximity of the installation of certain equipment and service areas, as well as continuous work during the construction and operation/maintenance stage, in general.
3 – Main access to the Neighbor's home	25°42'37.9"S 57°42'06.6"W	Registration point located at the main access to the neighbors' homes, they would be direct receivers of the noise levels that could occur in the different stages of the industry, which could affect their health and alter their quality of life.
4 – Future area of fixed noise sources	25°42'31.8"S 57°42'06.8"W	It corresponds to a sector of industry where emission sources such as machinery and equipment of continuous operation (mainly compressors) would be found, which could generate high noise levels, which could affect occupational and housing levels.

Figure 1 shows the location of each of the 4 selected points.

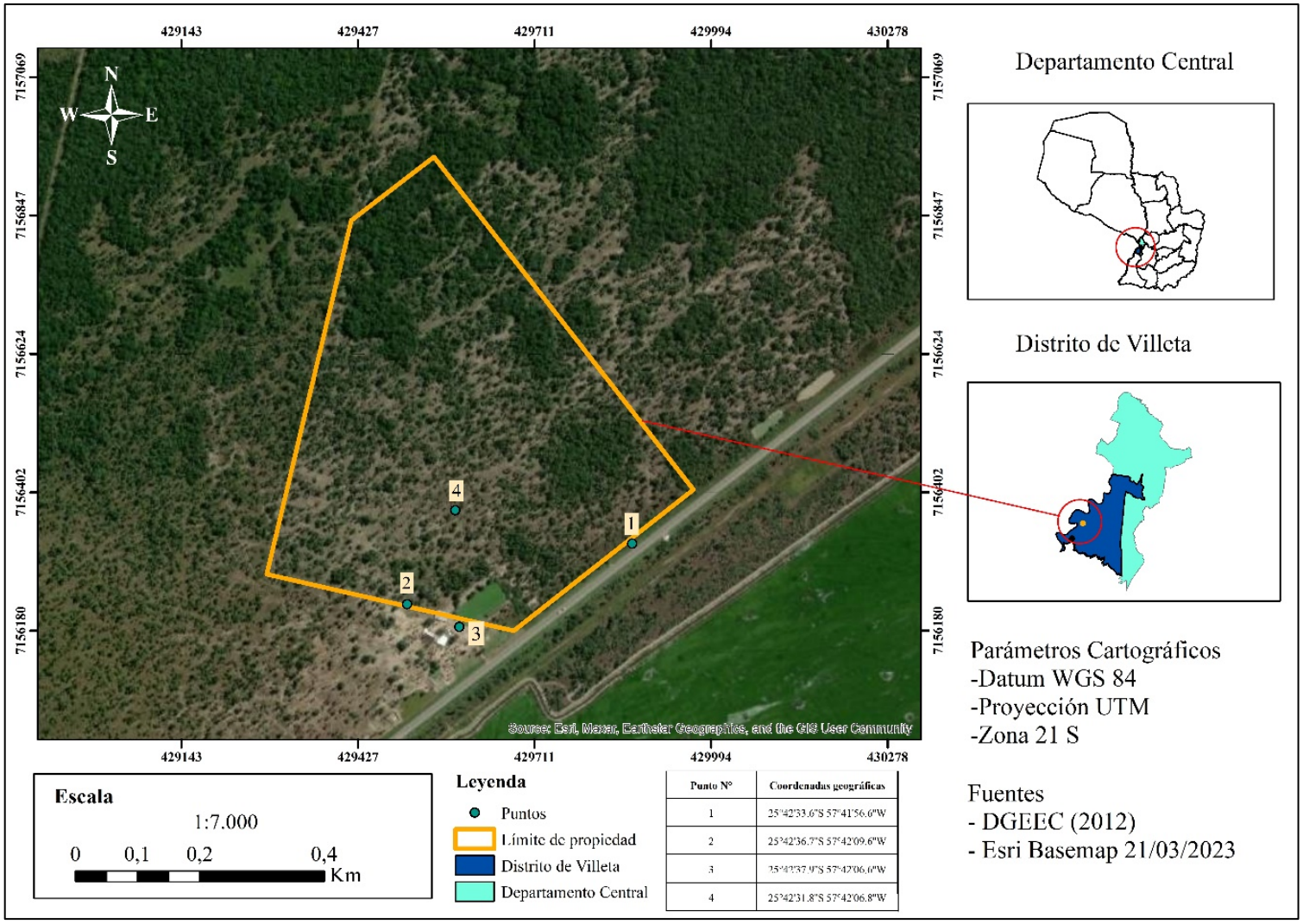

Figura 1. Localización de los puntos de medición de niveles sonoros.

3.2 Equipment

Sound level monitoring was performed with two Class 2 sound level meters that comply with IEC 61672-1 and IEC PUB 651 standards, the **PCE-322A sound level meter** and the **Minipa MSL-1355B sound level meter,** respectively**.**

Both are high-performance instruments, suitable for measuring sounds in the industrial, health, safety and environmental sectors. Both sound level meters comply with the provisions of the International Finance Corporation's General Guidelines on Environment, Health and Safety (2007): they are Type 2, frequency weighting A was used and comply with the applicable IEC standards.

The technical specifications of sound level meters are presented in Annex 8.1. Likewise, Annex 8.3 and 8.4 include the calibration certificates issued by LABSOL S.A., a calibration service provider company accredited by the National Accreditation Body (ONA), as a calibration laboratory, in accordance with the NP-ISO/IEC 17025:2018 Standard, equivalent to the ISO/IEC 17025:2017 Standard "General requirements for the competence of testing and calibration laboratories" and the requirements established in the regulations, ONA criteria and policies applicable to calibration laboratories in their current version.

3.3 Data collection

Data collection was carried out for 20 continuous hours at the 4 measurement points. The sound level meters were programmed to measure with frequency weighting A, in a range of 30 to 130 dB. The sound level meters were placed on a tripod to be placed at a distance of approximately 1.5 meters above the ground, and it was also taken into account that they are no closer than 3 meters from any reflective surface (walls, structures, obstacles), as specified in the IFC/World Bank MASS Guidelines.

According to the IFC General Guidelines on Environment, Health and Safety (2007), the usual monitoring periods should be sufficient for the statistical study and can last 48 hours with the use of noise monitoring devices that should have the ability to record data continuously during this period of time. or hourly or more frequently as deemed appropriate (or otherwise covering periods of time within multiple days, including weekdays on weekdays or over the weekend).

Due to the capacity of the Minipa MSL-1355B Sound Level Meter **Datalogger** and in order to have the largest number of records during the total measurement time, the equipment was configured in a measurement time interval of 1 data every 16 seconds, thus obtaining 4,502 records in 20 hours of measurement. As for the **PCE-322A sound level meter,** whose *Datalogger* has a larger data storage memory, yielding 1 data per second, 72,000 records were obtained in the 20 hours of measurement.

At the same time, the atmospheric variables in the weather forecast of the Directorate of Meteorology and Hydrology (DMH) were verified daily, considering the impact that climatic conditions may have on the sound measurements. A cap was used to protect the equipment from the wind and on rainy days the measurements were suspended and re-planned.

Table 4 below shows the details of the measurement schedules at each of the measurement points.

Table 4. Measurement schedules at each of the registration points.

Point N°	Measurement Start Time	End Time Measurements	Total Measurement Time
1	04:31:00	00:31:16	20 hours, 16 seconds
2	05:35:00	01:35:16	20 hours, 16 seconds
3	05:33:12	01:33:28	20 hours, 16 seconds
4	05:51:00	01:51:16	20 hours, 16 seconds

3.4 Data Processing and Analysis

3.4.1 Data Pre-Processing

Considering the differences in measurement time interval of each sound level meter, the records were pre-processed in order to standardize the amount of data between the two devices for analysis in the 20 hours of measurement at each of the 4 points. To this end, the following was done:

1) First, the data from each sound level meter were pooled every 1 hour, for the Minipa sound level meter 225 records were obtained, and for the PCE sound level meter 3,600 records were obtained.

2) Next, a simple random sampling was carried out by means of Microsoft Excel, which consists of a technique in which all the elements of a population or universe can be selected for the sample of a research. This selection process is carried out randomly or randomly, without the intervention of the researcher. This was done to randomly collect 225 recordings from the 3,600 PCE sound level meter records every hour, and thus have the same amount of data between the two sound level meters.

3.4.1 Data Processing

The data obtained by the sound level meters were processed in Microsoft Excel in order to obtain a spreadsheet with the means for each point. Due to the logarithmic nature of the sound level values, the equivalent continuous sound level (Leq) was calculated using the following formula:

$$Leq = 10\log((\Sigma ti \cdot 10^{Li/10})/T)\ dBA$$

Where:

T: This is the total duration of the measurement
Ti: is the instantaneous observation time per second
Li: Instantaneous Sound Pressure

It is important to determine the Leq value, as it represents the constant total exposure to sound levels over a period of time of interest.

The results of the Leq value measurements were calculated by specifying the frequency weight that was used (dBA), and the desired measurement time duration. For this study, it was defined to represent the Leq data every 1 hour **(LAeq1hour),** thus having 20 data for the total measurement time of 20 hours at each point.

The results were analyzed and presented in figures and tables, in such a way that the sound levels in dBA and their behavior are visualized. In this way, the temporal variability for each of the selected points is made visible.

The figures show the data on instantaneous sound levels in dB and the cumulative Leq levels in dBA, with the corresponding contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the IFC/World Bank EHS Guidelines.

A sound map is also presented to achieve a graphical presentation of the behavior of sound levels in the study area.

4. RESULTS

4.1 Weather conditions

The climatic variables were obtained from the weather forecast of the Directorate of Meteorology and Hydrology (DMH). The following conditions were considered to develop the measurements:

1. Precipitation: dry weather.
2. Temperature: range above -10 °C and below 50°C.
3. Relative humidity: up to 90%.
4. Wind speed: up to 5 m/s (18 km/h). At higher wind speeds, the turbulent noise caused by the wind can mask the source of noise to be measured. However, measurements with wind speeds of up to 10 m/s (36 km/h) can be accepted. In general, wind noise peaks should be at least 10 dB below the noise source to be measured.

Table 5 shows the climatic conditions recorded every 2 hours in Villeta during the measurement days.

Table 5. Climatic conditions recorded in the city of Villeta during the measurement days.

Day	**Hour**	**Atmospheric Variables**				
		Temperature °C	*Relative humidity %*	*Velocity of the wind km/h*	*Wind Direction N, S, E, O*	*Rainfall mm*
30/09/2023	05:00	17	77	14	Sur Sur Oeste	-
	07:00	19	77	11	Sur Sur Oeste	-
	09:00	22	73	7	On	-
	11:00	25	69	5	On	-
	13:00	26	63	11	South West	-
	15:00	26	55	17	Sur Sur Oeste	-
	17:00	24	56	19	South West	-
	19:00	23	56	19	South West	-
	21:00	21	54	20	On	-
	23:00	20	63	18	On	-
	01:00	18	60	18	On	-
09/10/2023	05:00	17	85	3	South East	-
	07:00	18	80	3	South East	-
	09:00	22	68	4	On	-
	11:00	26	41	7	On	-
	13:00	29	31	9	On	-
	15:00	28	35	9	South East	-
	17:00	26	41	11	On	-
	19:00	26	41	13	South West	-
	21:00	22	40	13	On	-
	23:00	19	38	11	On	-
	01:00	18	38	11	On	-

Source: Directorate of Meteorology and Hydrology, DMH (daytime forecast).

The climatic conditions presented in the two days of measurement were suitable for recording the sound levels.

4.2 Results of LAeq1hour (dBA) sound levels in Point 1

Table 6 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 1 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the IFC MASS Guidelines.

The total compliance of the results obtained with the provisions of the IFC Guidelines is highlighted. With regard to compliance with Law No. 1100/97, it was also possible to verify full compliance with the schedule from 07:00 to 20:00; However, from 20:00 to 07:00 the levels were higher than what is allowed by law, except for the first time of measurement (04:31:00).

Table 6. Compliance with national and international regulations of the results of the sound levels LAeq1hour (dBA) in Point 1

Point	Timetable	Cumulative sound level LAeq1hour (dBA)	Compliance			
			Ley N° 1100/97		CFI Guides	
			07:00 to 20:00	8:00 p.m. to 7:00 a.m.	07:00 to 22:00	10:00 p.m. to 7:00 a.m.
			75 dBA	60 dBA	70 dBA	
1 – Main Access to the Property	04:31:00	57,1*		✓	✓	
	05:31:00	64,44431207		×	✓	
	06:31:00	63,0156269		×	✓	
	07:31:00	61,34709751	✓		✓	
	08:31:00	61,32018686	✓		✓	
	09:31:00	60,75769404	✓		✓	
	10:31:00	64,25489113	✓		✓	
	11:31:00	63,80845616	✓		✓	
	12:31:00	64,83809346	✓		✓	
	13:31:00	64,45128289	✓		✓	
	14:31:00	64,61098871	✓		✓	
	15:31:00	64,56975525	✓		✓	
	16:31:00	65,2993824	✓		✓	
	17:31:00	65,14630637	✓		✓	
	18:31:00	65,06028275	✓		✓	
	19:31:00	65,37374355*	✓		✓	
	20:31:00	65,33555629		×	✓	
	21:31:00	65,11980296		×	✓	
	22:31:00	64,93759659		×	✓	
	23:31:00	64,8339658		×	✓	
	00:31:16	64,71544284		×	✓	

*The maximum recorded value of LAeq1hour was 65.37 dBA; while the minimum value of LAeq1hour was 57.1 dBA.

4.2.1 Behaviour of sound levels in Point 1

Figure 2 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The highest value of instantaneous sound levels was 89.4 dB; It was produced and recorded at the exact moment that one of the tires of a medium-sized cargo truck that was traveling along the Villeta-Alberdi Route exploded. It is important to remember that Point 1 of measurement was located at the future main access of the Industrial Plant, therefore, it was very close to the aforementioned Route. This incident occurred approximately 30 meters away from where the sound level meter was located.

The other instantaneous sound levels recorded, which are in a range between 70 and 85 dB, were caused by the different mobile sources, mainly large trucks that traveled along the Route at high speeds. The circulation of heavy trucks was more frequent at night and early in the morning.

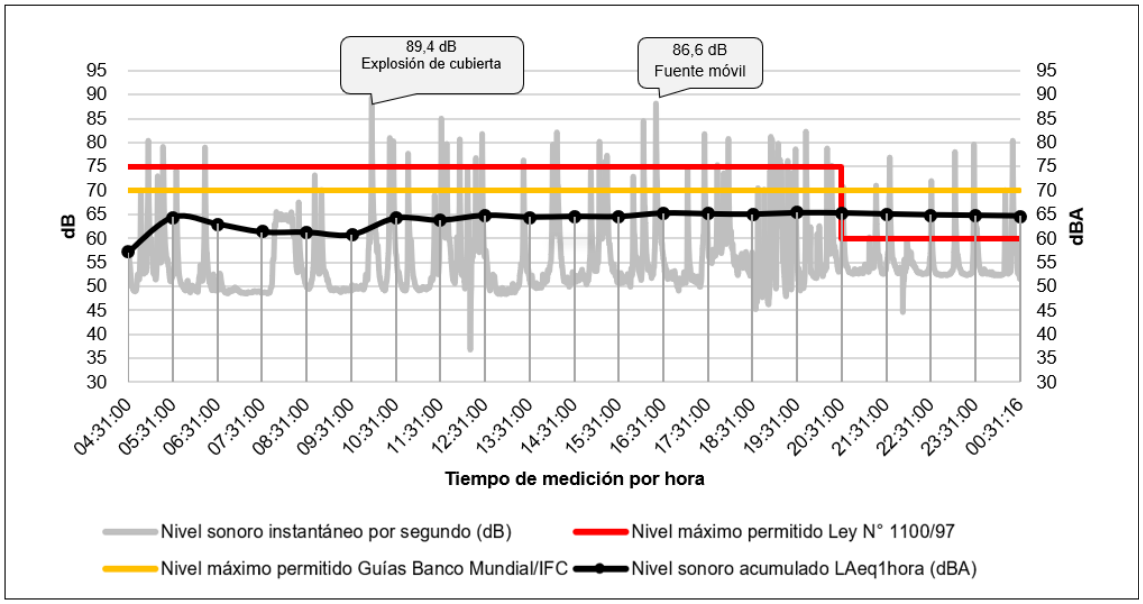

Figure 2. Behaviour of LAeq1hour (dBA) sound levels and their contrast with national and international standards in Point 1

The minimum instantaneous sound level recorded was 36.8 dB; and the average was 55.1 dB; which would be practically the levels that were maintained in the vicinity of the measurement point (in the absence of any external source, for example: mobile sources) produced by different types of insects, amphibians, birds.

LAeq1hour results remained in a range of 57.1 and 65.3 dBA during the 20 hours of measurement.

4.3 Results of sound levels LAeq1hour (dBA) in Point 2

Table 7 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 2 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's MASS Guidelines.

The results obtained have been fully complied with in accordance with the provisions of the IFC's MASS Guidelines and Law No. 1100/97 on the prevention of noise pollution.

Table 7. Compliance with national and international regulations of the results of the sound levels LAeq1hour (dBA) in Point 2

Point	Timetable	Cumulative sound level LAeq1hour (dBA)	Compliance			
			Ley N° 1100/97		CFI Guides	
			07:00 to 20:00	8:00 p.m. to 7:00 a.m.	07:00 to 22:00	10:00 p.m. to 7:00 a.m.
			75 dBA	60 dBA	70 dBA	
2 – ATOME Property Boundary – Near Neighbor's Barn	05:35:00	58,2		✓	✓	
	06:35:00	58,24211962		✓	✓	
	07:35:00	59,62836528	✓		✓	
	08:35:00	59,95574047*	✓		✓	
	09:35:00	58,74830527	✓		✓	
	10:35:00	58,09150913	✓		✓	
	11:35:00	57,32191866	✓		✓	
	12:35:00	57,22802704	✓		✓	
	13:35:00	57,78400861	✓		✓	
	14:35:00	57,80089311	✓		✓	
	15:35:00	57,76402453	✓		✓	
	16:35:00	58,11401744	✓		✓	
	17:35:00	57,838031	✓		✓	
	18:35:00	57,60459953	✓		✓	
	19:35:00	57,64053894	✓		✓	
	20:35:00	57,36483823		✓	✓	
	21:35:00	57,18615704		✓	✓	
	22:35:00	57,15483786		✓	✓	
	23:35:00	56,92197917		✓	✓	
	00:35:00	56,69516653		✓	✓	
	01:35:16	56,62094827*		✓	✓	

*The maximum recorded value of LAeq1hour was 59.9 dBA; while the minimum value of LAeq1hour was 56.62 dBA.

4.3.1 Behaviour of sound levels in Point 2

Figure 3 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC MASS Guidelines (orange line).

Point 2 of measurement was located on Atome's property but close to the home of the neighbors of the adjoining property, whose activity is characterized by the breeding of various types of farm animals. It is important to remember the dynamics of the environment of the measurement point, since the

highest value of instantaneous sound levels recorded was 83.6 dB; that they occurred at two times of the day, one of them in the early hours of the morning (07:17:08) which coincides exactly with the time when the horses were taken to graze, and the other in the afternoon (16:28:20) when the horses returned to the barn; The coming and going of the animals involved their passage through the vicinity of the measuring point (neighing and galloping), generating the aforementioned sound levels.

In addition, other values that exceed 70 dB could be attributed to the other animals on the farm, mainly birds such as chickens, ducks, turkeys, geese, roosters, etc., which at times also moved in the vicinity of the measurement point and that with their songs and clucks became sources of sound levels.

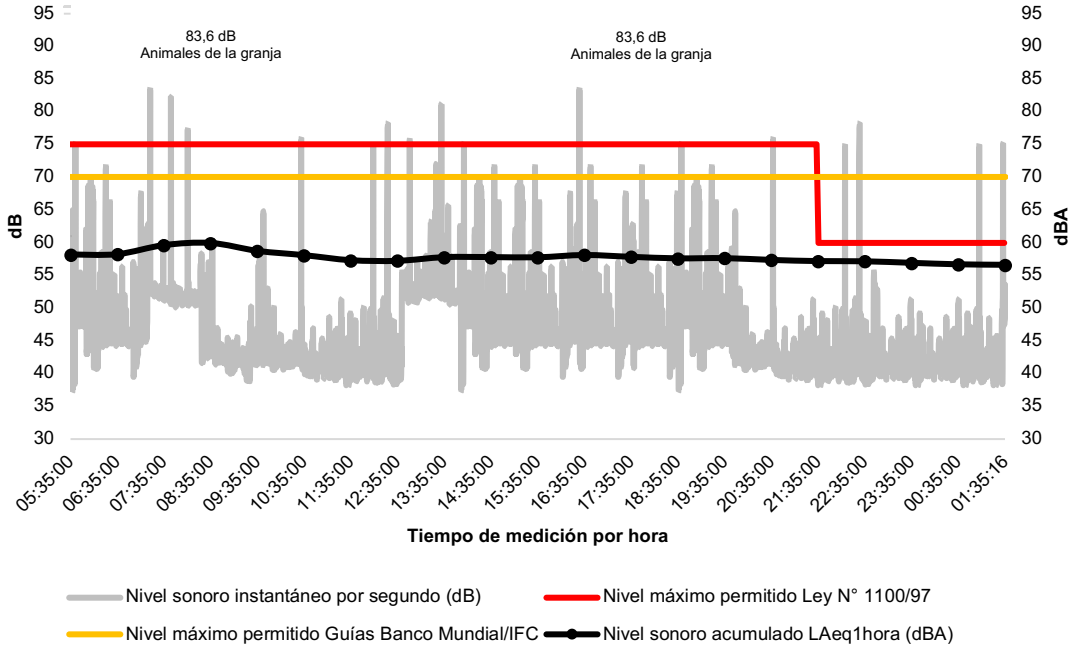

Figure 3. Behaviour of $LAeq_{1hora}$ (dBA) and its contrast with national and international regulations in Point 2

At night and early in the morning, when the farm animals were already sheltering in the barn or in the pens, the canines with their barking became sources of sound levels.

The minimum instantaneous sound level recorded was 37.4 dB; and the average yielded a value of 45.6 dB. In addition, the sounds generated by different types of insects, amphibians, and birds were a constant.

LAeq1hour results remained in a range of 56.6 and 59.9 dBA during the 20 hours of measurement.

4.3 Results of LAeq1hour (dBA) sound levels in Point 3 considering limits for Industrial Area

Table 8 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 3 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's General Guidelines on Environment, Health and Safety for the Industrial Area.

Regarding the contrast of the results obtained with the IFC's General Guidelines on the Environment, Health and Safety, it was possible to detect in the hours of 06:33:12 and 07:33:12 values that exceed what is allowed, in the rest of the schedules values below 70 dBA were presented.

With regard to compliance with Law No. 1100/97, total compliance was observed between 07:00 and 20:00; However, from 20:00 to 07:00 the levels were higher than what is allowed by law at all times.

Table 8. Compliance with national and international regulations of the results of the sound levels LAeq1hora (dBA) in Point 3 – Industrial Area

Point	Time	Cumulative sound level $LAeq_{1hora}$ (dBA)	Compliance			
			Law No. 1100/97 on the Prevention of Noise Pollution		IFC General Environmental, Health and Safety Guidelines	
			07:00 to 20:00	20:00 to 07:00	07:00 to 22:00	22:00 to 07:00
			75 dBA	60 dBA	70 dBA	
3 – Main access to the neighbours' house	05:33:12	61,2*		×	✓	
	06:33:12	73,14897839*		×	×	
	07:33:12	71,04904653	✓		×	
	08:33:12	70,17712384	✓		✓	
	09:33:12	69,80148867	✓		✓	
	10:33:12	69,65807204	✓		✓	
	11:33:12	69,61756739	✓		✓	
	12:33:12	69,12150994	✓		✓	
	13:33:12	68,66589614	✓		✓	
	14:33:12	68,37534767	✓		✓	
	15:33:12	68,11324953	✓		✓	
	16:33:12	67,74555474	✓		✓	
	17:33:12	67,38566265	✓		✓	
	18:33:12	67,0629521	✓		✓	
	19:33:12	66,80702657	✓		✓	
	20:33:12	66,51956989		×	✓	
	21:33:12	66,25814196		×	✓	
	22:33:12	66,01255585		×	✓	
	23:33:12	65,79616673		×	✓	
	00:33:12	65,57730409		×	✓	

Point	Time	Cumulative sound level $LAeq_{1hora}$ (dBA)	Compliance			
			Law No. 1100/97 on the Prevention of Noise Pollution		IFC General Environmental, Health and Safety Guidelines	
			07:00 to 20:00	20:00 to 07:00	07:00 to 22:00	22:00 to 07:00
			75 dBA	60 dBA	70 dBA	
	01:33:28	65,37485103		✗	✓	

*The maximum recorded value of LAeq1hour was 73.1 dBA; while the minimum value of LAeq1hour was 61.2 dBA.

4.3.1 Behaviour of sound levels in Point 3 considering limits for Industrial Area

Figure 4 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The highest noise levels were produced by the different activities related to the care and maintenance of the farm. In addition, another source that generated sound levels that was perceived from the measurement point were the mobile sources that traveled at high speeds along the Villeta-Alberdi Route.

According to the conditions in which the measurements were carried out, the possibility that a source generating sound levels from the property where the Industrial Plant would be installed could produce exposure levels that could affect the inhabitants of the house of the neighboring property is ruled out.

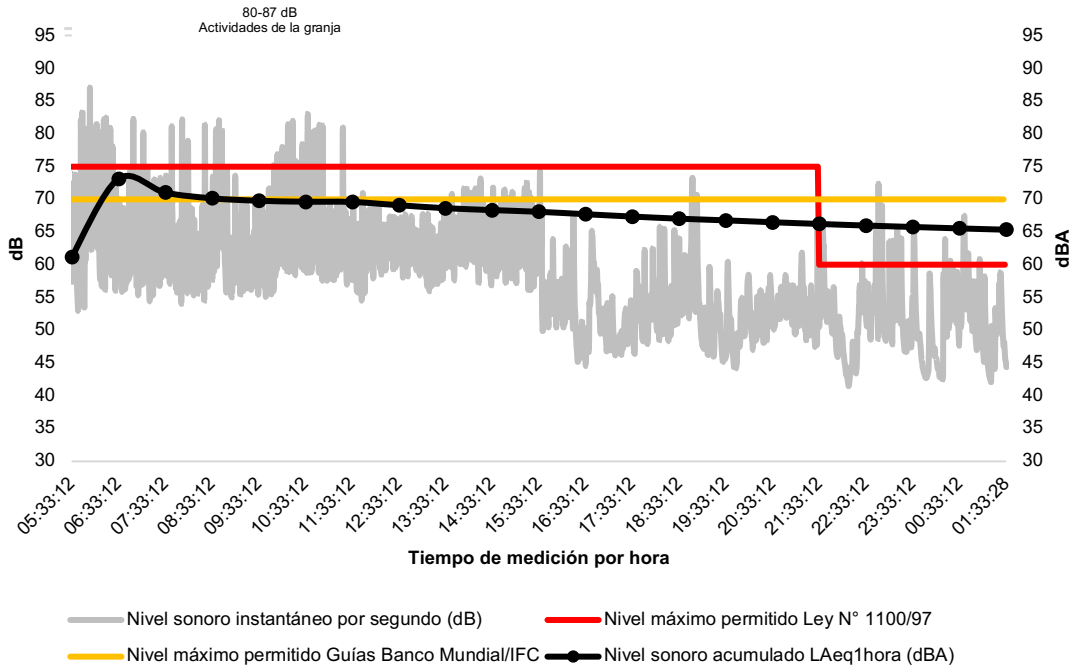

Figure 4. Behaviour of LAeq1hour (dBA) sound levels and their contrast with national and international regulations in Point 3 – Industrial Area.

The minimum instantaneous sound level recorded was 41.5 dB; and the average yielded a value of 57.7 dB.

LAeq1hour results remained in a range of 61.2 and 73.1 dBA during the 20 hours of measurement.

4.3 Results of LAeq1hour (dBA) sound levels in Point 3 considering limits for Residential Area

Table 9 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 3 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's General Guidelines on Environment, Health and Safety for the Residential Area.

In the contrast of the LAeq1hour results in dBA with both regulations, it was found that in all cases the maximum allowed in each of the schedules is exceeded.

Table 10. Compliance with national and international regulations of the results of the sound levels LAeq1hour (dBA) in Point 3 – Residential Area

Point	Time	Cumulative sound level $LAeq_{1hora}$ (dBA)	Compliance			
			Law No. 1100/97 on the Prevention of Noise Pollution		Guías Generales sobre Medio Ambiente, Salud y Seguridad de la IFC	
			07:00 to 20:00	20:00 a 07:00	07:00 a 22:00	22:00 a 07:00
			60 dBA	45 dBA	55 dBA	45 dBA
3 – Main access to the neighbours' home	05:33:12	61,2*		×		×
	06:33:12	73,14897839*		×		×
	07:33:12	71,04904653	×		×	
	08:33:12	70,17712384	×		×	
	09:33:12	69,80148867	×		×	
	10:33:12	69,65807204	×		×	
	11:33:12	69,61756739	×		×	
	12:33:12	69,12150994	×		×	
	13:33:12	68,66589614	×		×	
	14:33:12	68,37534767	×		×	
	15:33:12	68,11324953	×		×	
	16:33:12	67,74555474	×		×	
	17:33:12	67,38566265	×		×	
	18:33:12	67,0629521	×		×	
	19:33:12	66,80702657	×		×	
	20:33:12	66,51956989		×	×	
	21:33:12	66,25814196		×	×	
	22:33:12	66,01255585		×	×	
	23:33:12	65,79616673		×		×
	00:33:12	65,57730409		×		×
	01:33:28	65,37485103		×		×

*The maximum recorded value of LAeq1hour was 73.1 dBA; while the minimum value of LAeq1hour was 61.2 dBA.

4.3.1 Behavior of sound levels in Point 3 considering limits for Residential Area

Figure 5 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The highest noise level recorded was 87 dB, produced by the different activities of the inhabitants of the house, mainly related to the care and maintenance of the farm, such as the use of wheelbarrows to transport balance bags to feed the animals, the use of edgers and weeders to clear the land and the circulation of motorcycles to access the farm. Also in the morning, during the measurements, the farm managers were observed carrying out repair activities on the zinc-coated galvanized sheet metal roof of the barn, producing sound levels due to the succession of continuous blows with the hammer through the metal.

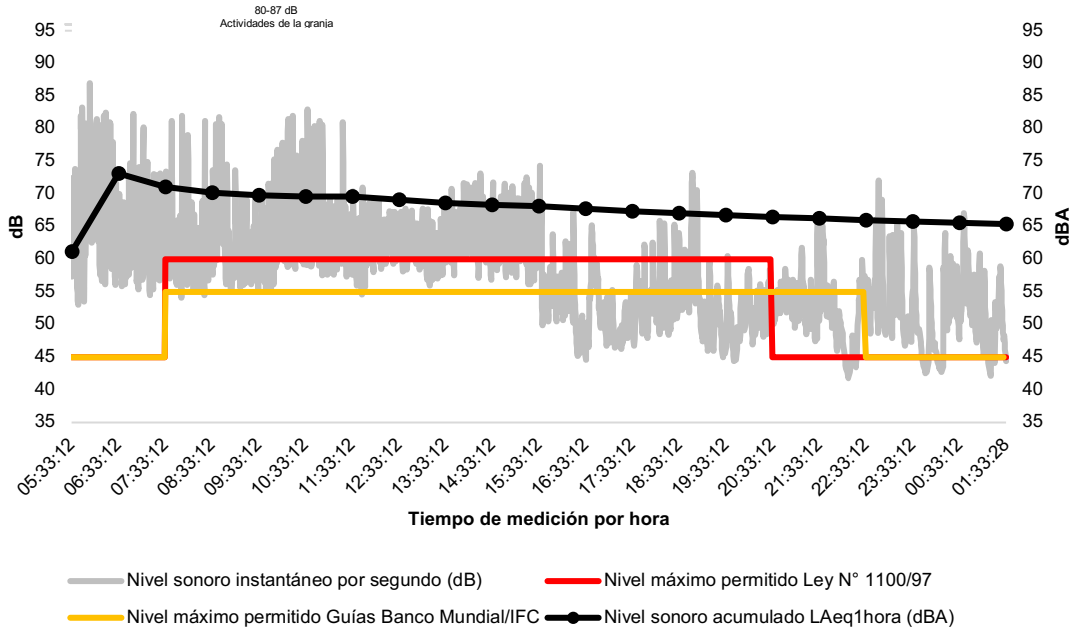

Figure 5. Behaviour of the LAeq1hour (dBA) sound levels and their contrast with national and international regulations in Point 3 – Residential Area.

Other main sources that contributed to high noise levels were the barking of the 4 canines on the farm. Other instantaneous sound level values are also related to the constant transit of different types of farm animals and their own characteristic sounds, becoming sound sources.

4.5 Results of sound levels LAeq1hour (dBA) in Point 4

Table 11 shows the results of the sound levels in LAeq1hour in dBA corresponding to Point 4 of measurement and their contrast with Law No. 1100/97 on the Prevention of Noise Pollution and the international requirements established in the IFC's General Guidelines on the Environment, Health and Safety.

The total compliance of the results obtained with the provisions of the IFC's General Guidelines on Environment, Health and Safety is highlighted.

With regard to compliance with Law No. 1100/97, it was only possible to detect at 05:51:00 a value that exceeds that allowed by law.

Table 11. Compliance with national and international regulations of the sound levels results LAeq1hora (dBA) in Point 4.

Point	Time	Cumulative noise level $LAeq_{1hora}$ (dBA)	Compliance			
			Law N° 1100/97		IFC Guidelines	
			07:00 to 20:00	20:00 to 07:00	07:00 to 22:00	22:00 to 07:00
			75 dBA	60 dBA	70 dBA	
4 – Future area of fixed noise-emitting sources	05:51:00	63,2*		×	✓	
	06:51:00	55,01006306		✓	✓	
	07:51:00	54,87408975	✓		✓	
	08:51:00	53,5705438	✓		✓	
	09:51:00	55,17344041	✓		✓	
	10:51:00	54,46582421	✓		✓	
	11:51:00	53,79619023	✓		✓	
	12:51:00	53,27662597	✓		✓	
	13:51:00	52,93351851	✓		✓	
	14:51:00	52,9336212*	✓		✓	
	15:51:00	54,59271033	✓		✓	
	16:51:00	55,78908322	✓		✓	
	17:51:00	55,87865794	✓		✓	
	18:51:00	55,80355215	✓		✓	
	19:51:00	55,64230626	✓		✓	
	20:51:00	55,45257598		✓	✓	
	21:51:00	55,25446216		✓	✓	
	22:51:00	55,05381386		✓	✓	
	23:51:00	54,97782434		✓	✓	
	00:51:00	54,96970173		✓	✓	
	01:51:16	54,84299224		✓	✓	

*The maximum recorded value of LAeq1hour was 63.2 dBA; while the minimum value of LAeq1hour was 52.9 dBA.

4.5.1 Behaviour of sound levels in Point 4

Figure 6 shows the behavior of the instantaneous sound levels per second in dB recorded during the total measurement time, as well as the results obtained from LAeq1hour in dBA. In addition, the figure shows the lines that represent the maximum permitted values established in Law No. 1100/97 on the Prevention of Noise Pollution (red line) and the IFC's General Guidelines on the Environment, Health and Safety (orange line).

The value of 80.5 dB was the highest recorded, this could be presumed to be due to an isolated case, that according to the characteristics of the site where the sound level meter was located, flocks of parrots *(Tu'i karanda'y)* were observed that could have been perched by the equipment or with their song could have become sound sources. Also, during the measurements, the presence of a fox (*Aguara'i) could be observed*, an animal characterized by its cunning and curiosity, so it could also be presumed that at some point it could have approached the measuring equipment.

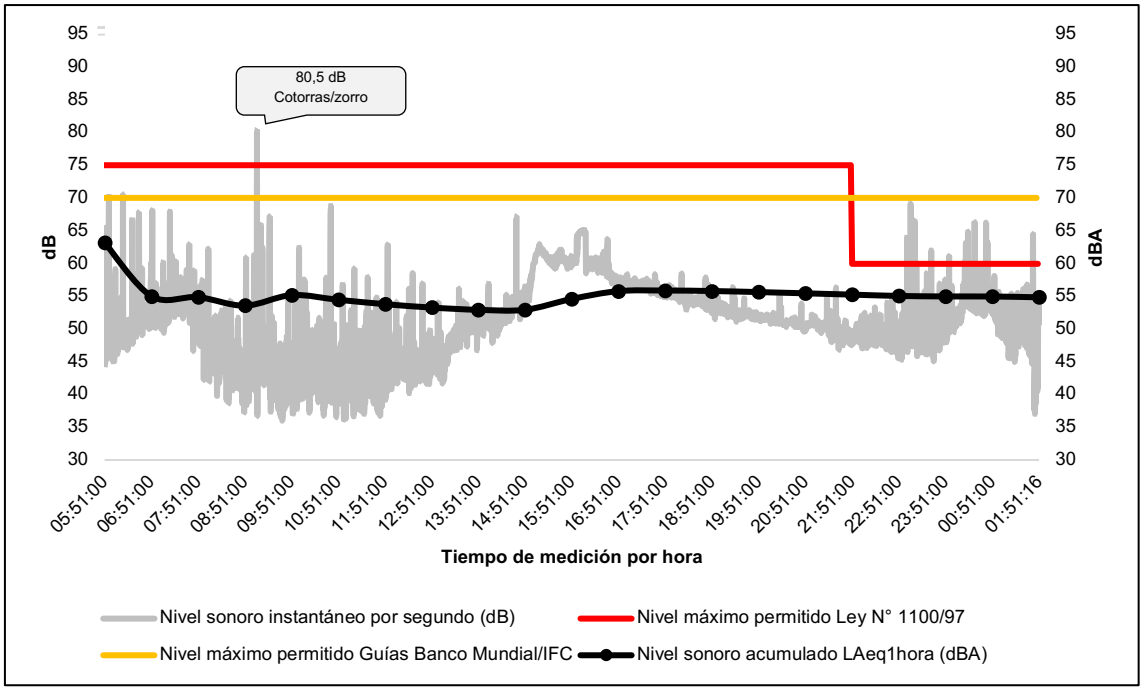

Figure 6. Behaviour of LAeq1hour (dBA) sound levels and their contrast with national and international regulations in Point 4.

The minimum instantaneous sound level recorded was 36 dB; and the average yielded a value of 50.8 dB; which would be practically the levels that were maintained in the vicinity of the measurement point (in the absence of any external source) produced by different types of insects, amphibians, birds.

The LAeq1hour results remained in a range of 52.9 and 63.2 dBA during the 20 hours of measurement.

Figure 7 shows the sound map of the behavior of the LAeq20 hours sound levels in the study area.

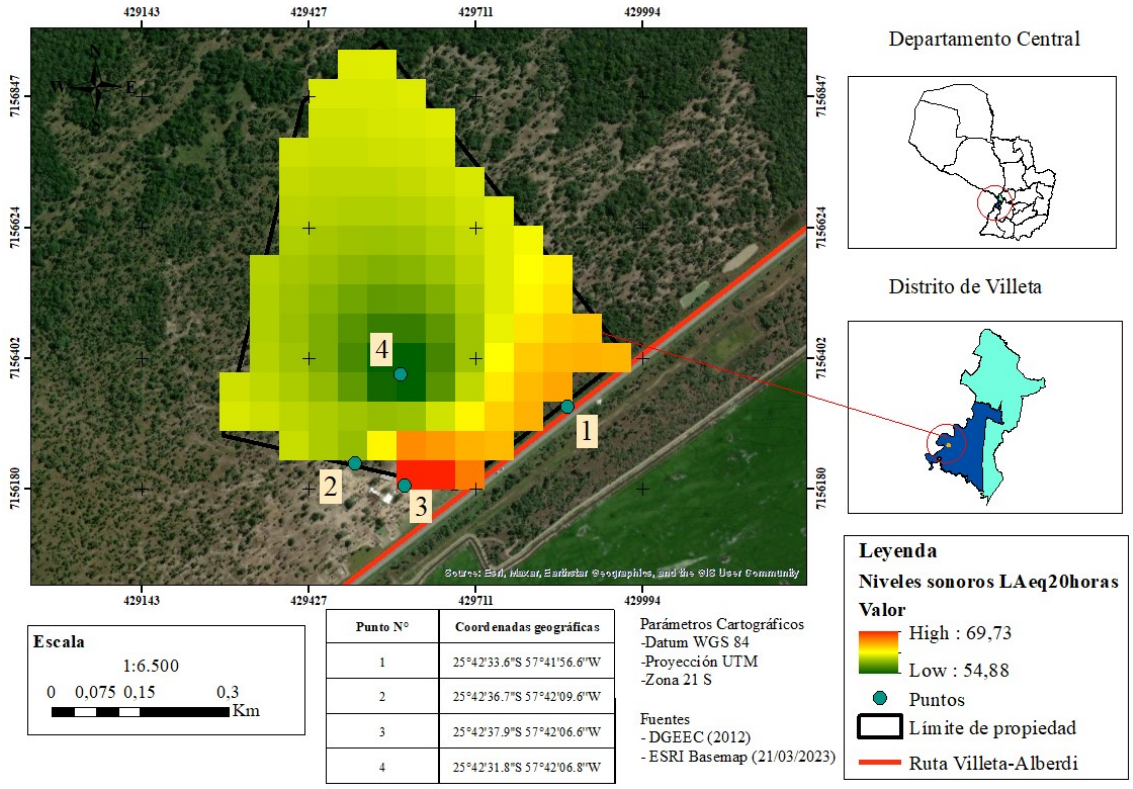

Figura 7. Sound map showing the behaviour of sound levels $LAeq_{20horas}$.

5. CONCLUSIONS

It was possible to monitor the sound levels in compliance with all the requirements established in the terms of reference provided for the consulting service.

All appropriate controls and procedures were applied to carry out the measurements of sound levels.

The peak instantaneous sound levels were maintained in a range of 80.5 and 89.4 dB between the 4 recording points during the 20 hours of measurement, which were produced by sources outside the property or by the activities of the farm adjacent to it.

Instantaneous sound levels were maintained in a range of 36 and 89.4 dB between the 4 recording points during the 20 hours of measurement

LAeq1hour levels were maintained in a range of 52.9 and 73.1 dBA between the 4 recording points during the 20 hours of measurement.

In Point 1, a level of compliance of 66.7% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 100% compliant.

In Point 2, a level of compliance of 100% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety also recorded 100% compliance.

For the analysis of Point 3 and its contrast as an Industrial Area, a level of compliance of 62% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 90% compliant.

Regarding the analysis of point 3 and its contrast as a Residential Area, a level of compliance of 0% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution and the IFC's General Guidelines on the Environment, Health and Safety.

In Point 4, a level of compliance of 95% was recorded with reference to Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 100% compliant.

In general, at the 4 recording points during the 20 hours of measurement, there was a level of compliance of 81% for Law No. 1100/97 on the Prevention of Noise Pollution. The IFC's General Guidelines on Environment, Health and Safety were 98% compliant.

The results obtained will constitute a fundamental input to fulfill the purpose of the consultancy, which is to carry out the modeling of the propagation of sound levels.

6. TECHNICAL TEAM

Table 12. Technical Team

Nombre y Apellido	Función
Bruno Lovera	Environmental Technician coordinator of the measurements, field collaborator
Eng. Amb. César Fleitas Franco	Professional Technician registered by the Ministry of Labour, Employment and Social Security
Eng. Amb. Julio Bordón Gadea	Field collaborator for measurements, data processing and reporting
Osvaldo Avalos Jara	Trained field collaborator to perform the measurements

7. REFERENCES

International Finance Corporation. 2007. General Guidelines on Environment, Health and Safety. World Bank Group. 116 p

Kiely, G. 1999. Environmental Engineering: Fundamentals, Environment, Technology and Management Systems. Madrid, ES. 1331 p.

Municipality of Villeta. 2017. Ordinance No. 25/2017 amending and updating Ordinance No. 2/94 regulating the advertising and noise nuisance system within the district of Villeta in accordance with the provisions of Law No. 1100/97 on the Prevention of Sound Pollution. Villeta. PY. 3 p.

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Paraguay. 2020. Law No. 6,390/20 Regulating Noise Emission. Asunción, PY. 4 p.

Seguéz, F. 2008. Noise mapping strategy (online). Center for the Study and Experimentation of Public Works. Available in: http://www.imac.unavarra.es/web_imac/pages/investigacion/proyectos_investigacion/ForoVerde/disturbeco/documentos/Estrategia_elaboracion_mapa_ruido.pdf

8. ATTACHMENTS

8.1 Technical Specifications of Sound Level Meters

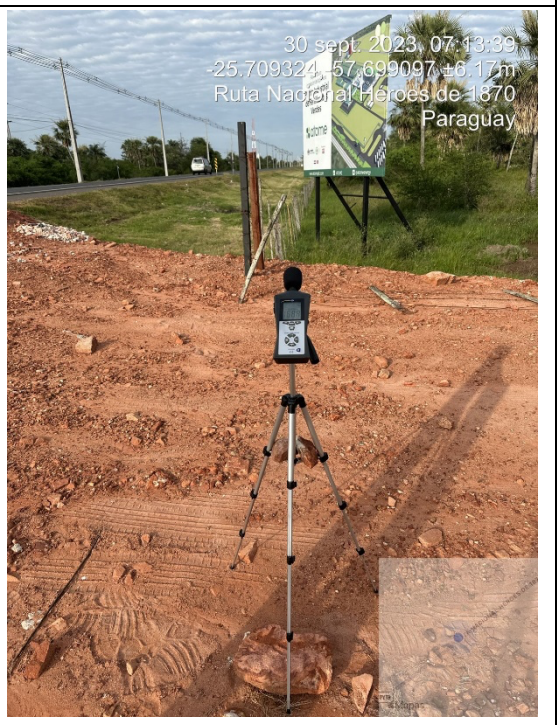
Table 13. Technical specifications of the PCE-322A sound level meter.

Technical Specifications		**Illustrative Image**
Measuring Ranges	Low: 30 a 80 dB	
	Medium: 50 a 100 dB	
	High: 80 a 130 dB	
	Auto: 30 a 130 dB	
Resolution	0,1 dB	
Precision	±1,4 dB	
Frequency	31,5 Hz a 8 kHz	
Memory	Approx. 32700 data + 32 GB memory card (accessory)	
Frequency Weighting	A - C	
Microphone Type	Electret Capacitor	
Functions	Values MIN, MAX, HOLD	
Operating Conditions	0 a 40 °C	
	< 90 % H.r.	
Power Source	Batery of 9 V	
Dimensions	280 x 95 x 45 mm	
Weight	Aprox. 350 g. (without batteries)	
Type	Class II	
Compliance with international standard	IEC61672-1	

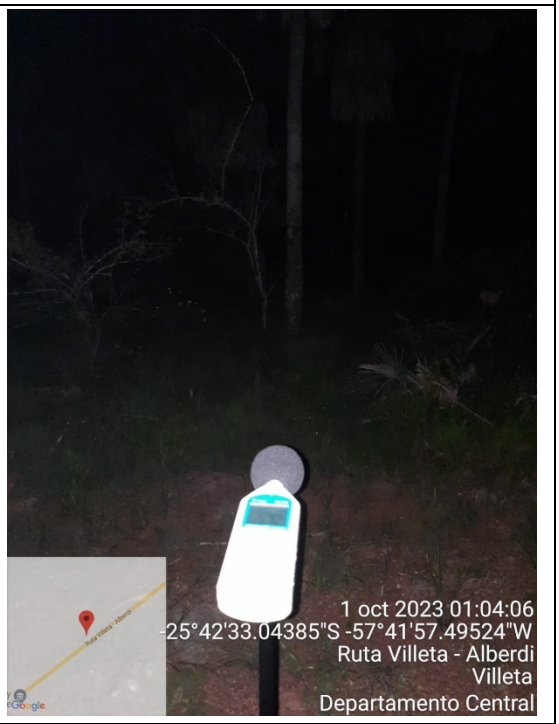
Tabla 14. Technical specifications of the Minipa MSL-1355B

Technical Specifications		**Illustrative Image**
Resolution	0,1 dB	
Frequency Weighting	A - C	
Response Time	Fast - Slow	
Datalogger (memoria)	Approx. 4422 data points	
Datalogger Time Interval	From 1 to 250 seconds	
Battery life	Approx. 20 hours of continuous use	
Operating Conditions	0°C – 40°C	
	HR ≤ 80%	
Dimensions	256 x 70 x 35 mm	
Weight	244 g (without batteries)	
Measuring Ranges	30 a 80 dB	
	30 a 130 dB	
	50 a 100 dB	
	60 a 110 dB	
	80 a 130 dB	
Precision	±1,5 dB	
Frequency	31,5 Hz a 8,5 kHz	
Type	Class II	
Compliance with international standard	IEC PUB 651	

8.2 Photographic record of measurements

<table>
<tr><th colspan="2">Point 1. Main access to the property</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photograph 1. Monitoring of Sound Levels in the morning hours</td><td>Photograph 2. Monitoring of Sound Levels in the morning hours</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photograph 3. Monitoring of Sound Levels at Point 1 at noon</td><td>Photograph 4. Monitoring of Sound Levels at Point 1 in the afternoon</td></tr>
</table>

<table>
<tr><th colspan="2">Point 1. Main access to the property</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Photograph 5. Monitoring of Sound Levels at night</td><td>Photographs 5 and 6. Monitoring of Sound Levels at night</td></tr>
</table>

Point 2. ATOME Property Boundary – Near Neighbor's Barn	
	
Photograph 7. Monitoring of Sound Levels in the morning hours.	Photograph 8. Monitoring of Sound Levels in the morning hours.
	
Photograph 9. Monitoring of Sound Levels in the Afternoon	Photograph 10. Monitoring of Sound Levels at night

Point 3. Main access to the neighbours' house.



Photograph 11. Monitoring of Sound Levels in the morning hours



Photograph 12. Monitoring of Sound Levels in the morning hours.

Point 3. Main access to the neighbours' house.



Photographs 13 and 14. Monitoring of Sound Levels at night



Photograph 14. Monitoring of Sound Levels at night

Punto 4. Futura zona de fuentes fijas emisoras de ruido



Photograph 15. Monitoring of Sound Levels at Point 4 in the morning hours



Photograph 16. Monitoring of Sound Levels at Point 4 in the morning hours



Photograph 17. Monitoring of Sound Levels in the morning hours

8.3 PCE-322A Sound Level Meter Calibration Certificate

LABSOL

CERTIFICADO DE CALIBRACIÓN

SERVICIO ACREDITADO

Organismo Nacional de Acreditación
NP-ISO/IEC 17025:2018
LC009

Certificado N°:	LS20977-2023

1. SOLICITANTE:	JULIO BORDON
Dirección:	Lomas Valentinas c/ Campo Via – Fdo. de la Mora
RUC:	3183136-2

2. DATOS DEL EQUIPO CALIBRADO			
Instrumento:	SONOMETRO	N° de Serie:	180924367
Identificación:	SON-01	Intervalo:	(94 a 114) dB
Marca:	PCE	Resolución:	0,1 dB
Modelo:	322A	Tipo:	DIGITAL

3. PATRONES UTILIZADOS				
Identificación:	PCA-01	PCT-35	---	---
Descripción:	Calibrador acústico	Termohigrometro	---	---
Certificado:	122.855	LS19107-2023	---	---
Próx. Calibración:	2024-02	2024-06	---	---

4. DATOS DE CALIBRACIÓN	
Fecha de calibración:	2023-09-28
Lugar de calibración:	Laboratorio LABSOL
Temperatura:	22,6 °C
Humedad Relativa:	55 %
Procedimiento/s:	LS-PRO-C37 Rev.01

5. ABREVIATURAS	
IP:	Promedio de indicacion del patrón
IEC:	Promedio de indicacion del equipo calibrado
E:	Error de medición
U:	Incertidumbre de medición
k:	Factor de cobertura

Realizado por: Tomás Duarte

Código: ID2022LS028

Autorizado por: Andrea Fernandez

Código: ID2017LS008

6. OBSERVACIONES

La incertidumbre expandida de medida informada se expresa como la incertidumbre de medida estándar multiplicado por el factor de cobertura k con una probabilidad correspondiente a aproximadamente del 95%.
La incertidumbre típica combinada fue determinada en conformidad con el documento Guía para la Expresión de la incertidumbre en las mediciones (GUM).

Firmado digitalmente por ANDREA BEATRIZ FERNANDEZ BAEZ

Este documento ha sido firmado digitalmente y tiene validez legal de acuerdo a la Ley 4017/2010

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohibe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

LS-FOR-038 Rev.06
Vigencia: 2021-09-11

8.3 PCE-322A Sound Level Meter Calibration Certificate (Continued)

LABSOL

CERTIFICADO DE CALIBRACIÓN

SERVICIO ACREDITADO

Organismo Nacional de Acreditación
NP-ISO/IEC 17025:2018
LC009

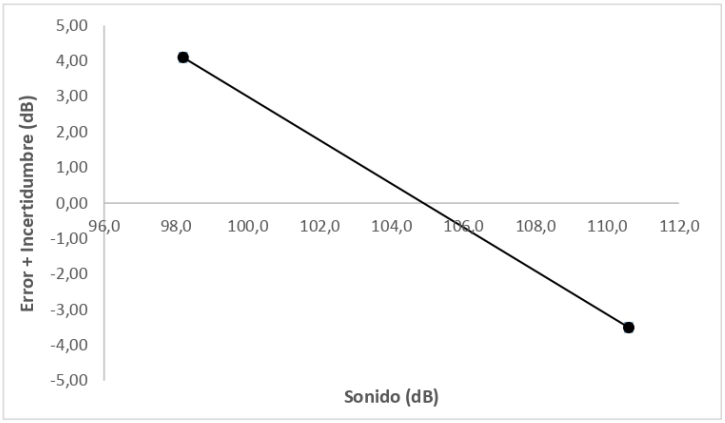
Certificado N°:	LS20977-2023

7. RESULTADOS

SONIDO (dB)

IP (dB)	IEC (dB)	E (dB)	U (dB)	k
94,1	98,2	4,10	0,12	2,00
114,1	110,6	-3,50	0,12	2,00

RESULTADO GRÁFICO DE LA CALIBRACIÓN



8. FECHA DE EMISIÓN DEL CERTIFICADO: 2023-10-02

--- FIN DEL CERTIFICADO ---

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohibe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

8.4 Minipa MSL-1355B Sound Level Meter Calibration Certificate

LABSOL

CERTIFICADO DE CALIBRACIÓN

SERVICIO ACREDITADO

Organismo Nacional de Acreditación NP-ISO/IEC 17025:2018 LC009

Certificado N°:	LS20702-2023

1. SOLICITANTE:	TECNOAMBIENTAL S.R.L.
Dirección:	Jose Viñuales - Fernando de La Mora
RUC:	80070966-7

2. DATOS DEL EQUIPO CALIBRADO			
Instrumento:	SONOMETRO	N° de Serie:	002182H
Identificación:	DB1	Intervalo:	(94 a 114) dB
Marca:	MINIPA	Resolución:	0,1 dB
Modelo:	MSL-1355B	Tipo:	DIGITAL

3. PATRONES UTILIZADOS				
Identificación:	PCA-01	PCT-35	---	---
Descripción:	Calibrador acústico	Termohigrometro	---	---
Certificado:	122.855	LS19107-2023	---	---
Próx. Calibración:	2024-02	2024-06	---	---

4. DATOS DE CALIBRACIÓN	
Fecha de calibración:	2023-09-08
Lugar de calibración:	Laboratorio LABSOL
Temperatura:	22,4 °C
Humedad Relativa:	83 %
Procedimiento/s:	LS-PRO-C37 Rev.00

5. ABREVIATURAS	
IP:	Promedio de indicacion del patrón
IEC:	Promedio de indicacion del equipo calibrado
E:	Error de medición
U:	Incertidumbre de medición
k:	Factor de cobertura

Realizado por: Juan Velázquez

Código: ID2023LS032

Autorizado por: Andrea Fernandez

Código: ID2017LS008

6. OBSERVACIONES

La incertidumbre expandida de medida informada se expresa como la incertidumbre de medida estándar multiplicado por el factor de cobertura k con una probabilidad correspondiente a aproximadamente del 95%.
La incertidumbre típica combinada fue determinada en conformidad con el documento Guía para la Expresión de la incertidumbre en las mediciones (GUM).

Firmado digitalmente por ANDREA BEATRIZ FERNANDEZ BAEZ

Este documento ha sido firmado digitalmente y tiene validez legal de acuerdo a la Ley 4017/2010

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohibe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

8.4 Minipa MSL-1355B Sound Level Meter Calibration Certificate (Continued)

LABSOL

CERTIFICADO DE CALIBRACIÓN

Certificado N°: LS20702-2023

SERVICIO ACREDITADO

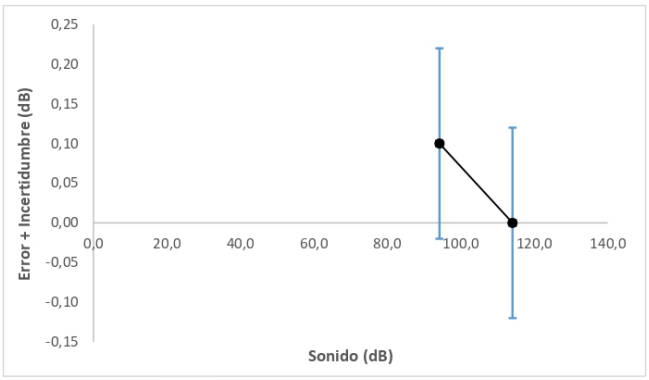
Organismo Nacional de Acreditación
NP-ISO/IEC 17025:2018
LC009

7. RESULTADOS

SONIDO (dB)

IP (dB)	IEC (dB)	E (dB)	U (dB)	k
94,1	94,2	0,10	0,12	2,00
114,1	114,1	0,00	0,12	2,00

RESULTADO GRÁFICO DE LA CALIBRACIÓN



8. FECHA DE EMISIÓN DEL CERTIFICADO: 2023-09-14

--- FIN DEL CERTIFICADO ---

Tel. +59521 202 846
E-Mail. info@labsol.com.py
Dirección. Tte. Jara Troche 346
Asunción, Paraguay

ADVERTENCIAS:
a) Se prohíbe la reproducción de este certificado de calibración de manera parcial.
b) Los resultados presentados se refieren exclusivamente al instrumento descripto en el presente certificado.
c) Los resultados presentados se refieren a las condiciones en las que se realizaron las mediciones.

8.5 Technical professional register of the Ministry of Labour, Employment and Social Security of the technician in charge of the measurements

Ministerio de TRABAJO, EMPLEO Y SEGURIDAD SOCIAL

GOBIERNO NACIONAL

Paraguay de la gente

Registrado en:
Dirección de Salud y Seguridad Ocupacional
VICEMINISTERIO DE TRABAJO
Registro Profesional Técnico

Nombre Completo
CESAR AUGUSTO FLEITAS FRANCO

C.I. Nro.
2859882

Foto Carnet



Categoría
Reg. Profesional Renovación A

Fecha Registro
4/9/2023

Fecha Vencimiento
4/9/2025

Annex 7 – Flora Sampling Data Sheets

Parcel physical data sheet

Parcel N°	Vegetation Type	Date	Location	Coord. X	Coord.Y	Elevation	Soil	Comments
1	Forest	19/06/2023	Villeta, PY	429,487.0942	7,156,608.738	64 m	Clayey loam, saturated, dark, with leaf litter	Adjacent to palm savannah
2	Forest	19/06/2023	Villeta, PY	429,480.488	7,156,651.695	66 m	Clayey loam, saturated, dark, with leaf litter	Forest interior, sparse, abundant lianas
3	Forest	20/06/2023	Villeta, PY	429,537.0654	7,156,929.211	67 m	Clayey loam, saturated, dark, with leaf litter	Forest interior, sparse, abundant lianas
4	Forest	21/06/2023	Villeta, PY	429,465.3045	7,156,830.544	67 m	Clayey loam, saturated, dark, with leaf litter	Forest interior, sparse, abundant lianas
1	Savannah	18/06/2023	Villeta, PY	429,530.0186	7,156,405.563	64 m	Flooded, cattle trampling, herbaceous cover	Several species in bloom
2	Savannah	20/06/2023	Villeta, PY	429,516.5581	7,156,298.627	63 m	Flooded, cattle trampling, herbaceous cover	Several species in bloom
3	Savannah	21/06/2023	Villeta, PY	429,391.7503	7,156,465.774	65 m	Flooded, cattle trampling, herbaceous cover	Several species in bloom
4	Savannah	21/06/2023	Villeta, PY	429,629.9176	7,156,624.025	64 m	Flooded, cattle trampling, herbaceous cover	Several species in bloom
5	Savannah	21/06/2023	Villeta, PY	429,744.1344	7,156,324.829	63 m	Flooded, cattle trampling, herbaceous cover	Several species in bloom

Data of the Forest Parcels. Alt: height, DBH: diameter at breast height, Fen: phenology, EF: phytosanitary status, Obs: observations.

N°	Parcel N°	Species	Alt.	DAP	Fen.	EF	Obs.
1	1	*Copernicia alba Morong*	7.50	22.61	fruits	healthy	Lichens
2	1	*Tabebuia nodosa (Griseb.) Griseb.*	7.00	14.92	sterile	Broken branches	Lichens
3	1	*Vachellia caven (Molina) Seigler & Ebinger*	4.00	11.78	sterile	nearly dry	Few leaves
4	1	*Sorocea saxicola Hassl.*	10.00	15.45	sterile	healthy	Lichens
5	1	*Pisonia zapallo Griseb.*	8.00	13.28	sterile	healthy	Lichens
6	1	*Sorocea saxicola Hassl.*	7.20	19.11	sterile	healthy	Microgramma vaccinifolia on stem
7	1	*Parapiptadenia rigida (Benth.) Brenan*	7.00	18.60	fruits	healthy	Inclined
8	1	*Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.*	8.50	30.60	sterile	lianas, broken branches	Tillandsia sp on stem
9	1	*Parapiptadenia rigida (Benth.) Brenan*	13.00	30.25	fruits	lianas	
10	1	*Chrysophyllum marginatum (Hook. & Arn.) Radlk. ssp. marginatum*	6.00	12.10	flowers	Broken branches	Inclined
11	1	*Eugenia uniflora L.*	5.00	10.00	sterile	healthy	Inclined
12	1	*Pisonia zapallo Griseb.*	10.00	47.16	sterile	hollow	Gills
13	1	*Pisonia zapallo Griseb.*	8.00	12.17	sterile	lianas	
14	1	*Sorocea saxicola Hassl.*	8.50	34.87	sterile	with termites	
15	1	*Sorocea saxicola Hassl.*	10.00	26.91	sterile	healthy	Microgramma vaccinifolia on stem
16	1	*Sorocea saxicola Hassl.*	7.50	16.88	sterile	healthy	Microgramma vaccinifolia on stem
17	1	*Parapiptadenia rigida (Benth.) Brenan*	14.00	29.30	fruits	parasitic, lianas	Phoradendron dipterum
18	1	*Sorocea saxicola Hassl.*	7.00	20.06	sterile	healthy	Microgramma vaccinifolia on stem
19	1	*Sorocea saxicola Hassl.*	7.00	14.97	sterile	healthy	Campylocentrum neglectum on stem
20	1	*Sorocea saxicola Hassl.*	6.80	10.19	sterile	healthy	
21	1	*Sorocea saxicola Hassl.*	8.00	17.83	sterile	healthy	C. neglectum y M. vacciniifolia on stem

N°	Parcel N°	Species	Alt.	DAP	Fen.	EF	Obs.
22	1	*Pisonia zapallo Griseb.*	12.00	34.24	sterile	broken branches	
23	1	*Syagrus romanzoffiana (Cham.) Glassman*	8.00	25.96	fruits	healthy	
24	1	*Copernicia alba Morong*	8.50	20.70	fruits	cut	
25	1	*Sorocea saxicola Hassl.*	11.00	28.98	sterile	healthy	Rhipsalis baccifera on stem
26	1	*Sorocea saxicola Hassl.*	12.00	21.66	sterile	healthy	
27	1	*Pisonia zapallo Griseb.*	10.00	15.92	sterile	healthy	Lichens
28	1	*Sorocea saxicola Hassl.*	8.00	13.06	sterile	healthy	Lichens
29	1	*Sorocea saxicola Hassl.*	10.00	11.94	sterile	healthy	Lichens
30	1	*Sorocea saxicola Hassl.*	11.00	17.20	sterile	healthy	Lichens
31	1	*Chrysophyllum marginatum (Hook. & Arn.) Radlk. ssp. marginatum*	7.00	11.31	fruits	healthy	Inclined
32	1	*Plinia rivularis (Cambess.) Rotman*	5.00	13.38	sterile	broken branches	Inclined
33	1	*Plinia rivularis (Cambess.) Rotman*	4.00	11.15	sterile	healthy	Inclined
34	2	*Parapiptadenia rigida (Benth.) Brenan*	5.00	37.58	fruits	healthy	Inclined
35	2	*Libidibia paraguariensis (D. Parodi) G.P. Lewis*	13.00	45.54	sterile	with termites	Endangered
36	2	*Parapiptadenia rigida (Benth.) Brenan*	15.00	51.11	fruits	healthy	
37	2	*Sorocea saxicola Hassl.*	6.00	12.74	sterile	healthy	
38	2	*Gleditsia amorphoides (Griseb.) Taub.*	7.00	28.54	sterile	with termites	C. neglectum y M. vacciniifolia on stem
39	2	*Pisonia zapallo Griseb.*	6.70	36.62	sterile	healthy	Inclined
40	2	*Randia armata (Sw.) DC.*	3.50	10.51	sterile	healthy	Inclined
41	2	*Pisonia zapallo Griseb.*	7.00	14.01	sterile	healthy	Inclined
42	2	*Copernicia alba Morong*	10.00	23.25	fruits	healthy	
43	2	*Ruprechtia laxiflora Meisn.*	6.80	18.15	sterile	leaves eaten by insects	Microgramma vaccinifolia on stem
44	2	*Coccoloba aff. cordata Cham.*	3.80	10.19	sterile	broken branches	Inclined

N°	Parcel N°	Species	Alt.	DAP	Fen.	EF	Obs.
45	2	*Ruprechtia laxiflora Meisn.*	12.00	35.67	sterile	Leaves eaten by insects	Microgramma vaccinifolia on stem
46	2	*Parapiptadenia rigida (Benth.) Brenan*	14.00	31.53	fruits	Lianas	
47	2	*Sorocea saxicola Hassl.*	7.00	13.54	sterile	Healthy	
48	2	*Parapiptadenia rigida (Benth.) Brenan*	8.00	15.13	fruits	Lianas	
49	2	*Ruprechtia laxiflora Meisn.*	6.50	16.88	sterile	Leaves eaten by insects	
50	2	*Ruprechtia laxiflora Meisn.*	7.00	16.56	sterile	Leaves eaten by insects	
51	2	*Ruprechtia laxiflora Meisn.*	5.80	11.78	sterile	Leaves eaten by insects	
52	2	*Gleditsia amorphoides (Griseb.) Taub.*	6.00	10.83	fruits	healthy	
53	2	*Sorocea saxicola Hassl.*	5.00	10.03	sterile	lianas	
54	2	*Ruprechtia laxiflora Meisn.*	9.00	18.79	sterile	lianas	
55	2	*Ruprechtia laxiflora Meisn.*	6.50	14.89	sterile	abundant lianas	
56	2	*Sorocea saxicola Hassl.*	5.80	12.26	sterile	lianas	Campylocentrum neglectum on stem
57	2	*Pisonia zapallo Griseb.*	7.00	11.46	sterile	Healthy	Campylocentrum neglectum on stem
58	2	*Ruprechtia laxiflora Meisn.*	10.00	23.25	sterile	Healthy	
59	2	*Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.*	14.00	27.07	sterile	Healthy	semiinclinado
60	2	*Pisonia zapallo Griseb.*	12.00	31.21	sterile	Lianas	
61	2	*Syagrus romanzoffiana (Cham.) Glassman*	9.00	17.52	sterile	Healthy	
62	2	*Eugenia uniflora L.*	5.80	12.98	sterile	Healthy	Inclined
63	2	*Eugenia uniflora L.*	6.00	12.74	sterile	Healthy	
64	2	*Eugenia uniflora L.*	6.50	14.01	sterile	Hollow	
65	2	*Eugenia uniflora L.*	5.00	10.51	sterile	Healthy	
66	3	*Indet 1*	8.50	30.57	sterile	Lianas	No leaves
67	3	*Syagrus romanzoffiana (Cham.) Glassman*	6.30	21.34	fruits	Healthy	
68	3	*Syagrus romanzoffiana (Cham.) Glassman*	2.50	11.31	fruits	Healthy	

N°	Parcel N°	Species	Alt.	DAP	Fen.	EF	Obs.
69	3	*Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.*	6.50	18.79	sterile	Hollow	semiinclinado
70	3	*Syagrus romanzoffiana (Cham.) Glassman*	6.50	20.70	fruits	Healthy	
71	3	*Syagrus romanzoffiana (Cham.) Glassman*	5.50	14.81	sterile	Healthy	Lichens
72	3	*Chrysophyllum marginatum (Hook. & Arn.) Radlk.* ssp. *marginatum*	4.50	12.10	sterile	Healthy	
73	3	*Syagrus romanzoffiana (Cham.) Glassman*	3.50	10.83	sterile	Healthy	Lichens
74	3	*Parapiptadenia rigida (Benth.) Brenan*	7.80	14.97	fruits	Healthy	Peperomia aceroana on stem
75	3	*Syagrus romanzoffiana (Cham.) Glassman*	4.00	22.61	sterile	Healthy	Lichens
76	3	*Eugenia uniflora L.*	4.00	11.94	sterile	with termites	
77	3	*Sorocea saxicola Hassl.*	6.00	14.65	sterile	healthy	Lichens
78	3	*Indet 2 Fabaceae*	8.00	20.76	sterile	hollow	Few leaves
79	3	*Zanthoxylum fagara (L.) Sarg.* ssp. *fagara*	6.00	15.92	sterile	Healthy	Lichens
80	3	*Indet 1*	8.00	29.30	sterile	lianas	Few leaves
81	3	*Schinopsis balansae Engl.*	14.00	47.77	sterile	Healthy	Lichens
82	3	*Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.*	6.00	10.51	sterile	Healthy	
83	3	*Gleditsia amorphoides (Griseb.) Taub.*	5.00	14.97	sterile	Holloe	Lichens
84	3	*Syagrus romanzoffiana (Cham.) Glassman*	4.00	19.11	sterile	Healthy	
85	4	*Tabebuia nodosa (Griseb.) Griseb.*	9.00	24.20	sterile	Healthy	C. neglectum y M. vacciniifolia on stem
86	4	*Cordia americana (L.) Gottschling & J.S. Mill.*	10.00	18.63	sterile	Healthy	Trichocentrum pumilum on stem
87	4	*Ruprechtia laxiflora Meisn.*	7.80	13.38	sterile	Healthy	P. aceroana y M. vacciniifolia on stem
88	4	*Ruprechtia laxiflora Meisn.*	8.00	18.15	sterile	lianas	Microgramma vaccinifolia on stem
89	4	*Casearia* sp	6.00	13.69	sterile	abundant lianas	
90	4	*Parapiptadenia rigida (Benth.) Brenan*	6.50	23.57	fruits	Broken branches	
91	4	*Cordia americana (L.) Gottschling & J.S. Mill.*	10.00	29.46	sterile	lianas	Semi-inclined
92	4	*Indet 3 Myrtaceae*	7.00	22.93	sterile	lianas	Rhipsalis lumbricoides on stem
93	4	*Indet 3 Myrtaceae*	6.50	10.51	sterile	lianas	Microgramma vaccinifolia on stem

N°	Parcel N°	Species	Alt.	DAP	Fen.	EF	Obs.
94	4	*Peltophorum dubium (Spreng.) Taub.*	11.00	26.11	fruits	lianas	Trichocentrum pumilum on stem
95	4	*Machaerium sp*	7.00	25.80	sterile	lianas	Rhipsalis lumbricoides on stem
96	4	*Ruprechtia laxiflora Meisn.*	8.50	17.09	sterile	Broken branches	Microgramma vaccinifolia on stem
97	4	*Indet 3 Myrtaceae*	6.00	19.75	sterile	abundant lianas, hollow	
98	4	*Guazuma ulmifolia Lam.*	5.70	18.15	fruits	lianas	
99	4	*Syagrus romanzoffiana (Cham.) Glassman*	4.80	11.15	sterile	Healthy	
100	4	*Chrysophyllum marginatum (Hook. & Arn.) Radlk.* ssp. *marginatum*	3.50	10.83	sterile	lianas	Inclined stem, with Microgramma vacciniifolia
101	4	*Schinopsis balansae Engl.*	10.00	28.03	sterile	lianas	Semi-inclined
102	4	*Schinopsis balansae Engl.*	9.00	21.97	sterile	Abundant lianas	
103	4	*Syagrus romanzoffiana (Cham.) Glassman*	3.80	14.01	sterile	Healthy	
104	4	*Chrysophyllum marginatum (Hook. & Arn.) Radlk.* ssp. *marginatum*	7.00	17.52	sterile	lianas	Inclined stem, with Microgramma vacciniifolia

Data of the Savannah Parcels

N°	Parcel N°	Family	Species	Habit	Comments
1	1	Cyperaceae	*Eleocharis elegans (Kunth) Roem. & Schult.*	Grass	aquatic-palustrine
2	1	Cyperaceae	*Eleocharis filiculmis Kunth Kunth*	Grass	aquatic-palustrine
3	1	Cyperaceae	*Cyperus entrerianus Boeck. var. entrerianus*	Grass	palustrine
4	1	Poaceae	*Setaria* sp	Grass	palustrine
5	1	Lythraceae	*Cuphea* sp1	Grass	esterile
6	1	Poaceae	*Panicum* sp	Grass	palustrine
7	1	Onagraceae	*Ludwigia decurrens Walter*	Subshrub	palustrine
8	1	Cyperaceae	*Cyperus odoratus L.*	Grass	aquatic-palustrine
9	1	Poaceae	*Hymenachne amplexicaulis (Rudge) Nees*	Grass	aquatic
10	1	Euphorbiaceae	*Caperonia castaneifolia (L.) A. St.-Hil.*	Grass	palustrine
11	1	Euphorbiaceae	*Caperonia palustris (L.) A. St.-Hil.*	Grass	palustrine
12	1	Oxalidaceae	*Oxalis paludosa A. St.-Hil.*	Grass	palustrine
13	1	Solanaceae	*Solanum glaucophyllum Desf.*	Subshrub	palustrine
14	1	Arecaceae	*Copernicia alba Morong*	Palm	palustrine
15	1	Cyperaceae	*Cyperus sesquiflorus (Torr.) Mattf. & Kük. ex Kük.*	Grass	palustrine, medicinal
16	1	Poaceae	*Echinochloa colona (L.) Link*	Grass	adventitia
17	1	Pontederiaceae	*Pontederia cordata L. var. cordata*	Grass	aquatic
18	1	Cyperaceae	*Rhynchospora* sp	Grass	palustrine
19	1	Asteraceae	*Eclipta prostata (L.) L.*	Grass	palustrine
20	1	Convolvulaceae	*Ipomoea* sp1	Grass	rambler, esterile
21	1	Fabaceae	*Sesbania virgata (Cav.) Poir.*	Shrub	palustrine
22	1	Asteraceae	*indet 1*	Grass	esterile
23	1	Phyllanthaceae	*Moeroris stipulata Raf.*	Grass	Palustrine
24	1	Asteraceae	*Pterocaulon virgatum (L.) DC.*	Grass	ruderal, palustrine, medicinal

N°	Parcel N°	Family	Species	Habit	Comments
25	1	Amaranthaceae	*Pfaffia glomerata (Spreng.) Pedersen*	Grass	palustrine, medicinal
26	1	Fabaceae	*Vachellia caven (Molina) Seigler & Ebinger*	Shrub	palustrine, medicinal
27	1	Passifloraceae	*Passiflora misera Kunth misera Kunth*	Grass	rambler, esterile
28	1	Fabaceae	*Mimosa debilis Humb. & Bonpl. ex Willd. var. debilis*	Grass	creeper
29	1	Malvaceae	*Sida aff. potentilloides A. St.-Hil.*	Subshrub	in less waterlogged areas
30	2	Fabaceae	*Sesbania virgata (Cav.) Poir.*	Shrub	palustrine
31	2	Cyperaceae	*Eleocharis elegans (Kunth) Roem. & Schult.*	Grass	palustrine
32	2	Cyperaceae	*Cyperus entrerianus Boeck. var. entrerianus*	Grass	palustrine
33	2	Poaceae	*Leersia hexandra Sw.*	Grass	palustrine
34	2	Poaceae	*Hymenachne amplexicaulis (Rudge) Nees*	Grass	aquatic
35	2	Oxalidaceae	*Oxalis paludosa A. St.-Hil.*	Grass	palustrine
36	2	Poaceae	*Paspalum* sp2	Grass	palustrine
37	2	Asteraceae	*Eupatorium* sp1	Grass	esterile
38	2	Euphorbiaceae	*Caperonia castaneifolia (L.) A. St.-Hil.*	Grass	palustrine
39	2	Phyllanthaceae	*Moeroris stipulata Raf.*	Grass	palustrine
40	2	Cyperaceae	*Eleocharis filiculmis Kunth Kunth*	Grass	palustrine
41	2	Araliaceae	*Hydrocotyle ranunculoides L. f.*	Grass	aquatic-palustrine
42	2	Plantaginaceae	*Bacopa salzmannii (Benth.) Wettst. ex Edwall*	Grass	palustrine
43	2	Apocynaceae	*Mandevilla angustifolia (Malme) Woodson*	Grass	rambler, esterile
44	2	Cyperaceae	*Rhynchospora* sp	Grass	palustrine
45	2	Malvaceae	*Pavonia* sp	Grass	in less waterlogged areas
46	2	Commelinaceae	*Commelina erecta L.*	Grass	ruderal, medicinal
47	2	Onagraceae	*Ludwigia decurrens Walter*	Subshrub	palustrine
48	2	Cyperaceae	*Cyperus odoratus L.*	Grass	palustrine
49	2	Asteraceae	*Eclipta prostata (L.) L.*	Grass	palustrine
50	2	Orobanchaceae	*Agalinis genistifolia (Cham. & Schltdl.) D'Arcy*	Grass	palustrine

N°	Parcel N°	Family	Species	Habit	Comments
51	2	Orobanchaceae	*Agalinis communis (Cham. & Schltdl.) D'Arcy*	Grass	palustrine
52	2	Apiaceae	*Eryngium elegans Cham. & Schltdl.*	Grass	palustrine, medicinal
53	2	Fabaceae	*Mimosa balansae Micheli*	Grass	in less waterlogged areas
54	2	Convolvulaceae	*Ipomoea* sp2	Grass	trepadora, esterile
55	2	Asteraceae	*indet 2*	Grass	Esterile
56	2	Malvaceae	*Sidastrum paniculatum (L.) Fryxell*	Grass	in less waterlogged areas
57	2	Malvaceae	*Sida spinosa L.*	Grass	ruderal, medicinal
58	2	Poaceae	*Setaria* sp	Grass	palustrine
59	2	Solanaceae	*Solanum glaucophyllum Desf.*	Subshrub	palustrine
60	2	Convolvulaceae	*Ipomoea carnea Jacq. subsp. fistulosa (Mart. ex Choisy). D.F. Austin*	Shrub	palustrine
61	2	Asteraceae	*Chromolaena laevigata (Lam.) R.M. King & H. Rob. var. laevigata*	Shrub	in less waterlogged areas
62	2	Amaranthaceae	*Alternanthera kurtzii Schinz ex Pedersen* ssp. *kurtzii*	Grass	palustrine
63	2	Malvaceae	*Hibiscus* sp	Grass	Esterile
64	2	Asteraceae	*indet 3*	Subshrub	with flower buds
65	2	Plantaginaceae	*Mecardonia procumbens (Mill.) Small var. flagellaris (Cham. & Schltdl.) V.C. Souza*	Grass	wet areas and roadsides
66	2	Arecaceae	*Copernicia alba Morong*	Palm	regeneration, food use, craft
67	2	Lythraceae	*Cuphea racemosa (L. f.) Spreng.* ssp. *racemosa*	Grass	ruderal, medicinal
68	2	Pontederiaceae	*Pontederia cordata L. var. cordata*	Grass	aquatic-palustrine
69	2	Poaceae	*Panicum* sp	Grass	palustrine
70	3	Arecaceae	*Copernicia alba Morong*	Palm	palustrine, alimenticio, uso artesanal
71	3	Poaceae	*Setaria* sp	Grass	dried fruit
72	3	Malvaceae	*Pavonia* sp	Grass	in less waterlogged areas
73	3	Onagraceae	*Ludwigia decurrens Walter*	Subshrub	palustrine
74	3	Cyperaceae	*Cyperus entrerianus Boeck. var. entrerianus*	Grass	palustrine
75	3	Poaceae	*Paspalum* sp2	Grass	palustrine

N°	Parcel N°	Family	Species	Habit	Comments
76	3	Poaceae	*Leersia hexandra Sw.*	Grass	palustrine
77	3	Menyanthaceae	*Nymphoides indica (L.) Kuntze*	Grass	aquatic
78	3	Oxalidaceae	*Oxalis paludosa A. St.-Hil.*	Grass	palustrine
79	3	Cyperaceae	*Eleocharis elegans (Kunth) Roem. & Schult.*	Grass	palustrine
80	3	Poaceae	*Hymenachne amplexicaulis (Rudge) Nees*	Grass	aquatic
81	3	Phyllanthaceae	*Moeroris stipulata Raf.*	Grass	palustrine
82	3	Poaceae	*Panicum* sp	Grass	palustrine
83	3	Pontederiaceae	*Pontederia cordata L. var. cordata*	Grass	aquatic
84	3	Araliaceae	*Hydrocotyle ranunculoides L. f.*	Grass	aquatic-palustrine
85	3	Asteraceae	*Eclipta prostata (L.) L.*	Grass	palustrine
86	3	Malvaceae	*Sida spinosa L.*	Grass	ruderal, medicinal
87	3	Solanaceae	*Solanum glaucophyllum Desf.*	Subshrub	palustrine
88	3	Commelinaceae	*Commelina erecta L.*	Grass	ruderal, medicinal
89	3	Asteraceae	*Eupatorium* sp1	Grass	Esterile
90	3	Fabaceae	*Macroptilium erythroloma (Mart. ex Benth.) Urb.*	Grass	Rambler
91	3	Lythraceae	*Cuphea lysimachioides Cham. & Schltdl.*	Grass	ruderal
92	3	Malvaceae	*Sidastrum paniculatum (L.) Fryxell*	Grass	In less waterlogged areas
93	3	Asteraceae	*Pterocaulon virgatum (L.) DC.*	Grass	ruderal, palustrine
94	3	Cyperaceae	*Rhynchospora* sp	Grass	palustrine
95	3	Orobanchaceae	*Agalinis genistifolia (Cham. & Schltdl.) D'Arcy*	Grass	palustrine
96	3	Alismataceae	*Helanthium* sp	Grass	palustrine
97	3	Cyperaceae	*Cyperus odoratus L.*	Grass	palustrine
98	3	Solanaceae	*Jaborosa integrifolia Lam.*	Grass	palustrine
99	3	Fabaceae	*Vachellia caven (Molina) Seigler & Ebinger*	Shrub	palustrine, medicinal
100	3	Bromeliaceae	*Tillandsia recurvifolia Hook.*	Grass	epiphyte, Vachellia caven on stem
101	3	Amaranthaceae	*Pfaffia glomerata (Spreng.) Pedersen*	Grass	palustrine, medicinal
102	4	Arecaceae	*Copernicia alba Morong*	Palm	palustrine, edible, craft use

N°	Parcel N°	Family	Species	Habit	Comments
103	4	Salicaceae	*Xylosma venosum N.E.Brown.*	Shrub	palustrine
104	4	Poaceae	*Panicum* sp	Grass	palustrine
105	4	Fabaceae	*Mimosa* sp	Grass	esterile
106	4	Oxalidaceae	*Oxalis paludosa A. St.-Hil.*	Grass	palustrine
107	4	Onagraceae	*Ludwigia decurrens Walter*	Subshrub	palustrine
108	4	Cyperaceae	*Cyperus entrerianus Boeck. var. entrerianus*	Grass	palustrine
109	4	Cyperaceae	*Eleocharis elegans (Kunth) Roem. & Schult.*	Grass	palustrine
110	4	Pontederiaceae	*Pontederia cordata L. var. cordata*	Grass	aquatic-palustrine
111	4	Cyperaceae	*Cyperus odoratus L.*	Grass	palustrine
112	4	Araliaceae	*Hydrocotyle ranunculoides L. f.*	Grass	aquatic-palustrine
113	4	Asteraceae	*Eclipta prostata (L.) L.*	Grass	palustrine
114	4	Cyperaceae	*Cyperus aff. digitatus Roxb.*	Grass	palustrine
115	4	Poaceae	*Paspalum* sp2	Grass	palustrine
116	4	Orobanchaceae	*Agalinis genistifolia (Cham. & Schltdl.) D'Arcy*	Grass	palustrine
117	4	Menyanthaceae	*Nymphoides indica (L.) Kuntze*	Grass	aquatic
118	4	Plantaginaceae	*Bacopa salzmannii (Benth.) Wettst. ex Edwall*	Grass	palustrine
119	4	Poaceae	*Hymenachne amplexicaulis (Rudge) Nees*	Grass	acuática
120	5	Arecaceae	*Copernicia alba Morong*	Palm	palustrine
121	5	Poaceae	*Paspalum* sp2	Grass	palustrine
122	5	Poaceae	*Lasiacis* sp	Grass	palustrine
123	5	Oxalidaceae	*Oxalis paludosa A. St.-Hil.*	Grass	palustrine
124	5	Poaceae	*Leersia hexandra Sw.*	Grass	palustrine
125	5	Asteraceae	*Eclipta prostata (L.) L.*	Grass	palustrine
126	5	Cyperaceae	*Cyperus entrerianus Boeck. var. entrerianus*	Grass	palustrine
127	5	Cyperaceae	*Cyperus aff. digitatus Roxb.*	Grass	palustrine
128	5	Fabaceae	*Aeschynomene* sp	Grass	palustrine

N°	Parcel N°	Family	Species	Habit	Comments
129	5	Poaceae	*Paspalum* sp1	Grass	palustrine
130	5	Commelinaceae	*Commelina erecta L.*	Grass	ruderal, medicinal
131	5	Fabaceae	*Vachellia caven (Molina) Seigler & Ebinger*	Shrub	palustrine, medicinal
132	5	Bromeliaceae	*Tillandsia recurvifolia Hook.*	Grass	epiphyte, Vachellia caven on stem
133	5	Polygonaceae	*Muehlenbeckia sagittifolia (Ortega) Meisn.*	Grass	rambler, medicinal
134	5	Convolvulaceae	*Ipomoea carnea Jacq. subsp. fistulosa (Mart. ex Choisy). D.F. Austin*	Shrub	palustrine
135	5	Fabaceae	*Senna pendula (Willd.) H.S. Irwin & Barneby var. paludicola H.S. Irwin & Barneby*	Shrub	palustrine
136	5	Cyperaceae	*Eleocharis elegans (Kunth) Roem. & Schult.*	Grass	palustrine
137	5	Bignoniaceae	*Tabebuia nodosa (Griseb.) Griseb.*	Tree	In les waterlogged areas
138	5	Lythraceae	*Cuphea* sp2	Grass	esterile
139	5	Vitaceae	*Cissus palmata Poir.*	Subshrub	rambler, on Tabebuia nodosa
140	5	Cyperaceae	*Eleocharis filiculmis Kunth Kunth*	Grass	palustrine
141	5	Alismataceae	*Helanthium* sp	Grass	palustrine
142	5	Malvaceae	*Pavonia* sp	Grass	Esterile
143	5	Asteraceae	*indet 4*	Subshrub	esterile
144	5	Asteraceae	*Eupatorium* sp2	Subshrub	Dried fruits
145	5	Asteraceae	*Vernonia* sp	Grass	Flower buds
146	5	Orobanchaceae	*Agalinis genistifolia (Cham. & Schltdl.) D'Arcy*	Grass	palustrine
147	5	Pontederiaceae	*Pontederia cordata L. var. cordata*	Grass	aquatic - palustrine

Annex 8 – List of Flora Species

Table 5.3.1.3.2.a
List of species recorded during the second survey

N°	Family	Species	Common name
1	Anacardiaceae	*Schinopsis balansae* Engl.	Quebracho colorado
2	Arecaceae	*Copernicia alba* Morong	Karanda'y
3	Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	Pindo
4	Bignoniaceae	*Tabebuia nodosa* (Griseb.) Griseb.	Labón
5	Boraginaceae	*Cordia americana* (L.) Gottschling & J.S. Mill.	Guajayvi
6	Fabaceae	*Gleditsia amorphoides* (Griseb.) Taub.	Yvope
7	Fabaceae	Indet 2	
8	Fabaceae	*Libidibia paraguariensis* (D. Parodi) G.P. Lewis	Guayacán
9	Fabaceae	*Machaerium* sp	
10	Fabaceae	*Parapiptadenia rigida* (Benth.) Brenan	Kurupa'yrâ
11	Fabaceae	*Peltophorum dubium* (Spreng.) Taub.	Yvyra pytâ
12	Fabaceae	*Vachellia caven* (Molina) Seigler & Ebinger	Aromita
13	Undetermined	Indet 1	
14	Malvaceae	*Guazuma ulmifolia* Lam.	Kamba akâ
15	Moraceae	*Sorocea saxicola* Hassl.	Ñandypami
16	Myrtaceae	*Eugenia uniflora* L.	Ñangapiry
17	Myrtaceae	Indet 3	
18	Myrtaceae	*Plinia rivularis* (Cambess.) Rotman	Yvaporoity
19	Nyctaginaceae	*Pisonia Griseb Pumpkin* .	Jukyryvusu
20	Polygonaceae	*Coccoloba* aff. *cordata* Cham.	Duraznillo moado
21	Polygonaceae	*Ruprechtia laxiflora* Meisn.	Yvyra pytâ'i
22	Rubiaceae	*Randia armata* (Sw.) DC.	Ñuatî kurusu
23	Rutaceae	*Zanthoxylum fagara* (L.) Sarg. ssp. *Fagara*	Mbarakaja pyâpe
24	Salicaceae	Casearia sp	
25	Sapotaceae	*Chrysophyllum marginatum* (Hook. & Arn.) Radlk. ssp. *marginatum*	Pykasu rembi'u
26	Sapotaceae	*Sideroxylon obtusifolium* (Roem. & Schult.) T.D. Penn.	Guajayvirai

Table 5.3.1.3.2.b
Distribution of species in the second survey

Species	Variance	Stocking	Probability	Distribution
Schinopsis balansae Engl.	0.92	0.75	0.30	random
Copernicia alba Morong	0.92	0.75	0.30	random
Syagrus romanzoffiana (Cham.) Glassman	8.25	2.75	0.03	random
Tabebuia nodosa (Griseb.) Griseb.	0.33	0.50	0.58	random
Cordia americana (L.) Gottschling & J.S. Mill.	1.00	0.50	0.11	random
Gleditsia amorphoides (Griseb.) Taub.	0.92	0.75	0.30	random
Indet 2	0.25	0.25	0.39	random
Libidibia paraguariensis (D. Parodi) G.P. Lewis	0.25	0.25	0.39	random
Machaerium sp	0.25	0.25	0.39	random
Parapiptadenia rigida (Benth.) Brenan	2.25	2.25	0.39	random
Peltophorum dubium (Spreng.) Taub.	0.25	0.25	0.39	random
Vachellia caven (Molina) Seigler & Ebinger	0.25	0.25	0.39	random
Indet 1	1.00	0.50	0.11	random
Guazuma ulmifolia Lam.	0.25	0.25	0.39	random

Table 5.3.1.3.2.b
Distribution of species in the second survey

Species	Variance	Stocking	Probability	Distribution
Sorocea saxicola Hassl.	40.92	4.75	0.00	aggregate
Eugenia uniflora L.	3.00	1.50	0.11	random
Indet 3	2.25	0.75	0.03	random
Plinia rivularis (Cambess.) Rotman	1.00	0.50	0.11	random
Pisonia Griseb Pumpkin .	6.92	2.25	0.03	random
Coccoloba aff. *cordata* Cham.	0.25	0.25	0.39	random
Ruprechtia laxiflora Meisn.	14.25	2.75	0.00	aggregate
Randia armata (Sw.) DC.	0.25	0.25	0.39	random
Zanthoxylum fagara (L.) Sarg. ssp. *Fagara*	0.25	0.25	0.39	random
Casearia sp	0.25	0.25	0.39	random
Chrysophyllum marginatum (Hook. & Arn.) Radlk. ssp. *marginatum*	0.92	1.25	0.54	random
Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.	0.67	1.00	0.58	random

Table 5.3.1.3.2.c
Species sorted by IVI values. A: Absolute abundance; F: Absolute frequency as a percentage; D: Absolute dominance; IVI: Importance Value Index

N°	Species	To	F	D	IVI
1	*Sorocea saxicola*	0.18	75	54.18	56.67
2	*Parapiptadenia rigida*	0.09	100	31.17	35.80
3	*Syagrus romanzoffiana*	0.11	100	17.59	29.77
4	*Pisonia zucchini*	0.09	50	22.91	26.51
5	*Ruprechtia laxiflora*	0.11	25	20.54	24.83
6	*Eugenia uniflora*	0.06	75	2.56	13.93
7	*Sideroxylon obtusifolium*	0.04	75	3.71	12.69
8	*Chrysophyllum marginatum* ssp. *marginatum*	0.05	75	2.00	12.65
9	*Schinopsis balansae*	0.03	50	4.69	10.08
10	*Copernicia alba*	0.03	50	2.17	8.60
11	*Gleditsia amorphoides*	0.03	50	1.45	8.18
12	*Tabebuia nodosa*	0.02	50	0.75	6.81
13	Indet 3	0.03	25	1.39	5.92
14	Indet 1	0.02	25	1.76	5.18
15	*Cordia americana*	0.02	25	1.13	4.81
16	*Plinia rivularis*	0.02	25	0.30	4.32
17	*Libidybia paraguariensis*	0.01	25	1.02	3.78
18	*Peltophorum dubium*	0.01	25	0.33	3.38
19	*Machaerium* sp	0.01	25	0.33	3.37
20	Indet 2	0.01	25	0.21	3.31
21	*Guazuma ulmifolia*	0.01	25	0.16	3.28
22	*Zanthoxylum fagara* ssp. *Fagara*	0.01	25	0.12	3.26
23	*Casearia* sp	0.01	25	0.09	3.24
24	*Vachellia caven*	0.01	25	0.07	3.22
25	*Randia armata*	0.01	25	0.05	3.22
26	*Coccoloba* aff. *cordata*	0.01	25	0.05	3.21

Table 5.3.1.3.2.d

Combined list of floristic composition in the semi-deciduous subhumid forest of the terrain

N°	Family	Species	Common name
1	Acanthaceae	*Brazilian Justice Roth*	
2	Acanthaceae	*Justice sp*	
3	Acanthaceae	*Ruellia sp*	
4	Alismataceae	*Echinodorus grandiflorus (Cham. & Schltdl.) Micheli*	Cucharero
5	Amaranthaceae	*Pfaffia glomerata (Spreng.) Pedersen*	Batatilla
6	Anacardiaceae	*Schinopsis balansae Engl.*	Quebracho colorado
7	Annonaceae	*Annona emarginata (Schltdl.) H. Rainer.*	Aratiku'i
8	Apocynaceae	*Forsteronia sp*	
9	Araceae	*Anthurium paraguayense Engl.*	Kalaguala guasu
10	Arecaceae	*Copernicia alba Morong*	Karanda'y
11	Arecaceae	*Syagrus romanzoffiana (Cham.) Glassman*	Pindo
12	Asteraceae	*Eclipta prostata (L.) L.*	Tangara ka'a
13	Asteraceae	*Eupatorium sp 1*	
14	Asteraceae	*Vernonanthura sp*	
15	Asteraceae	*Viguiera sp*	
16	Bignoniaceae	*Dolichandra cynanchoides Cham.*	
17	Bignoniaceae	*Dolichandra unguis-cati (L.) L.G. Lohmann.*	Uña de gato
18	Bignoniaceae	*Tabebuia nodosa (Griseb.) Griseb.*	Labón
19	Boraginaceae	*Cordia americana (L.) Gottschling & J.S. Mill.*	Guajayvi
20	Bromeliaceae	*Bromeliad balansae Mez*	Karaguata
21	Bromeliaceae	*Tillandsia recurvata (L.) L.*	Clavel del aire
22	Bromeliaceae	*Tillandsia recurvifolia Hook.*	Clavel del aire
23	Bromeliaceae	*Tillandsia streptocarpa Baker*	Clavel del aire
24	Bromeliaceae	*Tillandsia usneoides (L.) L.*	
25	Cactaceae	*Harrisia sp*	
26	Cactaceae	*Rhipsalis baccifera (J.S.Muell.) Stearn*	Suelta con suelta
27	Cactaceae	*Rhipsalis lumbricoides (Lem.) Lem. ex Salm-Dyck.*	
28	Cannabaceae	*Celtis sp*	Juasy'y
29	Capparaceae	*Cynophalla retusa (Griseb.) X. Dogwood & H.H. Iltis*	Indio kumanda

Table 5.3.1.3.2.d
Combined list of floristic composition in the semi-deciduous subhumid forest of the terrain

N°	Family	Species	Common name
30	Celastraceae	*Monteverdia ilicifolia (Mart. ex Reissek) Biral*	Kangorosa
31	Cleomaceae	*Tarenaya aculeata (L.) Soares Neto & Roalson*	
32	Commelinaceae	*Commelina diffusa Burm. f.*	Saint Lucia hovy
33	Commelinaceae	*Commelina erecta L.*	Saint Lucia hovy
34	Convolvulaceae	*Dichondra microcalyx (Hallier f.) Fabris*	
35	Convolvulaceae	*Ipomoea sp 1*	
36	Convolvulaceae	*Ipomoea sp 2*	
37	Cyperaceae	*Cyperus entrerianus Boeck.*	
38	Cyperaceae	*Cyperus odoratus L.*	
39	Cyperaceae	*Scleria sp*	
40	Euphorbiaceae	*Caperonia castaneifolia (L.) A. St.-Hil.*	
41	Euphorbiaceae	*Croton bonplandianus Baill.*	
42	Euphorbiaceae	*Gymnanthes discolor (Spreng.) Müll. Arg.*	
43	Euphorbiaceae	*Sebastiania ramosissima (A. St.-Hil.), A.L. Melo & M.F. Sales*	Yvyra kamby
44	Euphorbiaceae	*Tragia sp*	
45	Fabaceae	*Aeschynomene montevidensis Vogel*	
46	Fabaceae	*Calliandra sp*	Niño azote
47	Fabaceae	*Gleditsia amorphoides (Griseb.) Taub.*	Yvope
48	Fabaceae	*Indet 2*	
49	Fabaceae	*Undetermined*	
50	Fabaceae	*Indigofera asperifolia Bong. ex Benth.*	
51	Fabaceae	*Libidibia paraguariensis (D. Parodi) G.P. Lewis*	Guayacán
52	Fabaceae	*Machaerium sp*	
53	Fabaceae	*Macroptilium erythroloma (Mart. ex Benth.) Urb.*	
54	Fabaceae	*Neltuma affinis (Spreng.) C.E. Hughes & G.P. Lewis*	Algarrobillo
55	Fabaceae	*Parapiptadenia rigida (Benth.) Brenan*	Kurupa'yrâ
56	Fabaceae	*Peltophorum dubium (Spreng.) Taub.*	Yvyra pytâ
57	Fabaceae	*Prosopis nigra (Griseb.) They wounded.*	Algarrobo negro
58	Fabaceae	*Vachellia caven (Molina) Seigler & Ebinger*	Aromita

Table 5.3.1.3.2.d
Combined list of floristic composition in the semi-deciduous subhumid forest of the terrain

N°	Family	Species	Common name
59	Undetermined	*Indet 1*	
60	Iridaceae	*Sisyrinchium sp*	
61	Lamiaceae	*Salvia cardiophylla Benth.*	
62	Lauraceae	*Ocotea diospyrifolia (Meisn.) Mez*	Laurel
63	Malpighiaceae	*Janusia sp*	
64	Malvaceae	*Guazuma ulmifolia Lam.*	Kamba akâ
65	Malvaceae	*Sida rhombifolia L.*	Typycha hû
66	Malvaceae	*Sidastrum paniculatum (L.) Fryxell*	
67	Malvaceae	*Wissadula sp*	
68	Meliaceae	*Trichilia catigua A.Juss.*	Katigua pytâ
69	Meliaceae	*Trichilia sp*	
70	Moraceae	*Sorocea saxicola Hassl.*	Ñandypami
71	Myrtaceae	*Campomanesia xanthocarpa (Mart.) O.Berg*	Guavira pytâ
72	Myrtaceae	*Eugenia sp*	
73	Myrtaceae	*Eugenia uniflora L.*	Ñangapiry
74	Myrtaceae	*Indet 3*	
75	Myrtaceae	*Plinia rivularis (Cambess.) Rotman*	Yvaporoity
76	Nyctaginaceae	*Pisonia Griseb Pumpkin.*	Jukyryvusu
77	Orchidaceae	*Campylocentrum neglectum (Rchb. f. & Warm.) Cogn.*	
78	Orchidaceae	*Cohniella jonesiana (Rchb. f.) Christenson*	
79	Orchidaceae	*Cyclopogon sp*	
80	Orchidaceae	*Trichocentrum pumilum (Lindl.) M.W. Chase & N.H. Williams*	
81	Passifloraceae	*Passiflora giberti N.E. Br.*	Mburkuja'i
82	Petiveriaceae	*Petiveria alliacea L.*	Pipi
83	Phytolaccaceae	*Rivinia humilis L.*	
84	Piperaceae	*Peperomia sp*	
85	Plantaginaceae	*Angelonia salicariifolia Bonpl.*	
86	Plantaginaceae	*Bacopa salzmanii (Benth.) Wettst. ex Edwall*	
87	Poaceae	*Undetermined*	

Table 5.3.1.3.2.d
Combined list of floristic composition in the semi-deciduous subhumid forest of the terrain

N°	Family	Species	Common name
88	Poaceae	*Lasiasis sp*	
89	Poaceae	*Leersia hexandra Sw.*	
90	Poaceae	*Ocellochloa stolonifera (Poir.) Zuloaga & Morrone*	
91	Poaceae	*Panicum sp*	
92	Poaceae	*Paspalum sp*	Pasto
93	Polygonaceae	*Coccoloba aff. cordata Cham.*	Duraznillo Moado
94	Polygonaceae	*Coccoloba paraguariensis Lindau*	
95	Polygonaceae	*Polygonum punctatum Elliott*	Ka'atai
96	Polygonaceae	*Ruprechtia laxiflora Meisn.*	Yvyra pytâ'i
97	Polypodiaceae	*Microgramma aff. Squamulosa*	
98	Polypodiaceae	*Microgramma vacciniifolia Langsd & Fisch*	Anguja nambi
99	Pteridaceae	*Hemionitis tomentosa (Lam.) Raddi*	Doradilla
100	Rubiaceae	*Guettarda uruguensis Cham. & Schltdl.*	
101	Rubiaceae	*Manettia sp*	
102	Rubiaceae	*Psychotria sp*	
103	Rubiaceae	*Randia armata (Sw.) DC.*	Ñuatî kurusu
104	Rutaceae	*Zanthoxylum fagara (L.) Sarg. ssp. fagara*	Mbarakaja pyâpe
105	Salicaceae	*Casearia gossypiosperma Briq.*	Mbavy
106	Salicaceae	*Casearia sp*	
107	Salicaceae	*Xylosma venosum N.E.Brown.*	Ñuati creek
108	Sapindaceae	*Allophylus edulis (A. St.-Hil., A. Juss. & Cambess.) They wounded. ex Niederl.*	Kokû
109	Sapindaceae	*Paullinia sp*	
110	Sapindaceae	*Serjania sp*	
111	Sapotaceae	*Chrysophyllum marginatum (Hook. & Arn.) Radlk. ssp. marginatum*	Pykasu rembi'u
112	Sapotaceae	*Sideroxylon obtusifolium (Roem. & Schult.) T.D. Penn.*	Guajayvirai
113	Smilaceae	*Smilax sp*	
114	Solanaceae	*Solanum americanum Mill.*	Arachichu
115	Solanaceae	*Solanum glaucophyllum Desf.*	Duraznillo
116	Solanaceae	*Solanum sp*	

Table 5.3.1.3.2.d
Combined list of floristic composition in the semi-deciduous subhumid forest of the terrain

N°	Family	Species	Common name
117	Verbenaceae	*Glandularia peruviana (L.) Small.*	Yvoty la novia
118	Verbenaceae	*Phyla nodiflora (L.) Greene*	
119	Verbenaceae	*Stachytarpheta cayennensis (Rich.) Vahl*	Tatu ruguái
120	Verbenaceae	*Verbena litoralis Kunth*	
121	Vitaceae	*Cissus verticillata (L.) Nicolson & C.E. Jarvis.*	Ka'avurâ

Table 5.3.1.3.2.e
List of species recorded in the second sampling of the savannah

N°	Family	Species	Common name
1	Alismataceae	*Helanthium* sp.	
2	Amaranthaceae	*Alternanthera* kurtzii Schinz ex Pedersen ssp. *Kurtzii*	
3	Amaranthaceae	*Pfaffia glomerata* (Spreng.) Pedersen	Batatilla
4	Apiaceae	*Eryngium elegans* Cham. & Schltdl.	Karaguata'y
5	Apocynaceae	*Mandevilla angustifolia* (Malme) Woodson	
6	Araliaceae	*Hydrocotyle ranunculoides* L. f.	Akaryso
7	Arecaceae	*Copernicia alba* Morong	Karanda'y
8	Asteraceae	*Chromolaena laevigata* (Lam.) R.M. King & H. Rob. var. *Laevigata*	
9	Asteraceae	*Eclipta prostata* (L.) L.	
10	Asteraceae	*Eupatorium* sp1	
11	Asteraceae	*Eupatorium* sp2	
12	Asteraceae	INDET 1	
13	Asteraceae	Indet 2	
14	Asteraceae	Indet 3	
15	Asteraceae	INDET 4	
16	Asteraceae	*Pterocaulon virgatum* (L.) DC.	Bull Ka'a
17	Asteraceae	*Vernonia* sp	
18	Bignoniaceae	*Tabebuia nodosa* (Griseb.) Griseb.	Labon
19	Bromeliaceae	*Tillandsia recurvifolia* Hook.	Clavel del aire
20	Commelinaceae	*Commelina erecta* L.	Santa Lucia
21	Convolvulaceae	*Ipomoea carnea* Jacq. subsp. *fistulosa* (Mart. ex Choisy). D.F. Austin	Mandyjurâ
22	Convolvulaceae	*Ipomoea* sp1	
23	Convolvulaceae	*Ipomoea* sp2	
24	Cyperaceae	*Cyperus* aff. *digitatus* Roxb.	
25	Cyperaceae	*Cyperus entrerianus* Boeck. var. *entrerianus*	
26	Cyperaceae	*Cyperus odoratus* L.	
27	Cyperaceae	*Cyperus sesquiflorus* (Torr.) Mattf. & Kük. ex Kük.	
28	Cyperaceae	*Eleocharis elegans* (Kunth) Roem. & Schult.	
29	Cyperaceae	*Eleocharis filiculmis* Kunth Kunth	
30	Cyperaceae	*Rhynchospora* sp	
31	Euphorbiaceae	*Caperonia castaneifolia* (L.) A. St.-Hil.	
32	Euphorbiaceae	*Caperonia palustris* (L.) A. St.-Hil.	
33	Fabaceae	*Aeschynomene* sp	
34	Fabaceae	*Macroptilium erythroloma* (Mart. ex Benth.) Urb.	
35	Fabaceae	*Mimosa balansae* Micheli	
36	Fabaceae	*Mimosa debilis* Humb. & Bonpl. ex Willd. var. *Weakness*	
37	Fabaceae	*Mimosa* sp	
38	Fabaceae	Senna pendula (Willd.) H.S. Irwin & Barneby var. H.S. Irwin & Barneby	Taperyvami
39	Fabaceae	*Sesbania virgata* (Cav.) Poir.	Acacia negra
40	Fabaceae	*Vachellia caven* (Molina) Seigler & Ebinger	Aromita
41	Lythraceae	*Cuphea lysimachioides* Cham. & Schltdl.	
42	Lythraceae	*Cuphea racemosa* (L. f.) Spreng. ssp. *racemosa*	7 sangría
43	Lythraceae	*Cuphea* sp1	
44	Lythraceae	*Cuphea* sp2	
45	Malvaceae	*Hibiscus* sp	

Table 5.3.1.3.2.e
List of species recorded in the second sampling of the savannah

N°	Family	Species	Common name
46	Malvaceae	*Pavonia* sp	
47	Malvaceae	*Sida* aff. *potentilloides* A. St.-Hil.	
48	Malvaceae	*Sida spinosa* L.	Typycha hû
49	Malvaceae	*Sidastrum paniculatum* (L.) Fryxell	
50	Menyanthaceae	*Nymphoides indica* (L.) Kuntze	Camalotillo
51	Onagraceae	*Ludwigia decurrens* Walter	
52	Orobanchaceae	*Agalinis communis* (Cham. & Schltdl.) D'Arcy	
53	Orobanchaceae	*Agalinis genistifolia* (Cham. & Schltdl.) D'Arcy	
54	Oxalidaceae	*Oxalis paludosa* A. St.-Hil.	
55	Passifloraceae	*Passiflora misera* Kunth misera Kunth	
56	Phyllanthaceae	*Moeroris stipulata* Raf.	
57	Plataginaceae	*Bacopa salzmannii* (Benth.) Wettst. ex Edwall	
58	Plataginaceae	*Mecardonia procumbens* (Mill.) Small var. *flagellaris* (Cham. & Schltdl.) V.C. Souza	
59	Poaceae	*Panicum* sp	
60	Poaceae	*Paspalum* sp1	
61	Poaceae	*Echinochloa colona* (L.) Link	
62	Poaceae	*Hymenachne amplexicaulis* (Rudge) Nees	Camalotillo
63	Poaceae	*Lasiacis* sp	
64	Poaceae	*Leersia hexandra* Sw.	
65	Poaceae	*Paspalum* sp2	
66	Poaceae	*Setaria* sp	
67	Polygonaceae	*Muehlenbeckia sagittifolia* (Ortega) Meisn.	Zarzararrila
68	Pontederiaceae	*Pontederia cordata* L. var. *cordata*	Aguapé
69	Salicaceae	*Xylosma venosum* N.E.Brown.	Ñuatî arroyo
70	Solanaceae	*Sypy integrifolia* Lam.	
71	Solanaceae	*Solanum glaucophyllum* Desf.	Duraznillo
72	Vitaceae	*Cissus palmata* Poir.	

Table 5.3.1.3.2.f
Combined list of species recorded in the hydromorphic savannah of *Copernicia alba*

N°	Family	Species	Common name
1	Acanthaceae	*Justice sp*	
2	Acanthaceae	*Ruellia sp*	
3	Alismataceae	*Helanthum* sp	
4	Amaranthaceae	*Alternanthera kurtzii Schinz ex Pedersen* ssp. kurtzii	
5	Amaranthaceae	*Alternanthera* sp	
6	Amaranthaceae	*Gomphrena celosioides Mart.*	Perdudilla
7	Amaranthaceae	*Gomphrena perennis L.*	Siempreviva
8	Amaranthaceae	*Pfaffia glomerata (Spreng.) Pedersen*	Batatilla
9	Annonaceae	*Annona emarginata (Schltdl.) H. Rainer.*	Aratiku'i
10	Apiaceae	*Eryngium elegans Cham. & Schltdl.*	
11	Apocynaceae	*Mandevilla angustifolia (Malme) Woodson*	
12	Apocynaceae	*Oxypetalum sp*	
13	Araliaceae	*Hydrocotyle ranunculoides L. f.*	Akaryso
14	Arecaceae	*Copernicia alba Morong*	Karanda'y
15	Arecaceae	*Syagrus romanzoffiana (Cham.) Glassman*	Pindo
16	Asteraceae	*Aspilia* sp	
17	Asteraceae	*Chromolaena laevigata (Lam.) R.M. King & H. Rob. Var. Laevigata*	
18	Asteraceae	*Coniza* sp	
19	Asteraceae	*Eclipta prostata (L.) L.*	
20	Asteraceae	*Eupatorium* sp 2	
21	Asteraceae	*Eupatorium* sp1	
22	Asteraceae	*Gamochaeta* sp	
23	Asteraceae	*INDET 1*	
24	Asteraceae	*Indet 2*	
25	Asteraceae	*Indet 3*	
26	Asteraceae	*INDET 4*	
27	Asteraceae	*Mikania* sp	
28	Asteraceae	*Pluchea sagittalis (Lam.) Cabrera*	Yerba de lucero
29	Asteraceae	*Pterocaulon* sp	

Table 5.3.1.3.2.f
Combined list of species recorded in the hydromorphic savannah of *Copernicia alba*

N°	Family	Species	Common name
30	Asteraceae	*Pterocaulon virgatum (L.) DC.*	
31	Asteraceae	*Vernonia* sp	
32	Bignoniaceae	*Dolichandra unguis-cati (L.) L.G. Lohmann.*	Uña de gato
33	Bignoniaceae	*Tabebuia nodosa (Griseb.) Griseb.*	Labon
34	Boraginaceae	*Heliotropium* sp	
35	Brassicaceae	*Lepidium bonariense L.*	
36	Bromeliaceae	*Bromeliad balansae Mez*	Karaguata
37	Bromeliaceae	*Tillandsia recurvata (L.) L.*	Clavel del aire
38	Bromeliaceae	*Tillandsia recurvifolia Hook.*	Clavel del aire
39	Cleomaceae	*Tarenaya aculeata (L.) Soares Neto & Roalson*	
40	Commelinaceae	*Commelina diffusa Burm. f.*	
41	Commelinaceae	*Commelina erecta L.*	Santa Lucia hovy
42	Commelinaceae	*Tradescantia fluminensis Vell.*	
43	Convolulaceae	*Ipomoea carnea Jacq. subsp. fistulosa (Mart. ex Choisy). D.F. Austin*	Mandyjurâ
44	Convolulaceae	*Ipomoea* sp1	
45	Convolulaceae	*Ipomoea* sp2	
46	Cyperaceae	*Cyperus aff. digitatus Roxb.*	
47	Cyperaceae	*Cyperus aggregatus (Willd.) Endl.*	
48	Cyperaceae	*Cyperus brevifolius (Rottb.) Hassk.*	
49	Cyperaceae	*Cyperus entrerianus Boeck. Var. entrerianus*	
50	Cyperaceae	*Cyperus odoratus L.*	
51	Cyperaceae	*Cyperus sesquiflorus (Torr.) Mattf. & Kük. ex Kük.*	
52	Cyperaceae	*Eleocharis elegans (Kunth) Roem. & Schult.*	
53	Cyperaceae	*Eleocharis filiculmis Kunth Kunth*	
54	Cyperaceae	*Rhynchospora* sp	
55	Cyperaceae	*Rhynchospora* sp 2	
56	Cyperaceae	*Scleria* sp	
57	Euphorbiaceae	*Caperonia castaneifolia (L.) A. St.-Hil.*	
58	Euphorbiaceae	*Caperonia palustris (L.) A.St.- Hil.*	

Table 5.3.1.3.2.f
Combined list of species recorded in the hydromorphic savannah of *Copernicia alba*

N°	Family	Species	Common name
59	Euphorbiaceae	*Croton argenteus L.*	
60	Euphorbiaceae	*Croton bonplandianus Baill.*	
61	Fabaceae	*Aeschynomene montevidensis Vogel*	
62	Fabaceae	*Aeschynomene* sp	
63	Fabaceae	*Desmodium* sp	
64	Fabaceae	*Macroptilium erythroloma (Mart. ex Benth.) Urb.*	
65	Fabaceae	*Mimosa balansae Micheli*	
66	Fabaceae	*Mimosa debilis Humb. & Bonpl. ex Willd. Var. Weakness*	
67	Fabaceae	*Mimosa* sp	
68	Fabaceae	*Neltuma affinis (Spreng.) C.E. Hughes & G.P. Lewis*	
69	Fabaceae	*Neptunia* sp	
70	Fabaceae	Senna obtusifolia (L.) H.S. Irwin & Barneby	Taperyva
71	Fabaceae	*Senna pendula (Willd.) H.S. Irwin & Barneby var. H.S. Irwin & Barneby*	Taperyvami
72	Fabaceae	*Sesbania virgata (Cav.) Poir.*	Acacia negra
73	Fabaceae	*Vachellia caven (Molina) Seigler & Ebinger*	Aromita
74	Hydroleaceae	*Hydrolea spinosa L.*	
75	Lentibulariaceae	*Utricularia foliosa L.*	
76	Lythraceae	*Cuphea lysimachioides Cham. & Schltdl.*	
77	Lythraceae	*Cuphea racemosa (L. f.) Spreng. ssp. racemosa*	7 sangría
78	Lythraceae	*Cuphea* sp1	
79	Lythraceae	*Cuphea* sp2	
80	Lythraceae	*Heimia salicifolia Link.*	Yerba de la vida
81	Malvaceae	*Guazuma ulmifolia Lam.*	Kamba akâ
82	Malvaceae	*Hibiscus* sp	
83	Malvaceae	*Pavonia* sp	
84	Malvaceae	*Sida aff. potentilloides A. St.-Hil.*	
85	Malvaceae	*Sida rhombifolia L.*	Typycha hû
86	Malvaceae	*Sida spinosa L.*	Typycha hû
87	Malvaceae	*Sidastrum paniculatum (L.) Fryxell*	

Table 5.3.1.3.2.f
Combined list of species recorded in the hydromorphic savannah of *Copernicia alba*

N°	Family	Species	Common name
88	Menyanthaceae	*Nymphoides indica (L.) Kuntze*	Camalotillo
89	Onagraceae	*Ludwigia decurrens Walter*	Duraznillo de agua
90	Orobanchaceae	*Agalinis communis (Cham. & Schltdl.) D'Arcy*	
91	Orobanchaceae	*Agalinis genistifolia (Cham. & Schltdl.) D'Arcy*	
92	Oxalidaceae	*Oxalis paludosa A. St.-Hil.*	
93	Passifloraceae	*Passiflora misera Kunth misera Kunth*	
94	Phyllanthaceae	*Moeroris stipulata Raf.*	
95	Plantaginaceae	*Angelonia salicariifolia Bonpl.*	
96	Plantaginaceae	*Bacopa salzmannii (Benth.) Wettst. ex Edwall*	
97	Plantaginaceae	*Mecardonia procumbens (Mill.) Small var. flagellaris (Cham. & Schltdl.) V.C. Souza*	
98	Poaceae	*Cenchrus* sp	
99	Poaceae	*Paspalum* sp1	
100	Poaceae	*Coleataenia prionitis (Nees) Soreng.*	Cortadera
101	Poaceae	*Panicum* sp2	
102	Poaceae	*Echinochloa colona (L.) Link*	
103	Poaceae	*Hymenachne amplexicaulis (Rudge) Nees*	Camalotillo
104	Poaceae	*Lasiacis* sp	
105	Poaceae	*Leersia hexandra Sw.*	
106	Poaceae	*Panicum* sp	
107	Poaceae	*Paspalum* sp2	
108	Poaceae	*Setaria* sp	
109	Poaceae	*Steinchisma hians (Elliott) Nash*	
110	Polygonaceae	*Muehlenbeckia sagittifolia (Ortega) Meisn.*	Zarzaparilla colorada
111	Polygonaceae	*Polygonum punctatum Elliott*	Ka'atai
112	Pontederiaceae	*Pontederia cordata L. var. cordata*	Aguape
113	Portulacaceae	*Portulaca* sp	
114	Rubiaceae	*Borreria verticillata (L.) G. Mey.*	Typycha Runner
115	Rubiaceae	*Randa armata (Sw.) DC.*	Ñuatî kurusu
116	Rubiaceae	*Richardia brasiliensis Gomes*	Ype rupa

Table 5.3.1.3.2.f
Combined list of species recorded in the hydromorphic savannah of *Copernicia alba*

N°	Family	Species	Common name
117	Salicaceae	*Xylosma venosum N.E.Brown.*	Ñuatî arroyo
118	Sapindaceae	*Serjania* sp	
119	Smilacaceae	*Smilax* sp	
120	Solanaceae	*Sypy integrifolia Lam.*	
121	Solanaceae	*Solanum glaucophyllum Desf.*	Duraznillo
122	Solanaceae	*Solanum* sp	
123	Verbenaceae	*Salvia cardiophylla Benth.*	
124	Verbenaceae	*Stachytarpheta cayennensis (Rich.) Vahl*	Tatu ruguái
125	Vitaceae	*Cissus palmata Poir.*	
126	Vitaceae	*Cissus verticillata (L.) Nicolson & C.E. Jarvis.*	

Annex 9 – Fauna Photographic Record

JGP	**Free Trade Zone and Production Plant for Hydrogen, Ammonia and Green Fertilizers**	atome
	PHOTOGRAPHIC RECORD / **March/June 2023**	
Wildlife Surveys		



Photo 01: Lake located partly on the Project grounds and partly on a neighbouring property (First Campaign).



Photo 02: Detail of the environment sampled by the wildlife team (First Campaign).



Photo 03: Palm trees and small isolated trees registered in the vicinity of the Project (First Campaign).



Photo 04: Detail of the environment sampled by the wildlife team (Second Campaign)

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Photo 05: Detail of the environment sampled by the wildlife team (Second Campaign).



Photo 06: Detail of the environment sampled by the wildlife team (Second Campaign).



Photo 07: Detail of the environment sampled by the wildlife team (Second Campaign).

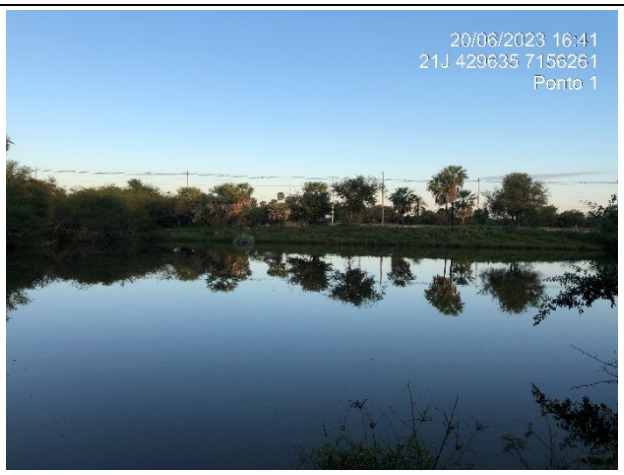

Photo 08: Detail of the environment sampled by the wildlife team (Second Campaign).



Photo 09: Detail of the environment sampled by the wildlife team (Second Campaign).



Photo 10: Inspection for the installation of camera traps and bioacoustic equipment (Songmeter) (First Campaign).





Photos 11 and 12: Installation of camera trap. The locations of the camera traps were selected by the team (First Campaign).



Photo 13: Installation of camera trap. The locations of the camera traps were selected by the team (Second Campaign).



Photo 14: Detail of the camera trap installed (First Campaign).



Figure 15: Field data collection using GPS (First Campaign).



Figure 16: Field data collection using GPS (Second Campaign).



Photo 17: Detail of the Songmeter bioacoustic device installed for the detection of bats (First Campaign).



Photo 18: Detail of the Songmeter bioacoustic device installed for the detection of bats (Second Campaign).



Figure 19: Study of the birdlife with binoculars (First Campaign).



Photo 20: Study of birdlife with binoculars (Second Campaign).



Photo 21: Active search for traces of wildlife (First Campaign).



Photo 22: Diurnal census of amphibians and reptiles (Second Campaign).



Photo 23: Active nocturnal search for herpetofauna (Second Campaign).



Photo 24: Active nocturnal search for mastofauna (Second Campaign).

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Wildlife Surveys		



Photo 25: *Alouatta caraya* (howler monkey) (First Campaign).



Photo 26: *Alouatta caraya* (howler monkey) (Second Campaign).



Photo 27: Feces of *Alouatta caraya* (howler monkey) (First Campaign).



Photo 28: Feces of *Alouatta caraya* (howler monkey) (Second Campaign).



Photo 29: Footprint of *Cerdocyon thous* (crabeater fox) (First Campaign).



Photo 30: Footprint of *Dasypus novemcinctus* (big mule) (Second Campaign).



Foto 31: Footprint of *Subulo gouazoubira* (roe deer) (Second Campaign).



Photo 32: Footprint of *Procyon cancrivorus* (crab-eating raccoon) (Second Campaign).



Photo 33: Feline feces (First Campaign).



Photo 34: *Sylvilagus brasiliensis* (wild bunny) feces (First Campaign).



Foto 35: Roadkill *Procyon cancrivorus* (First Campaign).



Photo 36: Footprint of *Subulo gouazoubira* (roe deer) (First Campaign).



Photo 37: *Alouatta caraya* (howler monkey) run over (First Campaign).



Photo 38: Footprint of *Dasypus novemcinctus* (large mule) (First Campaign).



Photo 39: *Didelphis albiventris* (common weasel) recorded on camera trap (First Campaign).



Photo 40: *Subulo gouazoubira* (roe deer) recorded on camera trap (First Campaign).



Photo 41: *Leopardus geoffroyi* (wildcat) recorded on camera trap (First Campaign).



Photo 42: *Cerdocyon thous* (crabeater fox) recorded on camera trap (First Campaign).



Photo 43: *Herpailurus yagouaroundi* (Moorish cat) recorded on camera trap (First Campaign).



Photo 44: *Daypus novemcinctus* (big mule) recorded on camera trap (First Campaign).



Photo 45: *Cerdocyon thous* (crabeater fox) recorded on camera trap (Second Campaign).



Foto 46: *Didelphis albiventris* (common weasel) recorded on camera trap (Second Campaign).



Photo 47: *Didelphis albiventris* (common weasel) recorded on camera trap (Second Campaign).



Photo 48: *Procyon cancrivorus* (crab-eating raccoon) recorded on camera trap (First Campaign).

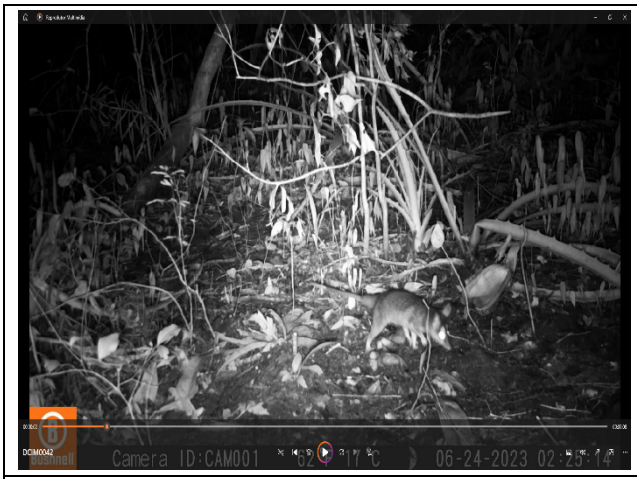

Photo 49: *Philander quica* (four-eyed weasel) recorded on camera trap (Second Campaign).



Photo 50: *Sylvilagus brasiliensis* (wild bunny) recorded on camera trap (First Campaign).



Photo 51: *Rhinella diptycha* (Kururu) (First Campaign).



Photo 52: *Leptodactylus podicipinus* (Frog) (First Campaign).



Photo 53: *Rhinella diptycha* (Kururu) (Second Campaign).



Photo 54: *Leptodactylus macrosternum* (Frog) (Second Campaign).

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Photo 55: *Leptodactulus latinasus* (Frog) (Second Campaign).



Photo 56: *Leptodactylus* fuscus (Rana, Ju'i) (First Campaign).



Photo 57: *Rhinella azarai* (Kururu toad) (Second Campaign).



Photo 58: *Odontophrynus americanus* (Frog) (Second Campaign).



Photo 59: *Bolivian Pseudopaludicola* (Frog) (First Campaign).



Photo 60: *Bolivian Pseudopaludicola* (Frog) (Second Campaign).

JGP	Free Trade Zone and Production Plant for Hydrogen, Ammonia and Green Fertilizers		atome
	PHOTOGRAPHIC RECORD	March/June 2023	
Wildlife Surveys			



Photo 61: *Dryophylax chaquensis* (Cat's Eye, Mboi capi'i) (Second Campaign).



Photo 62: *Boana raniceps* (Bramble Frog, Ju'i pakova) (Second Campaign).



Photo 63: *Physalaemus* sp2. (Rana, Ju'i) (Second Campaign).



Photo 64: *Scinax acuminatus* (Pool frog, Ju'i latrine) (Second Campaign).



Photo 65: *Hydrodynastes gigas* (Ñacaniná) (Second Campaign).



Photo 66: *Erythrolamprus poecilogyrus* (Snake, Captain Mboi) (Second Campaign).



Figure 67: *Amazona aestiva* (Talking Parrot) (First Campaign).



Photo 68: *Xiphocolaptes major* (Giant Nuthatch) (First Campaign).



Photo 69: *Euphonia chlorotica* (tanager) (first campaign).



Photo 70: *Pachyramphus viridis* (Greenish Anambé) (First Campaign).



Photo 71: *Aramides ypecaha* (moorhen) (Second Campaign).

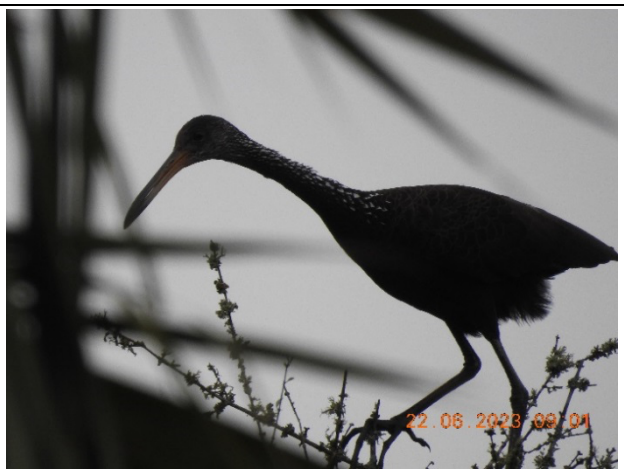

Photo 72: *Aramus guarauna* (carau) (Second Campaign).



Photo 73: *Campephilus leucopogon* (White-backed Woodpecker) (Second Campaign).



Photo 74: *Chloroceryle amazona* (medium-sized kingfisher) (Second Campaign).



Photo 75: *Columbina squammata* (scaly popcorn) (Second Campaign).



Photo 76: *Icterus pyrrhopterus* (Little Boy) (Second Campaign).



Photo 77: *Melanerpes cactorum* (cactus woodpecker) (Second Campaign).



Photo 78: *Milvago chimachima* (chimachima) (Second Campaign).



Photo 79: *Paroaria coronata* (cardinal) (Second Campaign).



Photo 80: *Piculus chrysochloros* (golden woodpecker) (Second Campaign).



Photo 81: *Pionus maximiliani* (Chocolate Parrot) (Second Campaign).



Photo 82: *Polioptila dumicola* (blue tacuarite) (Second Campaign).



Photo 83: *Pyrocephalus rubinus* (churrinche) (Second Campaign).



Photo 84: *Pyrrhura frontalis* (green-headed chiripepé) (Second Campaign).



Photo 85: *Xiphocolaptes major* (giant climber) (Second Campaign).

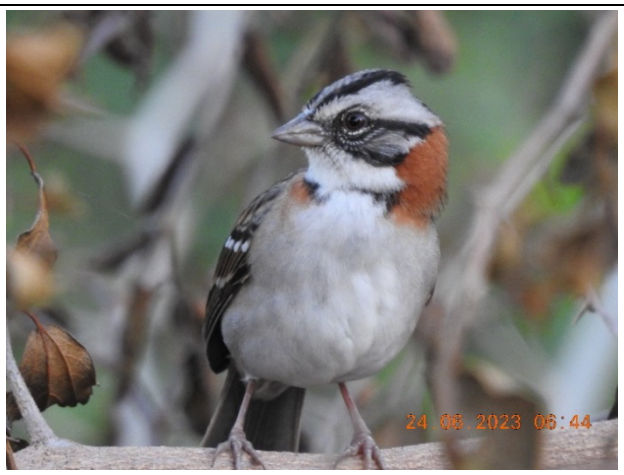

Photo 86: *Xiphocolaptes major* (Giant Nuthatch) (Second Campaign).

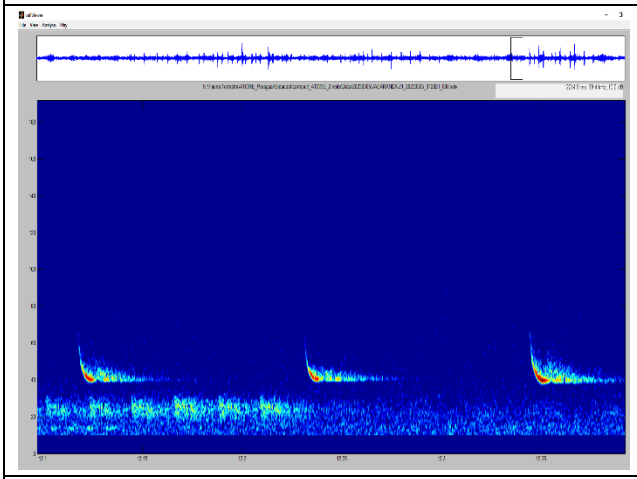

Photo 87: Acoustic signal of *Eptesicus furinalis* (bat) (First Campaign).

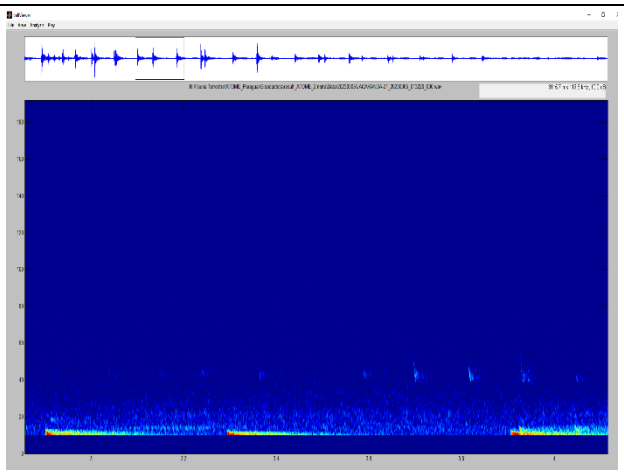

Photo 88: Acoustic signal of *Eumops perotis* (bat) (First Campaign).

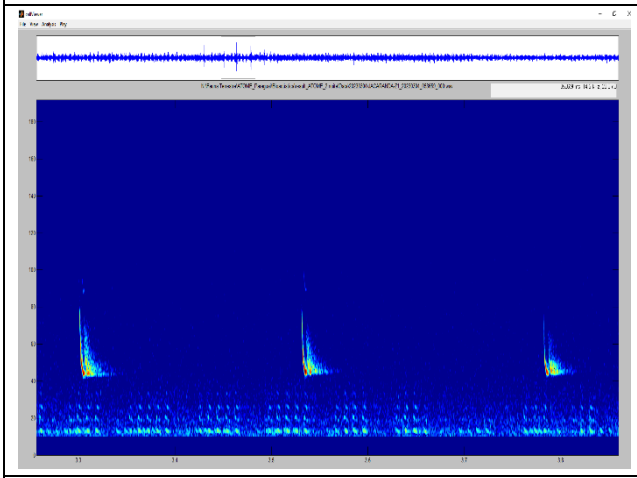

Photo 89: Acoustic signal of *Lasiurus blossevillii* (bat) (First Campaign).

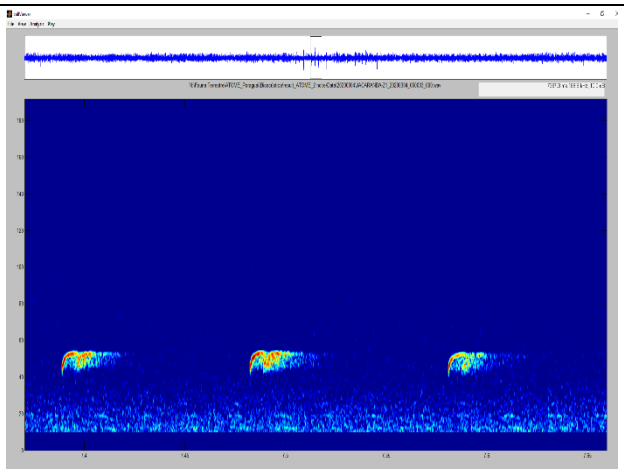

Photo 90: Acoustic signal of *Molossops temminckii* (bat) (First Campaign).

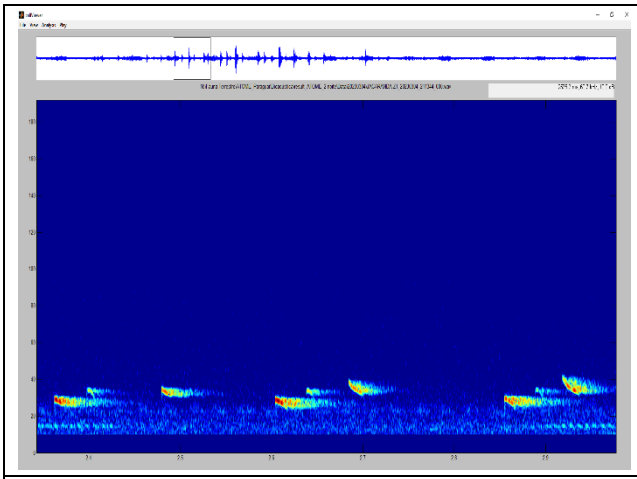

Photo 91: Acoustic signal of *Molossus rufus* (bat) (First Campaign).

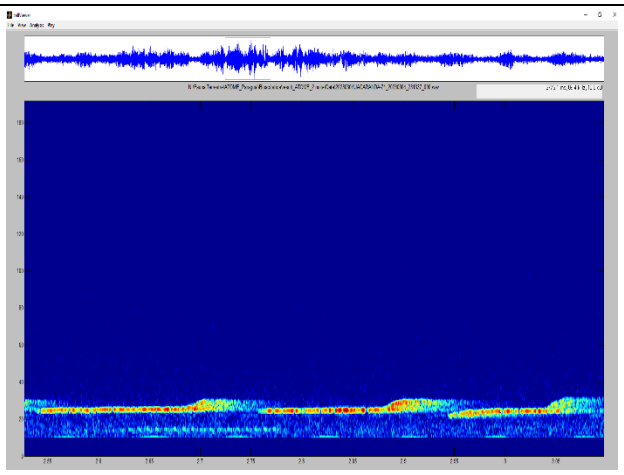

Photo 92: Acoustic signal of *central Promops* (bat) (First Campaign).

Annex 10 – Lists of Fauna Species

Lists of Avifauna Species

Table 5.3.2.4.1.a
List of species recorded during the first birding season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	IUCN 2022	CITES 2023
Accipitriformes					
Accipitridae					
Rostrhamus sociabilis	Caracolero	1	-	LC	II
Rupornis magnirostris	Taguató común	4	-	LC	II
Anseriformes					
Anatidae					
Amazonetta brasiliensis	Patillo	1	-	LC	-
Cairina moschata	Bragado	8	-	LC	-
Dendrocygna autumnalis	Pato silbón ala blanca	53	-	LC	-
Dendrocygna viduata	Pato silbón cara blanca	1	-	LC	-
Anhimidae					
Chauna torquata	Chajá	2	-	LC	-
Apodiformes					
Trochilidae					
Chlorostilbon lucidus	Picaflor verde	1	-	LC	II
Heliomaster furcifer	Picaflor de barbijo	1	-	LC	II
Hylocharis chrysura	Picaflor bronceado	3	-	LC	II
Caprimulgiformes					
Caprimulgidae					
Lurocalis semitorquatus	Añapero castaño	1	-	LC	-
Cariamiformes					
Cariamidae					
Cariama cristata	Saría patas rojas	1	-	LC	-
Cathartiformes					
Cathartidae					
Cathartes burrovianus	Cuervo cabeza amarilla	1	-	LC	-

Table 5.3.2.4.1.a
List of species recorded during the first birding season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	IUCN 2022	CITES 2023
Coragyps atratus	Cuervo negro	35	-	LC	-
Charadriiformes					
Charadriidae					
Vanellus chilensis	Tero tero	12	-	LC	-
Jacanidae					
Jacana jacana	Jacana	3	-	LC	-
Laridae					
Phaetusa simplex	Atí	1	-	LC	-
Scolopacidae					
Tringa solitaria	Pitotoi solitario	5	-	LC	-
Ciconiiformes					
Ciconiidae					
Ciconia maguari	Cigüeña americana	1	-	LC	-
Jabiru mycteria	Yabiru	37	-	LC	I
Mycteria americana	Tuyuyú	1	-	LC	-
Columbiformes					
Columbidae					
Columbina picui	Tortolita picuí	5	-	LC	-
Columbina squammata	Palomita escamada	3	-	LC	-
Columbina talpacoti	Tortolita colorada	2	-	LC	-
Leptotila verreauxi	Yerutí común	8	-	LC	-
Patagioenas picazuro	Paloma turca	17	-	LC	-
Zenaida auriculata	Torcaza	52	-	LC	-
Coraciiformes					
Alcedinidae					
Chloroceryle amazona	Martín pescador mediano	2	-	LC	-
Megaceryle torquata	Martín pescador grande	1	-	LC	-

Table 5.3.2.4.1.a
List of species recorded during the first birding season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	IUCN 2022	CITES 2023
Cuculiformes					
Cuculidae					
Crotophaga ani	Anó chico	18	-	LC	-
Guira guira	Piririta	16	-	LC	-
Falconiformes					
Falconidae					
Caracara plancus	Carancho	10	-	LC	II
Falco femoralis	Halcón plomizo	5	-	LC	II
Milvago chimachima	Chimachima	6	-	LC	II
Gruiformes					
Aramidae					
Aramus guarauna	Karau	2	-	LC	-
Rallidae					
Aramidas ypecaha	Gallineta de agua	3	-	LC	-
Nyctibiiformes					
Nyctibiidae					
Nyctibius griseus	Urutaú común	1	-	LC	-
Passeriformes					
Corvidae					
Cyanocorax chrysops	Urraca común	6	-	LC	-
Cyanocorax cyanomelas	Urraca morada	6	-	LC	-
Fringillidae					
Eufonía clorótica	Tangará	3	-	LC	-
Furnariidae					
Campylorhamphus trochilirostris	Picapalo colorado	3	-	LC	-
Certhiaxis cinnamomeus	Curutié colorado	2	-	LC	-
Furnarius rufus	Hornero	11	-	LC	-
Lepidocolaptes angustirostris	Chinchero chico	7	-	LC	-
Phacellodomus ruber	Espinero grande	6	-	LC	-

Table 5.3.2.4.1.a
List of species recorded during the first birding season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	IUCN 2022	CITES 2023
Schoeniophylax phryganophilus	Titisiri	1	-	LC	-
Sittasomus griseicapillus	Guirí	2	-	LC	-
Sinalaxis frontal	Pijuí frente gris	3	-	LC	-
Xiphocolaptes major	Trepador gigante	4	-	LC	-
Hirundinidae					
Progne tapera	Golondrina parda	46	-	LC	-
Icteridae					
Agelaioides badius	Tordo músico	35	-	LC	-
Agelasticus cyanopus	Varillero negro	1	-	LC	-
Cacicus chrysopterus	Boyero ala amarilla	3	-	LC	-
Cacicus solitarius	Boyero negro	2	-	LC	-
Chrysomus ruficapillus	Varillero congo	1	-	LC	-
Gnorimopsar chopi	Chopí	7	-	LC	-
Icterus pyrrhopterus	Boyerito	2	-	LC	-
Molothrus bonariensis	Tordo renegrido	102	-	LC	-
Molothrus rufoaxillaris	Tordo pico corto	6	-	LC	-
Parulidae					
Setophaga pitiayumi	Pitiayumí	1	-	LC	-
Passerellidae					
Arremon flavirostris	Afrechero de collar	3	-	LC	-
Zonotrichia capensis	Bendito Sea	2	-	LC	-
Polypropylidae					
Polioptila dumicola	Tacuarita azul	5	-	LC	-
Thamnophilidae					
Taraba mayor	Chororó	11	-	LC	-
Thamnophilus caerulescens	Batará plomizo	2	-	LC	-
Thamnophilus doliatus	Batará rayado	1	-	LC	-
Thraupidae					
Coryphospingus cucullatus	Brasita de fuego	2	-	LC	-

Table 5.3.2.4.1.a
List of species recorded during the first birding season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	IUCN 2022	CITES 2023
Paroaria capitata	Cardenilla	2	-	LC	II
Paroaria coronata	Cardenal	6	-	LC	II
Saltator coerulescens	Pepitero gris	1	-	LC	-
Sicalis flaveola	Canario paraguay	3	-	LC	-
Tangara sayaca	Chogüí	7	-	LC	-
Tityridae					
Pachyramphus polychopterus	Anambé negro	1	-	LC	-
Pachyramphus viridis	Anambé verde	2	-	LC	-
Troglodytidae					
Campylorhynchus turdinus	Rata grande	3	-	LC	-
Troglodytes aedon	Ratona común	6	-	LC	-
Turdidae					
Turdus amaurochalinus	Zorzal mandioca	2	-	LC	-
Turdus leucomelas	Zorzal alas canelas	1	-	LC	-
Turdus rufiventris	Zorzal colorado	1	-	LC	-
Tiránidos					
Camptostoma obsoletum	Piojito silbón	3	-	LC	-
Casiornis rufus	Suiriri castaño	3	-	LC	-
Elaenia spectabilis	Fiofío grande	1	-	LC	-
Hemitriccus margaritaceiventer	Mosqueta ojo dorado	4	-	LC	-
Machetornis rixosa	Caballerizo	4	-	LC	-
Megarynchus pitangua	Ñei ñei	2	-	LC	-
Myiarchus ferox	Burlisto pico negro	1	-	LC	-
Myiarchus swainsoni	Burlisto pico canela	1	-	LC	-
Myiarchus tyrannulus	Burlisto cola castaña	3	-	LC	-
Myiodynastes maculatus	Pitogüé rayado	4	-	LC	-
Pitangus sulphuratus	Pitogüé común	3	-	LC	-
Serpophaga griseicapilla	Piojito trinador	1	-	LC	-
Suiriri suiriri	Suiriri vientre blanco	1	-	LC	-

Table 5.3.2.4.1.a
List of species recorded during the first birding season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	IUCN 2022	CITES 2023
Tyrannus melancholicus	Suiriri real	3	-	LC	-
Xolmis irupero	Monjita blanca	1	-	LC	-
Vireonidae					
Cyclarhis gujanensis	Juan chiviro	2	-	LC	-
Pelecaniformes					
Ardeidae					
Ardea alba	Garza blanca	2	-	LC	-
Ardea cocoi	Garza mora	3	-	LC	-
Bubulcus ibis	Garcita bueyera	21	-	LC	-
Butorides striata	Garcita azulada	1	-	LC	-
Nycticorax nycticorax	Garza bruja	1	-	LC	-
Syrigma sibilatrix	Garza silbadora	6	-	LC	-
Threskiornithidae					
Phimosus infuscatus	Cuervillo cara pelada	201	-	LC	-
Theristicus caudatus	Bandurria baya	6	-	LC	-
Piciformes					
Picidae					
Campephilus leucopogon	Carpintero lomo blanco	2	-	LC	-
Colaptes campestris	Carpintero campestre	4	-	LC	-
Colaptes melanochloros	Carpintero real	3	-	LC	-
Melanerpes cactorum	Carpintero del cactus	1	-	LC	-
Picumnus cirratus	Carpinterito común	1	-	LC	-
Veniliornis passerinus	Carpinterito oliváceo	1	-	LC	-
Psittaciformes					
Psittacidae					
Amazona aestiva	Loro hablador	6	-	NT	II
Aratinga nenday	Ñanday	36	-	LC	II
Brotogeris chiriri	Catita chiriri	2	-	LC	II
Myiopsitta monachus	Cotorrita	5	-	LC	II

Table 5.3.2.4.1.a
List of species recorded during the first birding season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	IUCN 2022	CITES 2023
Pionus maximiliani	Loro choclero	2	-	LC	II
Psittacara acuticaudatus	Maracaná cabeza azulada	1	-	LC	II
Psittacara leucophthalmus	Maracaná ala roja	2	-	LC	II
Pyrrhura frontalis	Chiripepé cabeza verde	40	-	LC	II
Strigiformes					
Strigidae					
Megascops choliba	Lechucita común	1	-	LC	II
Suliformes					
Phalacrocoracidae					
Nannopterum brasilianus	Cormorán	1	-	LC	-
Tinamiformes					
Tinamidae					
Crypturellus tataupa	Tataupá común	5	-	LC	-
Trogoniformes					
Trogonidae					
Trogon curucui	Suricata aurora	1	-	LC	-
Total		**1037**			

Leyenda Estado de conservación: **LC** - "Preocupación **menor**", **NT** - "Casi amenazada", **Apéndice I - especies amenazadas de extinción cuyo** comercio sólo se permite en circunstancias excepcionales, **Apéndice II** - especies no necesariamente amenazadas de extinción, pero cuyo comercio debe controlarse para evitar usos incompatibles con su supervivencia.

Table 5.3.2.4.1.b
List of species recorded during the second bird conservation season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	UICN 2022	CITES 2023
Accipitriformes					
Accipitridae					
Rostrhamus sociabilis	Caracolero	1	-	LC	II
Rupornis magnirostris	Taguató común	11	-	LC	II
Anseriformes					
Anatidae					
Amazonetta brasiliensis	Patillo	3	-	LC	-
Anhimidae					
Chauna torquata	Chajá	3	-	LC	-
Apodiformes					
Trochilidae					
Chlorostilbon lucidus	Pito real	1	-	LC	II
Heliomaster furcifer	Picaflor de barbijo	1	-	LC	II
Hylocharis chrysura	Picaflor bronceado	3	-	LC	II
Caprimulgiformes					
Caprimulgidae					
Lurocalis semitorquatus	Añapero castaño	1	-	LC	-
Cathartiformes					
Cathartidae					
Cathartes aura	Cuervo cabeza roja	5	-	LC	-
Cathartes burrovianus	Cuervo cabeza amarilla	4	-	LC	-
Coragyps atratus	Cuervo negro	4	-	LC	-
Charadriiformes					
Charadriidae					
Vanellus chilensis	Tero tero	11	-	LC	-
Jacanidae					
Jacana jacana	Jacana	3	-	LC	-

Table 5.3.2.4.1.b
List of species recorded during the second bird conservation season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	UICN 2022	CITES 2023
Laridae					
Sternula superciliaris	Gaviotín chico	4	-	LC	-
Recurvirostridae					
Himantopus himantopus	Tero real	5	-	LC	-
Columbiformes					
Columbidae					
Columbina squammata	Palomita escamosa	7	-	LC	-
Columbina talpacoti	Tortolita de color	3	-	LC	-
Leptotila verreauxi	Yerutí común	7	-	LC	-
Patagioenas picazuro	Paloma turca	103	-	LC	-
Zenaida auriculata	Torcaza	1	-	LC	-
Coraciiformes					
Alcedinidae					
Chloroceryle amazona	Martín pescador mediano	2	-	LC	-
Cuculiformes					
Cuculidae					
Guira guira	Piririta	2	-	LC	-
Tapera naevia	Chochí	4	-	LC	-
Falconiformes					
Falconidae					
Caracara plancus	Carancho	11	-	LC	II
Falco sparverius	Halconcito colorado	2	-	LC	II
Micrastur semitorquatus	Halcón montés	1	-	LC	II
Milvago chimachima	Chimachima	7	-	LC	II
Gruiformes					
Aramidae					
Aramus guarauna	Karau	1	-	LC	-

Table 5.3.2.4.1.b
List of species recorded during the second bird conservation season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	UICN 2022	CITES 2023
Rallidae					
Aramides cajaneus	Chiricoe	5	-	LC	-
Aramidas ypecaha	Gallineta de agua	1	-	LC	-
Passeriformes					
Corvidae					
Cyanocorax chrysops	Urraca común	28	-	LC	-
Cyanocorax cyanomelas	Urraca morada	10	-	LC	-
Fringillidae					
Eufonía clorótica	Tangará	12	-	LC	-
Furnariidae					
Campylorhamphus trochilirostris	Picapalo colorado	5	-	LC	-
Furnarius rufus	Hornero	35	-	LC	-
Lepidocolaptes angustirostris	Chinchero chico	18	-	LC	-
Phacellodomus ruber	Espinero grande	1	-	LC	-
Schoeniophylax phryganophilus	Titisiri	5	-	LC	-
Sinalaxis frontal	Pijuí frente gris	2	-	LC	-
Xiphocolaptes major	Trepador gigante	7	-	LC	-
Icteridae					
Agelaioides badius	Tordo músico	15	-	LC	-
Cacicus chrysopterus	Boyero ala amarilla	10	-	LC	-
Cacicus solitarius	Boyero negro	6	-	LC	-
Chrysomus ruficapillus	Varillero congo	51	-	LC	-
Icterus pyrrhopterus	Boyerito	6	-	LC	-
Molothrus bonariensis	Tordo renegrido	42	-	LC	-
Parulidae					
Setophaga pitiayumi	Pitiayumí	2	-	LC	-
Passerellidae					
Arremon flavirostris	Afrechero de collar	3	-	LC	-

Table 5.3.2.4.1.b
List of species recorded during the second bird conservation season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	UICN 2022	CITES 2023
Zonotrichia capensis	Bendito Sea	1	-	LC	-
Polypropylidae					
Polioptila dumicola	Tacuarita azul	13	-	LC	-
Thamnophilidae					
Taraba mayor	Chororó	4	-	LC	-
Thamnophilus caerulescens	Batará plomizo	2	-	LC	-
Thraupidae					
Coryphospingus cucullatus	Brasita de fuego	3	-	LC	-
Paroaria capitata	Cardenilla	2	-	LC	II
Paroaria coronata	Cardenal	13	-	LC	II
Saltator coerulescens	Pepitero gris	5	-	LC	-
Sicalis flaveola	Canario paraguay	1	-	LC	-
Tachyphonus rufus	Frutero negro	6	-	LC	-
Tangara sayaca	Chogüí	11	-	LC	-
Troglodytidae					
Campylorhynchus turdinus	Ratona grande	41	-	LC	-
Troglodytes aedon	Ratona común	18	-	LC	-
Turdidae					
Turdus amaurochalinus	Zorzal mandioca	5	-	LC	-
Turdus leucomelas	Zorzal alas canelas	1	-	LC	-
Turdus rufiventris	Zorzal colorado	2	-	LC	-
Tiránidos					
Camptostoma obsoletum	Piojito silbón	6	-	LC	-
Casiornis rufus	Suiriri castaño	2	-	LC	-
Hemitriccus margaritaceiventer	Mosqueta ojo dorado	1	-	LC	-
Machetornis rixosa	Caballerizo	2	-	LC	-
Myiarchus tyrannulus	Burlisto cola castaña	4	-	LC	-
Pitangus sulphuratus	Pitogüé común	20	-	LC	-

Table 5.3.2.4.1.b
List of species recorded during the second bird conservation season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	UICN 2022	CITES 2023
Pyrocephalus rubinus	Churrinche	2	-	LC	-
Tyrannus melancholicus	Suiriri real	2	-	LC	-
Vireonidae					
Cyclarhis gujanensis	Juan chiviro	7	-	LC	-
Pelecaniformes					
Ardeidae					
Ardea alba	Garza blanca	64	-	LC	-
Egretta thula	Garcita blanca	19	-	LC	-
Syrigma sibilatrix	Garza silbadora	13	-	LC	-
Tigrisoma lineatum	Hocó colorado	1	-	LC	-
Threskiornithidae					
Phimosus infuscatus	Cuervillo cara pelada	135	-	LC	-
Platalea ajaja	Espátula rosada	12	-	LC	-
Plegadis chihi	Cuervillo de cañada	16	-	LC	-
Theristicus caudatus	Bandurria baya	3	-	LC	-
Piciformes					
Picidae					
Campephilus leucopogon	Carpintero lomo blanco	4	-	LC	-
Colaptes melanochloros	Carpintero real	2	-	LC	-
Melanerpes cactorum	Carpintero del cactus	3	-	LC	-
Melanerpes candidus	Carpintero blanco	9	-	LC	-
Piculus chrysochloros	Carpintero dorado	1	-	LC	-
Picumnus cirratus	Carpinterito común	4	-	LC	-
Veniliornis mixtus	Carpintero bataraz	2	-	LC	-
Veniliornis passerinus	Carpinterito oliváceo	1	-	LC	-
Psittaciformes					
Psittacidae					
Amazona aestiva	Loro hablador	8	-	NT	II

Table 5.3.2.4.1.b
List of species recorded during the second bird conservation season

Order/Family/Species	Popular name	Records	Status of Conservation		
			MADES 2019	UICN 2022	CITES 2023
Aratinga nenday	Ñanday	50	-	LC	II
Brotogeris chiriri	Catita chiriri	24	-	LC	II
Forpus xanthopterygius	Catita viuda	4	-	LC	II
Myiopsitta monachus	Cotorrita	6	-	LC	II
Pionus maximiliani	Loro choclero	7	-	LC	II
Psittacara acuticaudatus	Maracaná cabeza azulada	6	-	LC	II
Psittacara leucophthalmus	Maracaná ala roja	4	-	LC	II
Pyrrhura frontalis	Chiripepé cabeza verde	53	-	LC	II
Tinamiformes					
Tinamidae					
Crypturellus tataupa	Tataupá común	3	-	LC	-
Total		**1103**			

Legend Conservation Status: **LC** - "Little Concern, **NT** - "Near Threatened", **Apendix II -** Species not necessarily threatened with extinction, but whose trade must be controlled to avoid uses incompatible with its survival.

Table 5.3.2.4.1.c
List of species recorded during bird survey campaigns and through secondary data (AII)

Order/Family/Species	Popular name	Campaign		Total	AII	Status of conservation				State of residence	Endemism	Cynegetic	Inserted	Invasive Exotics	Invasive Native	Aquatic	Grasslands	Sensitivity
		1C	2C			MADES 2019	UICN 2022	CITES 2023	CMS 2022									
Accipitriformes																		
Accipitridae																		
Busarellus nigricollis	gavilán de estero				X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Rostrhamus sociabilis	caracolero	1	1	2	X	-	LC	II	II	AS	-	-	-	-	-	-	-	L
Rupornis magnirostris	taguató común	4	11	15	X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Elanidae																		
Gampsonyx swainsonii	milano chico				X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Pandionidae																		
Pandion haliaetus	águila pescadora				X	-	LC	II	II	N	-	-	-	-	-	-	-	M
Anseriformes																		
Anatidae																		
Amazonetta brasiliensis	patillo	1	3	4	X	-	LC	-	-	R	-	A	-	-	-	X	-	L
Cairina moschata	bragado	8		8	X	-	LC	-	-	R	-	A	-	-	-	X	-	M
Dendrocygna autumnalis	pato silbón ala blanca	53		53	X	-	LC	-	-	R	-	A	-	-	-	X	-	L
Dendrocygna viduata	pato silbón cara blanca	1		1	X	-	LC	-	-	R	-	A	-	-	-	X	-	L
Anhimidae																		
Chauna torquata	chajá	2	3	5	X	-	LC	-	-	R	-	A	-	-	-	X	-	L
Apodiformes																		
Trochilidae																		
Chlorostilbon lucidus	picaflor verde	1	1	2	X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Heliomaster furcifer	picaflor de barbijo	1	1	2	X	-	LC	II	-	R	-	-	-	-	-	-	-	M
Hylocharis chrysura	picaflor bronceado	3	3	6	X	-	LC	II	-	R	-	-	-	-	-	-	-	M
Polytmus guainumbi	picaflor de antifaz				X	-	LC	II	-	R	-	-	-	-	-	-	O	M
Caprimulgiformes																		
Caprimulgidae																		
Chordeiles menores	añapero boreal				X	-	LC	-	-	N	-	-	-	-	-	-	-	L
Chordeiles nacunda	ñacundá				X	-	LC	-	-	AS	-	-	-	-	-	-	F	L
Lurocalis semitorquatus	añapero castaño	1	1	2	X	-	LC	-	-	AN,R?	-	-	-	-	-	-	-	M
Nyctidromus albicollis	curiango				X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Cariamiformes																		
Cariamidae																		
Cariama cristata	saría patas rojas	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	F	M
Cathartiformes																		
Cathartidae																		
Cathartes aura	cuervo cabeza roja		5	5	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Cathartes burrovianus	cuervo cabeza amarilla	1	4	5	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Coragyps atratus	cuervo negro	35	4	39	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Charadriiformes																		
Charadriidae																		
Charadrius collaris	chorlito de collar				X	-	LC	-	-	R	-	-	-	-	-	X	-	H
Vanellus chilensis	tero tero	12	11	23	X	-	LC	-	-	R	-	-	-	-	-	X	O	L
Jacanidae																		
Jacana jacana	jacana	3	3	6	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Laridae																		
Phaetusa simplex	atí	1		1	X	-	LC	-	-	R	-	-	-	-	-	X	-	H
Rynchops niger	rayador				X	-	LC	-	-	R	-	-	-	-	-	X	-	H
Sternula superciliaris	gaviotín chico		4	4	X	-	LC	-	-	R	-	-	-	-	-	X	-	H
Recurvirostridae																		
Himantopus himantopus	tero real		5	5		-	LC	-	-	R	-	-	-	-	-	X	-	M
Scolopacidae																		

Table 5.3.2.4.1.c
List of species recorded during bird survey campaigns and through secondary data (AII)

Order/Family/Species	Popular name	Campaign		Total	AII	Status of conservation				State of residence	Endemism	Cynegetic	Inserted	Invasive Exotics	Invasive Native	Aquatic	Grasslands	Sensitivity
		1C	2C			MADES 2019	UICN 2022	CITES 2023	CMS 2022									
Actitis macularius	playerito manchado				X	-	LC	-	II	N	-	-	-	-	-	X	-	L
Gallinago paraguaiae	becasina chica				X	-	LC	-	-	R	-	-	-	-	-	X	O	L
Tringa solitaria	pitotoi solitario	5		5	X	-	LC	-	II	N	-	-	-	-	-	X	-	L
Ciconiiformes																		
Ciconiidae																		
Ciconia maguari	cigüeña americana	1		1	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Jabiru mycteria	yabirú	37		37	X	-	LC	I	-	R	-	-	-	-	-	X	-	M
Mycteria americana	tuyuyú	1		1	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Columbiformes																		
Columbidae																		
Columba livia	paloma doméstica				X	-	LC	-	-	C1	-	-	X	-	-	-	-	L
Columbina picui	tortolita picuí	5		5	X	-	LC	-	-	R	-	A	-	-	-	-	-	L
Columbina squammata	palomita escamada	3	7	10	X	-	LC	-	-	R	-	A	-	-	-	-	-	L
Columbina talpacoti	tortolita colorada	2	3	5	X	-	LC	-	-	R	-	A	-	-	-	-	-	L
Leptotila verreauxi	yerutí común	8	7	15	X	-	LC	-	-	R	-	A	-	-	-	-	-	L
Patagioenas picazuro	paloma turca	17	103	120	X	-	LC	-	-	AS	-	A	-	-	-	-	F	M
Zenaida auriculata	torcaza	52	1	53	X	-	LC	-	-	R	-	A	-	-	-	-	F	L
Coraciiformes																		
Alcedinidae																		
Chloroceryle amazona	martín pescador mediano	2	2	4	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Chloroceryle americana	martín pescador chico				X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Megaceryle torquata	martín pescador grande	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Cuculiformes																		
Cuculidae																		
Crotophaga ani	anó chico	18		18	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Crotophaga major	anó grande				X	-	LC	-	-	AN	-	-	-	-	-	-	-	M
Guira guira	piririta	16	2	18	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Tapera naevia	chochí		4	4	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Falconiformes																		
Falconidae																		
Caracara plancus	carancho	10	11	21	X	-	LC	II	-	R	-	-	-	-	-	-	F	L
Falco femoralis	halcón plomizo	5		5	X	-	LC	II	-	R	-	-	-	-	-	-	O	L
Falco sparverius	halconcito colorado		2	2	X	-	LC	II	-	R	-	-	-	-	-	-	F	L
Micrastur semitorquatus	halcón montés		1	1		-	LC	II	-	R	-	-	-	-	-	-	-	M
Milvago chimachima	chimachima	6	7	13	X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Galliformes																		
Cracidae																		
Ortalis canicollis	charata				X	-	LC	-	-	R	CHA	-	-	-	-	-	-	L

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		1C	2C			MADES 2019	UICN 2022	CITES 2023	CMS 2022									
Gruiformes																		
Aramidae																		
Aramus guarauna	carau	2	1	3	X	-	LC	-	-	R	-	-	-	-	-	X	-	M
Rallidae																		
Aramides cajaneus	chiricoe		5	5		-	LC	-	-	R	-	-	-	-	-	X	-	H
Aramidas ypecaha	gallineta de agua	3	1	4	X	-	LC	-	-	R	-	-	-	-	-	X	-	M
Porzana albicollis	burrito grande				X	-	LC	-	-	R	-	-	-	-	-	X	-	M
Nyctibiiformes																		
Nyctibiidae																		
Nyctibius griseus	urutaú común	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Passeriformes																		
Corvidae																		
Cyanocorax chrysops	urraca común	6	28	34	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Cyanocorax cyanomelas	urraca morada	6	10	16	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Donacobiidae																		
Donacobius atricapilla	angú				X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Fringillidae																		
Eufonía clorótica	tangará	3	12	15	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Spinus magellanicus	cabecita negra				X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Furnariidae																		
Anumbius annumbius	leñatero				X	-	LC	-	-	R	-	-	-	-	-	-	F	M
Campylorhamphus trochilirostris	picapalo colorado	3	5	8	X	-	LC	-	-	R	-	-	-	-	-	-	-	H
Certhiaxis cinnamomeus	curutié colorado	2		2	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Furnarius rufus	hornero	11	35	46	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Lepidocolaptes angustirostris	chinchero chico	7	18	25	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Phacellodomus ruber	espinero grande	6	1	7	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Schoeniophylax phryganophilus	titisiri	1	5	6	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Sittasomus griseicapillus	guirí	2		2	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Sinalaxis frontal	pijuí frente gris	3	2	5	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Xiphocolaptes major	trepador gigante	4	7	11	X	-	LC	-	-	R	CHA	-	-	-	-	-	-	M
Hirundinidae																		
Hirundo rustica	golondrina tijerita				X	-	LC	-	-	N	-	-	-	-	-	-	F	L
Petrochelidon pyrrhonota	golondrina rabadilla canela				X	-	LC	-	-	N	-	-	-	-	-	-	F	L
Progne chalybea	golondrina doméstica				X	-	LC	-	-	AN	-	-	-	-	-	-	-	L
Progne tapera	golondrina parda	46		46	X	-	LC	-	-	AN	-	-	-	-	-	-	F	L
Stelgidopteryx ruficollis	golondrina ribereña				X	-	LC	-	-	AN	-	-	-	-	-	-	-	L
Icteridae																		
Agelaioides badius	tordo músico	35	15	50	X	-	LC	-	-	R	-	O	-	-	-	-	F	L
Agelasticus cyanopus	varillero negro	1		1	X	-	LC	-	-	R	-	O	-	-	-	-	-	M
Amblyramphus holosericeus	federal				X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Cacicus chrysopterus	boyero ala amarilla	3	10	13	X	-	LC	-	-	R	-	O	-	-	-	-	-	L
Cacicus solitarius	boyero negro	2	6	8	X	-	LC	-	-	R	-	O	-	-	-	-	-	M
Chrysomus ruficapillus	varillero congo	1	51	52	X	-	LC	-	-	R	-	O	-	-	-	-	-	L
Gnorimopsar chopi	chopí	7		7	X	-	LC	-	-	R	-	O	-	-	-	-	F	L
Icterus pyrrhopterus	boyerito	2	6	8	X	-	LC	-	-	R	-	O	-	-	-	-	-	M
Molothrus bonariensis	tordo renegrido	102	42	144	X	-	LC	-	-	R	-	O	-	-	X	-	F	L
Molothrus rufoaxillaris	tordo pico corto	6		6	X	-	LC	-	-	R	-	O	-	-	-	-	F	L
Pseudoleistes guirahuro	chopí estero				X	-	LC	-	-	R	-	-	-	-	-	-	O	L
Mimidae																		

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		1C	2C			MADES 2019	UICN 2022	CITES 2023	CMS 2022									
Mimus saturninus	calandria grande				X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Motacillidae																		
Anthus lutescens	cachirla chica				X	-	LC	-	-	R	-	-	-	-	-	-	O	L
Parulidae																		
Basileuterus culicivorus	arañero coronado				X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Setophaga pitiayumi	pitiayumí	1	2	3	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Passerellidae																		
Ammodramus humeralis	cachilo ceja amarilla				X	-	LC	-	-	R	-	-	-	-	-	-	O	L
Arremon flavirostris	afrechero de collar	3	3	6	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Zonotrichia capensis	bendito sea	2	1	3	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Passeridae																		
Passer domesticus	Corbatita				X	-	LC	-	-	C1	-	-	X	-	-	-	-	L
Polypropylidae																		
Polioptila dumicola	tacuarita azul	5	13	18	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Thamnophilidae																		
Taraba mayor	chororó	11	4	15	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Thamnophilus caerulescens	batará plomizo	2	2	4	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Thamnophilus doliatus	batará rayado	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Thraupidae																		
Coryphospingus cucullatus	brasita de fuego	2	3	5	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Emberizoides herbicola	coludo grande				X	-	LC	-	-	R	-	-	-	-	-	-	O	L
Embernagra platensis	verdón				X	-	LC	-	-	R	-	-	-	-	-	-	O	L
Paroaria capitata	cardenilla	2	2	4	X	-	LC	II	-	R	-	O	-	-	-	-	-	L
Paroaria coronata	cardenal	6	13	19	X	-	LC	II	-	R	-	O	-	-	-	-	F	L
Saltator coerulescens	pepitero gris	1	5	6	X	-	LC	-	-	R	-	O	-	-	-	-	-	L
Sicalis flaveola	canario paraguay	3	1	4	X	-	LC	-	-	R	-	O	-	-	-	-	-	L
Sporophila angolensis	curió				X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Sporophila caerulescens	corbatita común				X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Sporophila collaris	corbatita dominó				X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Sporophila hypoxantha	capuchino canela				X	-	LC	-	-	R	-	-	-	-	-	-	O	M
Sporophila leucoptera	corbatita blanco				X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Tachyphonus rufus	frutero negro		6	6	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Tangara sayaca	chogüí	7	11	18	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Volatinia jacarina	volatinero				X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Tityridae																		
Pachyramphus polychopterus	anambé negro	1		1	X	-	LC	-	-	AN	-	-	-	-	-	-	-	L
Pachyramphus viridis	anambé verdoso	2		2	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Troglodytidae																		
Campylorhynchus turdinus	ratona grande	3	41	44	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Troglodytes aedon	ratona común	6	18	24	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Turdidae																		
Turdus amaurochalinus	zorzal mandioca	2	5	7	X	-	LC	-	-	R	-	O	-	-	-	-	F	L
Turdus leucomelas	zorzal alas canelas	1	1	2	X	-	LC	-	-	R	-	O	-	-	-	-	-	L
Turdus rufiventris	zorzal colorado	1	2	3	X	-	LC	-	-	R	-	O	-	-	-	-	-	L
Tiránidos																		
Alectrurus risora	yetapá de collar				X	ES	VU	-	I	R	-	-	-	-	-	-	F	M
Arundinicola leucocephala	lavandera				X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Camptostoma obsoletum	piojito silbón	3	6	9	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Casiornis rufus	suiriri castaño	3	2	5	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Cnemotriccus fuscatus	mosqueta ceja blanca				X	-	LC	-	-	AN	-	-	-	-	-	-	-	L

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		1C	2C			MADES 2019	UICN 2022	CITES 2023	CMS 2022									
Elaenia spectabilis	fiofío grande	1		1	X	-	LC	-	-	AN	-	-	-	-	-	-	-	L
Fluvicola albiventer	viudita blanca				X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Hemitriccus margaritaceiventer	mosqueta ojo dorado	4	1	5	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Hymenops perspicillatus	pico de plata				X	-	LC	-	-	AS	-	-	-	-	-	-	F	M
Knipolegus cyanirostris	viudita pico celeste				X	-	LC	-	-	AV	-	-	-	-	-	-	-	L
Machetornis rixosa	caballerizo	4	2	6	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Megarynchus pitangua	ñei ñei	2		2	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Myiarchus ferox	burlisto pico negro	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Myiarchus swainsoni	burlisto pico canela	1		1	X	-	LC	-	-	AN	-	-	-	-	-	-	-	L
Myiarchus tyrannulus	burlisto cola castaña	3	4	7	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Myiodynastes maculatus	pitogüé rayado	4		4	X	-	LC	-	-	AN	-	-	-	-	-	-	-	L
Myiopagis viridicata	fiofío corona dorada				X	-	LC	-	-	AN	-	-	-	-	-	-	-	M
Pitangus sulphuratus	pitogüé común	3	20	23	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Pyrocephalus rubinus	churrinche		2	2	X	-	LC	-	-	AS	-	-	-	-	-	-	F	L
Satrapa icterophrys	suirirí amarillo				X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Serpophaga griseicapilla	piojito trinador	1		1	X	-	LC	-	-	AV	-	-	-	-	-	-	-	L
Suiriri suiriri	suirirí vientre blanco	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Tolmomyias sulphurescens	picochato grande				X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Tyrannus melancholicus	suiriri real	3	2	5	X	-	LC	-	-	AN	-	-	-	-	-	-	F	L
Tyrannus savana	tijereta				X	-	LC	-	-	AN	-	-	-	-	-	-	O	L
Xolmis cinereus	monjita gris				X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Xolmis irupero	monjita blanca	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Vireonidae																		
Cyclarhis gujanensis	juan chiviro	2	7	9	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Pelecaniformes																		
Ardeidae																		
Ardea alba	garza blanca	2	64	66	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Ardea cocoi	garza mora	3		3	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Bubulcus ibis	garcita bueyera	21		21	X	-	LC	-	-	R	-	-	-	X	-	X	F	L
Butorides striata	garcita azulada	1		1	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Egretta thula	garcita blanca		19	19	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Nycticorax nycticorax	garza bruja	1		1	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Syrigma sibilatrix	garza silbadora	6	13	19	X	-	LC	-	-	R	-	-	-	-	-	X	F	M
Tigrisoma lineatum	hocó colorado		1	1	X	-	LC	-	-	R	-	-	-	-	-	X	-	M
Threskiornithidae																		
Mesembrinibis cayennensis	tapicurú				X	-	LC	-	-	R	-	-	-	-	-	X	-	M
Phimosus infuscatus	cuervillo cara pelada	201	135	336	X	-	LC	-	-	R	-	-	-	-	-	X	-	M
Platalea ajaja	espátula rosada		12	12		-	LC	-	-	R	-	-	-	-	-	X	-	M
Plegadis chihi	cuervillo de cañada		16	16		-	LC	-	-	R	-	-	-	-	-	X	-	L
Theristicus caudatus	bandurria baya	6	3	9	X	-	LC	-	-	R	-	-	-	-	-	X	F	L
Piciformes																		
Picidae																		
Campephilus leucopogon	carpintero lomo blanco	2	4	6	X	-	LC	-	-	R	CHA	-	-	-	-	-	-	M
Celeus lugubris	carpintero copete pajizo				X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Colaptes campestris	carpintero campestre	4		4	X	-	LC	-	-	R	-	-	-	-	-	-	F	L
Colaptes melanochloros	carpintero real	3	2	5	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Melanerpes cactorum	carpintero del cactus	1	3	4	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Melanerpes candidus	carpintero blanco		9	9		-	LC	-	-	R	-	-	-	-	-	-	-	L
Piculus chrysochloros	carpintero dorado		1	1		-	LC	-	-	R	-	-	-	-	-	-	-	M
Picumnus cirratus	carpinterito común	1	4	5	X	-	LC	-	-	R	-	-	-	-	-	-	-	L

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		1C	2C			MADES 2019	UICN 2022	CITES 2023	CMS 2022									
Veniliornis mixtus	carpintero bataraz		2	2	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Veniliornis passerinus	carpinterito oliváceo	1	1	2	X	-	LC	-	-	R	-	-	-	-	-	-	-	L
Psittaciformes																		
Psittacidae																		
Amazona aestiva	loro hablador	6	8	14	X	-	NT	II	-	R	-	O	-	-	-	-	-	M
Aratinga nenday	ñanday	36	50	86	X	-	LC	II	-	R	-	O	-	-	-	-	-	M
Brotogeris chiriri	catita chiriri	2	24	26	X	-	LC	II	-	R	-	O	-	-	-	-	-	M
Forpus xanthopterygius	catita viuda		4	4	X	-	LC	II	-	R	-	O	-	-	-	-	-	L
Myiopsitta monachus	cotorrita	5	6	11	X	-	LC	II	-	R	-	O	-	-	-	-	F	L
Pionus maximiliani	loro choclero	2	7	9	X	-	LC	II	-	R	-	O	-	-	-	-	-	M
Psittacara acuticaudatus	maracaná cabeza azulada	1	6	7	X	-	LC	II	-	R	-	O	-	-	-	-	-	M
Psittacara leucophthalmus	maracaná ala roja	2	4	6	X	-	LC	II	-	R	-	O	-	-	-	-	-	L
Pyrrhura frontalis	chiripepé cabeza verde	40	53	93	X	-	LC	II	-	R	ATL	O	-	-	-	-	-	M
Strigiformes																		
Strigidae																		
Athene cunicularia	lechucita vizcachera				X	-	LC	II	-	R	-	-	-	-	-	-	O	M
Glaucidium brasilianum	caburé				X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Megascops choliba	lechucita común	1		1	X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Tytonidae																		
Tyto alba	lechuza de campanario				X	-	LC	II	-	R	-	-	-	-	-	-	-	L
Suliformes																		
Anhingidae																		
Anhinga anhinga	aninga				X	-	LC	-	-	R	-	-	-	-	-	X	-	M
Phalacrocoracidae																		
Nannopterum brasilianus	cormorán	1		1	X	-	LC	-	-	R	-	-	-	-	-	X	-	L
Tinamiformes																		
Tinamidae																		
Crypturellus tataupa	tataupá común	5	3	8	X	-	LC	-	-	R	-	A	-	-	-	-	-	L
Nothura maculosa	perdiz chica				X	-	LC	-	-	R	-	-	-	-	-	-	O	L
Rhynchotus rufescens	martineta				X	-	LC	-	-	R	-	-	-	-	-	-	O	L
Trogoniformes																		
Trogonidae																		
Trogon curucui	surucuá aurora	1		1	X	-	LC	-	-	R	-	-	-	-	-	-	-	M
Total general		**1037**	**1103**	**2140**														

Legend: Conservation Status: (MADES, 2019 and UICN 2022) **LC** - "Low Concern", **NT** - "Near Threatened", **VU** - "Vulnerable", **EN** - "Endangered". (CITES 2023) **Appendix I** - endangered species whose trade is only allowed in exceptional circumstances, **Appendix II** - species that are not necessarily threatened with extinction, but whose trade must be controlled to avoid uses incompatible with their survival; (CMS) **Appendix I - Endangered migratory species**, **Appendix II** - Migratory species in an unfavourable conservation status that should be the subject of international agreements; Residency Status (DEL CASTILLO & CLAY 2005): **R** - Permanent Nesting Resident, year-round breeder, **N** - Nearctic Migrator, **V** - Vacationer, It does not nest but is present in its breeding season, **NA** - Northern southern migrant, nests and migrates north, **AS** - Southern Migrant Nesting Swelling Ramp Increase in Winter, **AV** – Winter visitor, does not nest, **AT** – Transitory species, does not nest, **I** - Intratropical migrant, does not nest, **E** – Wandering or rambling , **NOM** - Nomadic Migrant, **? –** Unknown status, **C1** - Inserted; Endemism: **ATL –** Atlantic Forest, **CHA** - Chaco; Hunting: **A – Cynegetic species used for consumption**, **O** - Synegetic species intended for ornamentation; Grasslands: **O** - Obligatory; **F** - Facultative; Sensitivity: **H –***High*, **M** –*Medium*, **L** –*Low*.

Lists of Herpetofauna Species

Table 5.3.2.3.2.a
List of species recorded during the first and second herpetofauna survey campaigns

CLASS/ Order/Family/Species	Popular name	Campaign		Status of Conservation			End.
		1C	2C	IUCN (2022)	CITES (2023)	MADES (2019, 2020)	
Amphibia							
Anura							
Bufonidae							
Rhinella azarai	Sapito, Kururu	x	5	-	-	-	-
Rhinella diptycha	Sapo, Kururu	x	1	DD	-	-	W
Hylidae							
Boana raniceps	Rana del zarzal, Ju'i pakova	x	1	LC	-	-	W
Dendropsophus minutus	Rana enana, Ju'i	x		LC	-	-	W
Dendropsophus nanus	Rana enana, Ju'i	x		LC	-	-	W
Scinax acuminatus	Rana de pileta, Ju'i letrina		3	LC	-	-	-
Scinax fuscovarius	Rana de pileta, Ju'i letrina		1	LC	-	-	W
Scinax nasicus	Rana de pileta, Ju'i letrina	x		LC	-	-	W
Leptodactylidae							
Adenomera diptyx	Rana, Ju'i	x		LC	-	-	-
Leptodactylus elenae	Rana, Ju'i	x		LC	-	-	-
Leptodactylus fuscus	Rana, Ju'i	x		LC	-	-	W
Leptodactylus latinasus	Rana, Ju'i	x	3	LC	-	-	-
Leptodactylus latrans	Rana, Ju'i	x		LC	-	-	W
Leptodactylus macrosternum	Rana, Ju'i	x	1	-	-	-	-
Leptodactylus mystacinus	Rana, Ju'i	x		LC	-	-	W
Leptodactylus podicipinus	Rana, Ju'i	x	1	LC	-	-	W
Physalaemus cuvieri	Rana, Ju'i	x		LC	-	-	W
Physalaemus sp.1	Rana, Ju'i		2	-	-	-	-
Physalaemus sp.2	Rana, Ju'i		1				
Pseudopaludicola boliviana	Rana, Ju'i	x	4	LC	-	-	-

Table 5.3.2.3.2.a
List of species recorded during the first and second herpetofauna survey campaigns

CLASS/ Order/Family/Species	Popular name	Campaign		Status of Conservation			End.
		1C	2C	IUCN (2022)	CITES (2023)	MADES (2019, 2020)	
Odontophrynidae							
Odontophrynus americanus			3	LC	-	-	-
Reptilia							
Squamata (Lagartos)							
Teiidae							
Salvator merianae	Lagarto overo, Teju guasu	x		LC	II	-	-
Squamata (Serpentes)							
Colubridae							
Drymarchon corais	Culebra	x		LC	-	-	W
Dipsadidae							
Dryophylax chaquensis	Ojo de gato, Mboi capi'i	x	1	-	-	-	-
Erythrolamprus almadensis	Falsa yarará	x		LC	-	-	W
Erythrolamprus poecilogyrus	Culebra, Mboi capitán		2	LC	-	-	W
Hydrodynastes gigas	Ñacaniná		1	LC	-	-	W

Legend: Conservation Status: DD – Insuficient data, LC - "Low Concern". Endemism: W – Large distribution.

Table 5.3.2.3.2.c
List of species recorded during herpetofauna survey campaigns and secondary data (AII)

Order/Family/*Species*	Popular name	Campaign		Total	AII	Status of Conservation			End.
		1C	2C			IUCN (2022)	CITES (2023)	MADES (2019, 2020)	
Anura									
Amphibia									
Bufonidae			6	6					
Rhinella azarai	Sapito, Kururu	X	5	5	X	-	-	-	-
Rhinella diptycha	Sapo, Kururu	X	1	1	X	DD	-	-	W
Hylidae									
Boana punctata	Rana punteada, Ju'i				X	LC	-	-	W
Boana raniceps	Rana del zarzal, Ju'i pakova		1	1	X	LC	-	-	W
Dendropsophus minutus	Rana enana, Ju'i	X			X	LC	-	-	W
Dendropsophus nanus	Rana enana, Ju'i	X			X	LC	-	-	W
Lysapsus limellum	Rana boyadora, Ju'i				X	LC	-	-	-
Scinax acuminatus	Rana de pileta, Ju'i letrina		3	3	X	LC	-	-	-
Scinax fuscovarius	Rana de pileta, Ju'i letrina		1	1	X	LC	-	-	W
Scinax nasicus	Rana de pileta, Ju'i letrina	X			X	LC	-	-	W
Trachycephalus typhonius	Rana lechera, Ju'i nekere				X	LC	-	-	-
Leptodactylidae									
Adenomera diptyx	Rana, Ju'i	X			X	LC	-	-	-
Leptodactylus bufonius	Rana, Ju'i				X	LC	-	-	-
Leptodactylus elenae	Rana, Ju'i	X			X	LC	-	-	-
Leptodactylus fuscus	Rana, Ju'i	X			X	LC	-	-	W
Leptodactylus gracilis	Rana, Ju'i				X	LC	-	-	-
Leptodactylus latinasus	Rana, Ju'i	X	3	3		LC	-	-	-
Leptodactylus latrans	Rana, Ju'i	X				LC	-	-	W
Leptodactylus luctator	Rana criolla, Ju'i				X	-	-	-	-
Leptodactylus macrosternum	Rana, Ju'i	X	1	1	X	-	-	-	-
Leptodactylus mystacinus	Rana, Ju'i	X			X	LC	-	-	W
Leptodactylus podicipinus	Rana, Ju'i	X	1	1	X	LC	-	-	W

Table 5.3.2.3.2.c
List of species recorded during herpetofauna survey campaigns and secondary data (AII)

Order/Family/*Species*	Popular name	Campaign		Total	AII	Status of Conservation			End.
		1C	2C			IUCN (2022)	CITES (2023)	MADES (2019, 2020)	
Physalaemus albonotatus	Rana, Ju'i vakara'y				X	LC	-	-	-
Physalaemus biligonigerus	Rana cuatro ojos, Ju'i vakara'y				X	LC	-	-	-
Physalaemus cuvieri	Rana, Ju'i	X			X	LC	-	-	W
Physalaemus sp.1	Rana, Ju'i		2	2		LC	-	-	-
Physalaemus sp.2	Rana, Ju'i		1	1					
Pseudopaludicola boliviana	Ranita, Ju'i	X	4	4	X	LC	-	-	-
Microhylidae									
Dermatonotus muelleri	Escuercito, Ju'i				X	LC	-	-	W
Elachistocleis bicolor	Rana aceituna, Ju'i				X	LC	-	-	-
Odontophrynidae									
Odontophrynus americanus			3	3	X	LC	-	-	-
Phyllomedusidae									
Pithecopus azureus	Rana monito, Ju'i pakova				X	DD	-	-	W
Squamata (Lagartos)									
Reptilia									
Amphisbaenidae									
Amphisbaena alba	Culebra, Yvy'ja				X	LC	-	-	W
Diploglossidae									
Ophiodes intermedius	Lagarto, Mboi pepe				X			-	
Gymnophthalmidae									
Cercosaura schreibersii	Lagartija, Tju'i				X	LC	-	-	-
Mabuyidae									
Notomabuya frenata	Lagartija, Ambere				X	LC	-	-	-
Polychrotidae									
Polychrus acutirostris	Falso camaleón, Teju tara				X	LC	-	-	-
Teiidae									
Ameiva ameiva	Lagartija, Teju asaje				X	LC	-	-	-

Table 5.3.2.3.2.c
List of species recorded during herpetofauna survey campaigns and secondary data (AII)

Order/Family/*Species*	Popular name	Campaign		Total	AII	Status of Conservation			End.
		1C	2C			IUCN (2022)	CITES (2023)	MADES (2019, 2020)	
Salvator merianae	Lagarto overo, Teju guasu	X			X	LC	II	-	-
Squamata (Serpentes)									
Reptilia									
Boidae									
Eunectes notaeus	Anaconda amarilla, Kuriju				X	LC	II	-	W
Colubridae									
Drymarchon corais		X			X	LC	-	-	W
Leptophis ahaetulla	Culebra, Mboi hovy				X	LC	-	-	W
Dipsadidae									
Dipsas turgida	Culebra, Ñandurire				X	-	-	-	W
Dipsas ventrimaculata	Culebra, Ñandurire				X	-	-	-	W
Dryophylax chaquensis	Ojo de gato, Mboi capi'i	X	1	1	X	LC	-	-	W
Erythrolamprus aesculapii	Falsa coral, Mboi chumbe				X	LC	-	-	W
Erythrolamprus almadensis	Falsa yarará	X			X	LC	-	-	W
Erythrolamprus jaegeri	Culebra, Mboi hovy				X	LC	-	-	W
Erythrolamprus poecilogyrus	Culebra, Mboi capitán		2	2	X	LC	-	-	W
Erythrolamprus semiaureus	Culebra de agua, Mboi				X	LC	-	-	W
Helicops leopardinus	Culebra de agua, Mboi				X	LC	-	-	W
Hydrodynastes gigas	Ñacaniná		1	1	X	LC	-	-	W
Lygophis dilepis	Culebra, Mboi capi'i				X	LC	-	-	W
Mussurana bicolor	Musurana, Ñakanina hũ				X	LC	-	-	W
Oxyrhopus guibei	Falsa coral, Mboi chumbe				X	LC	-	-	W
Phalotris matogrossensis	Culebra, Mboi tata				X	LC	-	-	W
Philodryas olfersii	Culebra, Mboi hovy				X	LC	-	-	W
Pseudablabes patagoniensis	Parejera, Ñuaso				X	LC	-	-	-
Xenodon merremii	Sapera, Mboi pe say'ju				X	-	-	-	W
Elapidae									

Table 5.3.2.3.2.c
List of species recorded during herpetofauna survey campaigns and secondary data (AII)

Order/Family/*Species*	Popular name	Campaign		Total	AII	Status of Conservation			End.
		1C	2C			IUCN (2022)	CITES (2023)	MADES (2019, 2020)	
Micrurus frontalis	Coral, Mboi chumbe				X	LC	-	-	W
Typhlopidae									
Amerotyphlops brongersmianus	Culebra, Yvytaso				X	LC	-	-	W
Viperidae									
Bothrops alternatus	Crucera, Jarara				X	LC	-	-	W
Bothrops diporus	Yarara, Kyryry'o				X	LC	-	-	W
Total			**30**	**30**					

Legend: Conservation Status: DD - "Insuficient data", LC - "Low Concern"; Appendix II (CITES, 2023) - species that are not necessarily threatened with extinction, but whose trade must be controlled to avoid uses incompatible with their survival. Endemism: EC – Open Areas, W – Large Distribution.

Lists of Bats Species

Table 5.3.2.4.3.a
List of species recorded during the first bat survey campaign

Order/Family/*Species*	Popular name	Records	Status of Conservation		
			MADES 2017	IUCN 2022	CITES 2023
Chiroptera					
Molossidae					
Eumops perotis	murciélago	28	-	LC	-
Eumops sp.	murciélago	50	-		
Molossops temminckii	murciélago	27	-	LC	-
Molossus molossus	murciélago	6	-	LC	-
Molossus rufus	murciélago	7	-	LC	-
Nyctinomops laticaudatus	murciélago	35	-	LC	-
Promops centralis	murciélago	8	-	LC	-
Vespertilionidae					
Eptesicus furinalis	murciélago	90	-	LC	-
Lasiurus blossevillii	murciélago	36	-	LC	-
Lasiurus ega	murciélago	168	-	LC	-
Myotis albescens	murciélago	24	-	LC	-
Myotis nigricans	murciélago	8	-	LC	-
Myotis riparius	murciélago	1	-	LC	-
Total		**488**			

Legend: Status of conservation: LC - "Low Concern".

Table 5.3.2.4.3.b
List of species recorded during the second bat survey campaign

Order/Family/*Species*	Popular name	Records	Status of Conservation		
			MADES 2017	IUCN 2022	CITES 2023
Chiroptera					
Molossidae					
Eumops perotis	murciélago	5	-	LC	-
Eumops sp.	murciélago	12	-		
Nyctinomops laticaudatus	murciélago	13	-	LC	-
Promops centralis	murciélago	2	-	LC	-
Noctilionidae					
Noctilio leporinus	murciélago pescador	2	-	LC	-
Vespertilionidae					
Eptesicus furinalis	murciélago	16	-	LC	-
Lasiurus blossevillii	murciélago	34	-	LC	-
Lasiurus ega	murciélago	18	-	LC	-
Myotis nigricans	murciélago	1	-	LC	-
Total		**103**			

Legend: Status of conservation: LC - "Low Concern".

Table 5.3.2.4.3.c
List of species recorded during bat survey campaigns and secondary data (AII)

Order/Family/Species	Popular name	Campaign		AII	Total	Status of Conservation		
		1ªC	2ªC			MADES 2019	IUCN 2022	CITES 2023
Chiroptera								
Emballonuridae								
Peropteryx macrotis	bat			x		Sí	LC	-
Molossidae								
Cynomops abrasus	bat			x		-	DD	-
Cynomops planirostris	bat			x		-	LC	-
Eumops auripendulus	bat			x		-	LC	-
Eumops bonariensis	bat			x		-	LC	-
Eumops dabbenei	bat			x		-	LC	-
Eumops glaucinus	bat			x		-	LC	-
Eumops perotis	bat	28	5	x	33	-	LC	-
Eumops sp.	bat	50	12		62	-		-
Molossops temminckii	bat	27		x	27	-	LC	-
Molossus molossus	bat	6		x	6	-	LC	-
Molossus rufus	bat	7		x	7	-	LC	-
Nyctinomops laticaudatus	bat	35	13	x	48	-	LC	-
Promops centralis	bat	8	2	x	10	-	LC	-
Promops nasutus	bat			x		-	LC	-
Tadarida brasiliensis	bat			x		-	LC	-
Noctilionidae								
Noctilio albiventris	Sinful bat			x		-	LC	-
Noctilio leporinus	Sinful bat		2	x	2	-	LC	-
Vespertilionidae								
Eptesicus diminutus	bat			x			LC	
Eptesicus furinalis	bat	90	16	x	106	-	LC	-
Lasiurus blossevillii	bat	36	34	x	70	-	LC	-
Lasiurus ega	bat	168	18	x	186	-	LC	-

Table 5.3.2.4.3.c
List of species recorded during bat survey campaigns and secondary data (AII)

Order/Family/Species	Popular name	Campaign		AII	Total	Status of Conservation		
		1ªC	2ªC			MADES 2019	IUCN 2022	CITES 2023
Lasiurus villosissimus	bat			x		-	LC	-
Myotis albescens	bat	24		x	24	-	LC	-
Myotis levis	bat			x		-	LC	-
Myotis nigricans	bat	8	1	x	9	-	LC	-
Myotis riparius	bat	1		x	1	-	LC	-
Myotis ruber	bat			x		-	NT	-
Myotis simus	bat			x		-	DD	-
Total		**488**	**103**		**591**			

Legend: Conservation Status: LC - "Low Concern", NT - "Near Threatened", DD – Insuficient data.

Lists of Large and Medium Mammal Species

Table 5.3.2.4.a
List of species recorded during the first survey campaign of Medium and Large Mammals

Order/Family/*Species*	Popular name	Records	Status of Conservation		
			MADES 2017	IUCN 2022	CITES 2023
Didelphimorphia					
Didelphidae					
Didelphis albiventris	comadreja común	1	-	LC	-
Cingulata					
Dasypodidae					
Dasypus novemcinctus	mulita grande	1	-	LC	-
Pilosa					
Myrmecophagidae					
Tamandua tetradactyla	oso melero	1	-	LC	-
Primates					
Atelidae					
Alouatta caraya	mono aullador	5	-	LC	II
Lagomorpha					
Leporidae					
*Sylvilagus brasiliensis**	conejito de monte	1	-	LC	-
Carnivora					
Canidae					
Cerdocyon thous	zorro cangrejera	7	-	LC	II
Procyonidae					
Procyon cancrivorus	mapache comedor de cangrejos	2	-	LC	-
Felidae					
Felidae NI	felino silvestre	1	-	-	II
Herpailurus yagouaroundi	gato moro	1	-	LC	II
Leopardus geoffroyi	gato montés	1	-	LC	II

Table 5.3.2.4.a
List of species recorded during the first survey campaign of Medium and Large Mammals

Order/Family/*Species*	Popular name	Records	Status of Conservation		
			MADES 2017	IUCN 2022	CITES 2023
Cetartiodactyla					
Cervidae					
Subulo gouazoubira	corzuela	2	-	LC	-
Total		**23**			

Legend: * Concept of species lato sensu. Conservation Status: LC - "Low Concern"; Appendix II - species that are not necessarily threatened with extinction, but whose trade must be controlled to avoid uses incompatible with their survival.

Table 5.3.2.4.b
List of species recorded during the first survey campaign of Medium and Large Mammals

Order/Family/*Species*	Popular name	Records	Status of Conservation		
			MADES 2017	IUCN 2022	CITES 2023
Didelphimorphia					
Didelphidae					
Didelphis albiventris	comadreja común	11	-	LC	-
Philander quica	comadreja de cuatro ojos	8	-	-	-
Cingulata					
Dasypodidae					
Dasypus novemcinctus	mulita grande	7	-	LC	-
Primates					
Atelidae					
Alouatta caraya	mono aullador	1	-	LC	II
Lagomorpha					
Leporidae					
*Sylvilagus brasiliensis**	conejito de monte	2	-	LC	-
Carnivora					
Canidae					
Cerdocyon thous	zorro cangrejera	17	-	LC	II
Procyonidae					
Procyon cancrivorus	mapache comedor de cangrejos	8	-	LC	-
Felidae					
Felidae NI	felino silvestre	2	-	-	II
Cetartiodactyla					
Cervidae					
Subulo gouazoubira	corzuela	6	-	LC	-
Total		**62**			

Legend: * Concept of species lato sensu. Conservation Status: LC - "Low Concern"; Appendix II - species that are not necessarily threatened with extinction, but whose trade must be controlled to avoid uses incompatible with their survival.

Table 5.3.2.4.c
List of species recorded during mammalian survey campaigns and from secondary data (AII)

Order/Family/*Species*	Popular name	Campaign		AII	Total	Status of conservation		
		1ªC	2ªC			MADES 2019	IUCN 2022	CITES 2023
Didelphimorphia								
Didelphidae								
Didelphis albiventris	comadreja común	1	11	X	12	-	LC	-
Philander quica	comadreja de cuatro ojos		8		8	-	-	-
Dasypodidae								
Dasypus novemcinctus	mulita grande	1	7	X	8	-	LC	-
Cabassous chacoensis	cabasú chico			X		-	NT	-
Chaetophractus vellerosus	tatú llorón			X		-	LC	-
Chaetophractus villosus	tatú peludo			X		-	LC	-
Cingulata								
Dasypus hybridus	mulita pampeana			X		-	NT	-
Chlamyphoridae								
Euphractus sexcinctus	tatú peludo			X		-	LC	-
Priodontes maximus	armadillo gigante			X		Sí	VU	I
Tolypeutes matacus	tatú bolita			X		-	NT	-
Pilosa								
Myrmecophagidae								
Myrmecophaga tridactyla	oso hormiguero			X		Sí	VU	II
Tamandua tetradactyla	oso melero	1		X	1	-	LC	-
Primates								
Atelidae								
Alouatta caraya	mono aullador	5	1	X	6	-	LC	II
Cebidae								
Aotus azarae	mono de noche			X		-	LC	II
Mico melanurus	mono			X		-	LC	II
Sapajus cay	mono ka´i - ka´i			X		-	LC	II

Table 5.3.2.4.c
List of species recorded during mammalian survey campaigns and from secondary data (AII)

Order/Family/*Species*	Popular name	Campaign		AII	Total	Status of conservation		
		1ªC	2ªC			MADES 2019	IUCN 2022	CITES 2023
Pitheciidae								
Callicebus pallescens	mono titi			X		-	LC	II
Lagomorpha								
Leporidae								
*Sylvilagus brasiliensis**	conejito de monte	1	2	X	3	-	LC	-
Rodentia								
Caviidae								
Cavia aperea	cuis			X		-	LC	-
Hydrochoerus hydrochaeris	carpincho			X		-	LC	-
Myocastoridae								
Myocastor coipus	falsa nutria			X		-	LC	-
Cuniculidae								
Cuniculus paca	paca			X		-	LC	-
Carnivora								
Canidae								
Cerdocyon thous	zorro cangrejera	7	17	X	24	-	LC	II
Chrysocyon brachyurus	lobo de crin			X		Sí	LC	II
Lycalopex gymnocercus	zorro de campo			X		-	LC	II
Mephitidae								
Conepatus chinga	zorrino			X		-	LC	-
Mustelidae								
Eira barbara	hurón mayor			X		-	LC	-
Galictis cuja	grisón menor			X		-	LC	-
Lontra longicaudis	lobito de rio			X		-	NT	I
Pteronura brasiliensis	nutria gigante			X		Sí	EN	I
Procyonidae								
Nasua nasua	coati			X		-	LC	-

Table 5.3.2.4.c
List of species recorded during mammalian survey campaigns and from secondary data (AII)

Order/Family/*Species*	Popular name	Campaign		AII	Total	Status of conservation		
		1ªC	2ªC			MADES 2019	IUCN 2022	CITES 2023
Procyon cancrivorus	mapache comedor de cangrejos	2	8	X	10	-	LC	-
Felidae								
Herpailurus yagouaroundi	gato moro	1		X	1	-	LC	II
Leopardus braccatus	gato de los pajonales			X		-	NT	II
Leopardus geoffroyi	gato montés	1		X	1	-	LC	I
Leopardus pardalis	ocelote			X		-	LC	I
Leopardus tigrinus	jaguarete'i			X		Sí	VU	I
Leopardus wiedii	tigrillo de cola larga			X		-	NT	I
Puma concolor	léon			X		-	LC	II
Panthera onca	tigre			X		Sí	NT	I
Felidae NI	felino silvestre	1	2		3	-	-	II
Perissodactyla								
Tapiriidae								
Tapirus terrestris	tapir			X		Sí	VU	II
Cetartiodactyla								
Cervidae								
Blastocerus dichotomus	ciervo de los pantanos			X		Sí	VU	I
Mazama americana	venado rojo			X		-	DD	-
Subulo gouazoubira	corzuela	2	6	X	8	-	LC	-
Tayassuidae								
Catagonus wagneri	peccarí chaqueño			X		Sí	EN	II
Dicotyles tajacu	pecarí de collar			X		-	LC	II
Tayassu pecari	pecarí de labio blanco			X		Sí	VU	II
Total		**23**	**62**	**0**	**85**			

Legend: * Species concept lato sensu. Conservation Status: EN - "Endangered", VU - "Vulnerable", LC - "Low Concern", NT - "Neart Threatened", DD – Insufficient data; Appendix I - endangered species, trade in which will only be authorized in exceptional circumstances, Appendix II - species that are not necessarily endangered, but whose trade must be controlled to avoid uses incompatible with their survival.

Annex 11 – Expanded Stakeholder Map

Stakeholders Matrix

Table 1. Stakeholders Matrix

Institution/Organization	Mandate	Interests	Level of Incidence
ATOME	Executor of the project	Installation of an industrial plant in the city of Villeta.	High
Mayor of the Municipality of Villeta	City Manager, highest authority of the Municipality.	To achieve political legitimacy, to position Villeta as an industrial city, to increase revenues in the form of fees and taxes for the city.	High
Municipality Council	Legislative branch within the Municipality, in charge of enacting and enforcing municipal laws and ordinances	Ensure compliance with municipal regulations. Limit the establishment of new industries.	High
Ministry of Environment and Sustainable Development (MADES)	Institution responsible for granting environmental licenses for the execution of projects at the country level. Authority for the application of environmental regulations.	Ensure compliance with environmental regulations.	High
Ministry of Industry and Trade (MIC)	Develop strategies for the implementation of the country's industrial policy instruments, through actions that favor	Ensure compliance with legislation that regulates and favours investment and industrial development.	Medium

Institution/Organization	Mandate	Interests	Level of Incidence
	national and foreign investments and increase competitiveness in the face of globalization and trade liberalization.		
Ministry of Labour, Employment and Social Security (MTESS)	To govern the policy and exercise the administrative regulation of the Labor, Employment, and Social Security regime; supervising compliance with current labor regulations.	Foster decent work and promote productive employment through efficient and effective management that ensures compliance with labour rights.	Low
Ministry of Public Works and Communications (MOPC) Directorate of Roads	Responsible for public works at the national level.	Maintain the public road infrastructure in the area of influence (Villeta – Alberdi Route) in adequate service conditions. Approve a road impact mitigation project to be developed by ATOME.	Medium
National Secretariat of Culture (SNC)	Design and execute the cultural policies of the State, the governing body that designs, regulates and promotes cultural policies, committed to the protection of the country's	Protect cultural heritage, promote its dissemination and conserve, recover and restore the assets that make it up.	Low

Institution/Organization	Mandate	Interests	Level of Incidence
	cultural heritage and its diversity.		
San Rafael Farm	Property settled in the AID of the project.	Be a beneficiary of mitigation measures and compensation for the potential impacts of the project.	Medium
Workers of the San Rafael Farm	People who live and carry out economic activities in the area of influence.	Recipients of mitigation measures due to the potential impacts of the project.	Medium
Owner of Agricultural Land (Rice)	Property settled in the AID of the project.	Be a beneficiary of mitigation measures and compensation for the potential impacts of the project.	Medium
Lola Farm	Property settled in the AID of the project.	Recipients of mitigation measures due to the potential impacts of the project.	Medium
Substation Buey Rodeo (ANDE)	Provision of electricity in the area.	Provide an efficient electricity supply service in the area.	High
Police Station 49 Surubí-y km 19 Villeta	Institution responsible for citizen security in the project's area of influence. Intervention in criminal acts in the area.	Maintain public order and security in the area of its jurisdiction.	Low

Institution/Organization	Mandate	Interests	Level of Incidence
City of Villeta Firefighters	Institution in charge of prevention, extinguishment, assistance and education in the event of accidents and accidents.	Accident prevention through the verification of the installations of fire protection systems in the city's industries and companies.	Medium
Villeta Neighborhood Commission and Organizations	Community organizations in the territory with a social mobilization force.	Job opportunities for community members.	Low
Small economic units settled in the area	Residents of the area.	Opportunity for economic income from the sale of your products.	Low
Naval Prefecture of Villeta	Protection and control of activities carried out on the Paraguay River.	Maintain order, safety and ensure navigability.	Low
Corporate groups based in the area	Economic sector with an impact on the market.	Rent-seeking, market expansion, taking advantage of the Paraguay-Paraná waterway, limiting regulations. Find business partners.	Low
Private Ports	Facilitate international trade and improve the competitiveness of businesses by providing a favourable logistics environment.	Acquisition of business partners and customers.	Medium

Institution/Organization	Mandate	Interests	Level of Incidence
FAO (Environmentalist)	International NGO, advocacy on public opinion.	Work on various aspects related to the environment, carry out actions that avoid and minimize adverse environmental impacts.	Low

Annex 12 – Carbon Footprint Calculation

Carbon footprint associated with the ATOME value chain

December 2023

ATOME PARAGUAY S.A.E Avda. Aviadores del Chacho 2050 Edificio WTC Torre 3 Piso 15
Asunción, Paraguay

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Carbon footprint associated with the ATOME value chain

Carbon Footprint Calculation Framework

The carbon footprint calculation methodology involves assessing the environmental impact of an entity, an organization, a product, or even an individual, in terms of the amount of greenhouse gases (GHG) released into the atmosphere during its life cycle, which can be caused both directly and indirectly by daily activities. [1]

The main objective of the carbon footprint calculation is to provide an analysis to understand and quantify GHG emissions and their contribution to climate change. This information is crucial for making informed decisions and developing emission reduction strategies. In addition, the carbon footprint is also used to promote transparency and environmental accountability, as it allows organizations and consumers to assess their climate impact and take action to mitigate it.

ATOME Value Chain Emissions

ATOME's core business is the production of hydrogen, ammonia and green fertilizers. It is estimated that 100,000 tons of green ammonia will be produced, using 20,000 tons of hydrogen produced at the plant through the process of alkaline electrolysis of water with renewable energy sources, resulting in a production process of zero CO2 emissions. This ammonia production will be used in the plant for the production of calcium ammonium nitrate (CAN), a widely consumed nitrogen-based fertilizer. The annual production of CAN is estimated at 250,000 tons.

As for ATOME's direct emissions, they are mainly related to the green ammonia production process, composed mainly of non-polluting gases such as H2, N2, H2O, O2 and Ar. Pollutant gases such as traces of NOx, CO2, CO and NH3 would be emitted in specific events or emergency situations through flare systems. In addition, liquid droplets are expected in gaseous streams of KOH solution during ventilation. During fertilizer production, the main source of emissions is the production of nitric acid, where emissions of nitrogen oxide (NOx) gases, specifically unreacted N2O, resulting as a byproduct of the catalytic oxidation of ammonia (NH3) at high temperatures are expected to occur. In addition, a certain amount of NOx (NO, NO2 and N2O) is produced, mainly during the start-up and shutdown of the reaction, when the process is less stable. The nitric acid plant is designed to minimise N2O emissions with a tail gas outlet reduction system.

Finally, it is important to consider the logistics of transporting employees, as well as the distribution and marketing of the CAN. The flue gases would be emitted by land transport vehicles, barges and container ships used for river and sea transport.

Definition of scope and limits

To start accounting for GHG emissions, 2022 was selected as the start of construction and site preparation for plant installation, and 2025 was chosen as the baseline for the start of ATOME production. The accounting of GHGs in relation to the operational limit was carried out following the scope of the Greenhouse Gas Protocol, being: [2]

1. Scope 1: Direct emissions from ATOME's own or controlled activities, including those derived from the production of ammonia and CAN, vehicles used for personnel transport and effluent treatment.
2. Scope 2: indirect emissions associated with purchased electricity.
3. Scope 3: Indirect emissions from activities that occur from sources outside of ATOME's control and not classified as Scope 2. These include emissions from the operation phase of the plant, those inherent to the production of raw materials used in the operation, the movement of equipment, machinery and operating personnel, the transport and

distribution of raw materials and finished products, and the use and final disposal of final products.

Due to the fact that GHG emissions during the construction phase are not continuous throughout the useful life of the plant, such as those inherent to the production of the raw materials used (iron, cement, plastics, etc.), the movement of equipment, machinery and personnel, among others, an additional section is presented in the results with the total amount of GHG emissions in the passage of time of the constructions.

Methodology

The basic methodology used to estimate greenhouse gas emissions *(E)* is the generic equation that multiplies the Activity Data *(DA)* by its corresponding Emission Factor (*FAITH*) as shown in the equation (1). The *GIVES* are defined as the magnitude of a human activity that results in GHG emissions or removals (e.g., transportation fuel consumption), occurring over a given period of time and in a specific area. Emission factors facilitate the calculation of GHG emissions, expressed in their respective international units, and converted to metric tons of carbon dioxide equivalent (t CO2-eq)[i]. These are coefficients that are used to quantify the emissions or removals of a GHG, considering the unit of measurement of the *GIVES*. These factors are based on measurement samples, averaged with different levels of detail according to the level of methodology used, with the aim of developing a representative emission rate for a specific level of activity under a set of specific operating conditions. Numerous reference sources were consulted to select the most appropriate conversion factors, and the 2006 and 2019 IPCC Guidelines were applied, taking into account selection criteria such as accessibility, consistency, and transparency in revisions and updates. [1] [3]

$$\boldsymbol{E = EF \times AD} \qquad \textbf{(1)}$$

Calculation of GHG emissions associated with the value chain

Most of the emission factors were used directly as defined in the chosen references. In some cases, it was necessary to calculate specific appropriate factors, e.g. using average values when there were small differences between sources (i.e. type of transport, such as light vehicles, trucks, barges). In addition, in some cases, proprietary data and results of studies carried out by URBAS, ATOMA's contractor for the FEED study, were used[ii].

[i] CO2-eq is the universal unit of measurement that indicates the global warming potential (GWP) of greenhouse gases, expressed in terms of the GWP of one unit of carbon dioxide.

[ii] Front-end design engineering

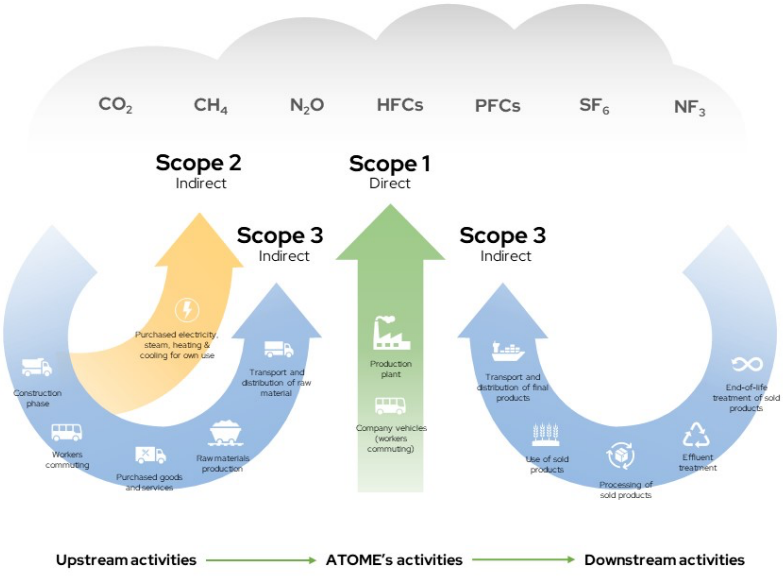

Figure 1. Carbon Footprint Scope Framework

Carbon footprint results

Ammonia Production Scenario

For the ammonia production scenario, the potential direct and indirect GHG emissions from the ATOME project are considered. Scope 1 covers emissions from the production process and employee displacement. Scope 2 covers indirect emissions from the procurement of energy services. Finally, Scope 3 considers indirect emissions from upstream activities, including emissions during the construction phase related to land use change and the production of raw materials to be used in the production process of the ATOME plant. Downstream activities include effluent treatment, transportation and distribution of green ammonia from the ATOME plant to industrial facilities in Paraguay, specifically in the Villeta Industrial Zone, capable of converting ammonia into ammonia-based fertilizers such as CAN. For comparison purposes, a grey ammonia carbon footprint scenario is included[iii], along with their potential direct and indirect emissions from production, energy consumption and downstream activities, such as transport and distribution from Europe to Paraguay for conversion into ammonia-based fertilisers – see Board 1. These two frameworks for studying the carbon footprint of ammonia will be used to compare and assess the GHG emissions avoided as a result of the implementation of the ATOME project. The methodologies, calculations, and benchmarks used to Board 1 are compiled in the section "Methodologies and calculations used for the carbon footprint"

Board 1. Carbon footprint scenario of ammonia production

Source of Emission			GHG emissions, t CO2 eq/ t NH3	
			ATOME (Green Ammonia)	World (Grey Ammonia)
Reach 1	1.1. Emissions from the production phase of NH3	1.1.1. Production Process	0.020	2.95
		1.1.2. Worker commuting	6.72E-04	-
		Subtotal	0.021	2.95
Scope 2	2.1. Fossil fuel combustion activities (electricity generation)		-	0.32

[iii] Produced from fossil fuels.

	2.2. Fugitive emissions from fuel production			-	1.33E-05
	2.3. Renewable energy (hydropower)			0.25	-
	Subtotal			0.25	0.32
Scope 3	1.1. Upstream activities	1.1.1. Emissions from the construction phase	Land Use Change	0.043	-
		1.1.2. Production of raw materials and inputs		0.0045	0.0045
		1.1.3. Transport of raw materials and inputs		1.39E-04	-
	1.2. Downstream activities	1.2.1. Ground Transportation and Distribution (a) ATOME Plant in the Villeta Industrial Zone (b) Port of Villeta to Villeta Industrial Zone		0.0032 (a)	0.0016 (b)
		1.2.2. River/sea transport and distribution c) European market to the port of Villeta		-	0.056 (c)
		1.2.3. Effluent treatment		-	-
	Subtotal			0.051	0.062
Total, t CO2-eq/t NH3				0.32	3.33
Total, t CO2-eq/t N				0.39	4.04
Total, t CO2-eq/year				32,000	333,000

In addition, GHG emissions during the 22 months of construction of the green ammonia plant were considered and separated from the carbon footprint scenario of ammonia production in Table 1 because they are not continuous emissions during the years of operation of the plant. Emissions related to the production of construction materials, emissions from the use of machinery and vehicles, and other construction activities are accounted for and summarized in the Board 2. The methodologies, calculations, and benchmarks used to Board 2 are compiled in the section "Methodologies and calculations used for the carbon footprint."

Board 2. Total Emissions During the Construction Phase of the Ammonia Plant

Source of Emission	GHG emissions, t CO2 eq
Materials, assembly and construction activities	3,165.27
Transmission Line	400
Emissions from vehicles and equipment used during construction	554.3[iv]
Workers' travel for the construction phase	42.74
Total, t CO2-eq	4,164.31

CAN Production Scenario

For the CAN production scenario, the potential direct and indirect GHG emissions of the ATOME project are considered. Scope 1 covers direct emissions from the production process and the posting of employees. Scope 2 considers indirect emissions related to the procurement of energy services. Finally, Scope 3 addresses initial indirect emissions or upstreams, including the acquisition and transportation of feedstock (dolomite) from the extraction quarries in Concepción to the ATOME plant. Downstream activities include GHG emissions and removals due to the use of fertilizer in Latin America's two largest crops, soybeans and sugarcane, as well as the transportation and distribution of green CAN from the ATOME plant to national and international

[iv] A range of emissions related to vehicles used in construction was assumed. The upper limit is used for a more conservative scenario.

markets, effluent treatment and final disposal of products. For comparison purposes, a scenario of the carbon footprint of CAN produced from fossil fuels is included, along with its potential direct and indirect emissions from production, energy consumption and downstream activities, such as transport and distribution from Europe to the markets of Paraguay and Brazil – see Board 3. These two frameworks for studying CAN's carbon footprint will be used to compare them and appreciate the greenhouse gas emissions avoided by the implementation of the ATOME project. The methodologies, calculations, and benchmarks used to Board 3 are compiled in the section "Methodologies and calculations used for the carbon footprint"

Board 3. Carbon footprint of the CAN production scenario

Source of Emission				GHG emissions, t CO2 eq/ t CAN	
				ATOME (Green CAN)	World (CAN Grey)
Scope 1	1.2. Emissions due to CAN production	1.2.1. Ammonia production		0.0083	1.18
		1.2.2. NA Production		0.023	1.80
		1.2.3. ANS, granulation and CAN production		-	-
		1.2.4. Worker commuting		5.4E-04	-
			Subtotal	0.032	2.98
Scope 2	2.4. Fossil fuel combustion activities (electricity generation)			-	0.13
	2.5. Fugitive emissions from fuel production			-	5.32E-06
	2.6. Renewable energy (hydro)			0.097	-
			Subtotal	0.097	0.13
Scope 3	3.1. Upstream activities	3.1.1. Emissions from the construction phase	Land Use Change	0.017	-
		3.1.2. Production of raw materials and inputs		0.44	-
		3.1.3. Transportation of raw materials and supplies (excluding Dolomite)		9.37E-04	-
		3.1.4. Transport from Dolomite to ATOME plant		3.09E-03	-
	3.2. Downstream activities	3.2.1. CO2 and N2O emissions from managed soils. Application of the CAN in agriculture		1.66	1.66
		3.2.2. CO2 removal through agricultural activity (sugarcane)		-1.48	-1.48
		3.2.3. Road transport and distribution (a) ATOME plant to the Paraguayan market (b) ATOME plant in the Brazilian market		0.0026 (a) 0.16 (b)[v]	-
		3.2.4. River/sea transport and distribution: (c) ATOME plant in the Brazilian market (d) European market to the Paraguayan market		0.018 (c)	0.074 (d)
		3.2.5. Effluent treatment		0.011	-
		3.2.6. End-of-life treatment of CAN		1.38E-04	1.38E-04
			Subtotal	0.83	0.25
			Total, t CO2-eq/t CAN	0.96	3.36
			Total, t CO2-eq/t N	3.55	12.44
			Total, t CO2-eq/year	240,000	840,000

[v] This value is used for the subtotal of Scope 3 emissions, as it represents the highest value for the "Transport and distribution of CAN by road" section.

In the same way as in the ammonia production scenario, GHG emissions during the 22 months of construction of the CAN plant were considered and separated from the CAN carbon footprint scenario (Table 3) because they are not continuous emissions during the years of operation of the plant. Emissions related to the production of construction materials, emissions from the use of machinery and vehicles, and other construction activities are accounted for and summarized in the Board 4. The methodologies, calculations and benchmarks used for the Board 4 are collected in the section "Methodologies and calculations used for the carbon footprint".

Board 4. Total Emissions During the Construction Phase of the CAN Plant

Source of Emission	GHG emissions, t CO2 eq
Materials, assembly and construction activities	11,728.2
Transmission Line	400
Emissions from vehicles and equipment used during construction	554.3[vi]
Workers' travel for the construction phase	42.74
Total, t CO2-eq	12,725.24

[vi] A range of emissions related to vehicles used in construction was assumed. The upper limit is used for a more conservative scenario.

Methodologies and calculations used for the carbon footprint

Scope 1

Direct emissions from activities owned or controlled by ATOME. These are direct emissions that occur during the production process using elements that are owned and controlled by the company, including emissions from boilers, furnaces, machinery and equipment, and fuel-using vehicles.

Source of Emission	Description	Methodology	Emissions	Reference
Grey ammonia production	The production of ammonia requires one source of nitrogen (N2) and one source of hydrogen (H2). Nitrogen is obtained from the air through cryogenic distillation, while hydrogen is primarily derived from natural gas (mainly methane, CH4). Since the industry is predominantly dependent on natural gas, the methodology and emission sources are based on the production of ammonia from natural gas. Emissions are estimated from total fuel requirements or values derived from estimates of total fuel requirements used in NH3 production. Energy requirements from fuels are not accounted for separately, so the value obtained from emissions from the energy sector must be corrected by eliminating it. The parameters and assumptions used for the calculation are as follows: [1] • AP = 100,000 t NH3/year • FR = 42.5 GJ/t of NH3 produced[VII] • CCF = 21.0 kg C/GJ • FOC = 1 • R_{CO2} = 0 t CO2 recovered for later use in a secondary process	CO2 emissions from ammonia production: $E_{CO2} = AP \cdot FR \cdot CCF \cdot FOC \cdot 44/12 - R_{CO2}$ Where: E_{CO2} = CO2 emissions, kg/year AP = Ammonia production, t NH3/year FR = Fuel requirement per unit of production, GJ/ton of ammonia produced CCF = Fuel Carbon Content Factor, kg C/GJ FOC = Fuel Carbon Oxidation Factor, Fraction R_{CO2} = CO2 recovered for further use in a secondary process (e.g. urea production), kg	E_{CO2} = 327,300 t CO2/year This value is corrected by eliminating the emissions generated by electricity consumption (Scope 2 – purchased electricity) E_{CO2} (corrected) = 295,455.4 t CO2/year	2006 IPCC guidelines for national greenhouse gas inventories. Volume 3: Industrial Processes and Product Use
Green ammonia production	The production of green ammonia is based on the replacement of the hydrogen source used in the process with hydrogen produced by electrolysis of water using renewable energy sources. In the case of the ATOME project, the hydrogen will be produced by electrolysis of treated and demineralized water from the Paraguay River with zero CO2 emissions. Certain sources of inert gas emissions such as O2, H2O (steam), N2, originate from various sources within the production process, in addition to occasional CO2 and NOx emissions from the operation of diesel emergency generators and auxiliary flares. The	The data and results obtained from the specific studies of the 120 MW Villeta project provided by the company in charge of the Engineering Design (URBAS) were used. Ammonia Secondary Torch: 29,626 kg/h*500 h/year = 14,813 t/year (composed mostly of N2) • 0.076 % (w/w) CO2 = 11.2 t CO2/year • 0.042 % (w/w) CO = 6.2 t CO2/year • 7.7e-03 % (w/w) NOx = 1.14 t NOx/year	Total Annual Emissions: • CO2 = 575.95 t CO2/year • CO = 124.05 t CO/year • NOx = 5.04 t NOx/year Total annual CO2-eq emissions: • CO2-eq = 575.95 t CO2/year*(1) + 5.04 t NOx/year*(296) = 2,067.8 t CO2-eq/year	FEED of the project carried out by URBAS/Casale

[VII] Information on fuel type, carbon content factor, and carbon oxidation factor is not available. Therefore, it is considered good practice to use the average value for partial oxidation as presented in Table 3.1, Volume 3: Industrial Processes and Product Use [1]

<table>
<tr><th>Source of Emission</th><th>Description</th><th>Methodology</th><th>Emissions</th><th>Reference</th></tr>
<tr>
<td></td>
<td>following table presents a summary of emissions from stationary sources within the ATOME project.
<table>
<tr><td></td><td>Quemador + pilotos C3H8</td><td>Quemador + pilotos C3H8</td><td>Dos pilotos (Standby)</td><td>Dos pilotos (Standby)</td></tr>
<tr><td>Componente</td><td>Caudal más. kg/h</td><td>Caudal vol. Nm³/h</td><td>Caudal más. kg/h</td><td>Caudal vol. Nm³/h</td></tr>
<tr><td>CO2</td><td>22.38</td><td>11.40</td><td>22.38</td><td>11.40</td></tr>
<tr><td>H2O</td><td>6,664.22</td><td>8,288.75</td><td>12.22</td><td>15.19</td></tr>
<tr><td>N2</td><td>22,920.34</td><td>18,340.14</td><td>89.34</td><td>71.49</td></tr>
<tr><td>NOx</td><td>2.28</td><td>1.70</td><td>0.010</td><td>0.008</td></tr>
<tr><td>CO</td><td>12.42</td><td>9.93</td><td>0.055</td><td>0.044</td></tr>
<tr><td>Inquemados</td><td>4.70</td><td>6.17</td><td>0.021</td><td>0.011</td></tr>
<tr><td>TOTAL</td><td>29,626.34 kg/h</td><td>26,658.09 Nm³/h</td><td>124.026 kg/h</td><td>98.143 Nm³/h</td></tr>
</table>
<table>
<tr><th>Descripción</th><th>Coordenadas</th><th>ncionamier</th><th>Altura</th><th>Vs</th><th>Caudal salida</th><th></th><th>Temp. Salida</th><th>Presión salida</th><th>Diámetro chimenea</th><th>Composición (%Vol)</th></tr>
<tr><td>Aux boiler exhaust stack</td><td>429539, 7156451</td><td>EVENTUAL <500h/año</td><td>25</td><td>22,6</td><td>841</td><td>1078</td><td>555</td><td>ambiente</td><td>200</td><td>71% N2, 9,5% H2O, 9% CO2, 8,5% CO, 2% Ar <2500 mg/Nm3 NOx, <25 mg/Nm3 PM, <450 mg/Nm3 CO, <125 mg/Nm3 HC, SO2 dependerá de contenido S en diesel</td></tr>
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<tr><th>Ítems</th><th>Coordenadas</th><th></th><th>Condición</th><th>altura</th><th>Velo.</th><th>Caudal salida</th><th></th><th>Temp. Salida</th><th>Presión salida</th><th>Diámetro Chimenea</th><th>Composición (%Vol)</th></tr>
<tr><td></td><td>X</td><td>Y</td><td></td><td>(m)</td><td>(m/s)</td><td>(Nm3/h)</td><td>(kg/h)</td><td>(ºC)</td><td>(bar)</td><td>(mm)</td><td></td></tr>
<tr><td>Grupo Diesel emergencia</td><td>429598</td><td>7156325</td><td>Eventual <500h/año</td><td>3,5</td><td>21,8</td><td>1244</td><td>1594</td><td>574</td><td>ambiente</td><td>250</td><td>71% N2; 9,5%H2O; 9%CO2; 8,5%CO; 2%Ar; <2500mg/Nm3NOx; <25mg/Nm3MP; <450mg/Nm3CO; <125mg/Nm3HC; SO2 en P. do S do</td></tr>
<tr><td>Grupo Diesel antincendios</td><td>4295400</td><td>7156363</td><td>Eventual promedio 0h/año</td><td>3,5</td><td>22,6</td><td>841</td><td>1078</td><td>555</td><td>ambiente</td><td>200</td><td></td></tr>
<tr><td>Venteo H2 Planta electrólisis B1</td><td>429452</td><td>7156517</td><td>Eventual <500h/año</td><td>45</td><td>17,3</td><td>20000</td><td>1800</td><td>40</td><td>30</td><td>125</td><td></td></tr>
<tr><td>Venteo O2 Planta electrólisis B1'</td><td>429565</td><td>7156398</td><td>Continuo</td><td>45</td><td>16,2</td><td>12000</td><td>16200</td><td>40</td><td>30</td><td>100</td><td>98,5%O2; 1,5%H2; 4g/Nm3 de H2O y 1mg/Nm3/g KOH</td></tr>
<tr><td>Venteo H2 Planta electrólisis B2</td><td>429452</td><td>7156517</td><td>Eventual<500h/año</td><td>45</td><td>17,3</td><td>20000</td><td>1800</td><td>40</td><td>30</td><td>125</td><td></td></tr>
<tr><td>Venteo O2 Planta electrólisis B2'</td><td>429565</td><td>7156398</td><td>Continuo</td><td>45</td><td>16,2</td><td>12000</td><td>16200</td><td>40</td><td>30</td><td>100</td><td>98,5%O2; 1,5%H2; 4g/Nm3 de H2O y 1mg/Nm3/g KOH</td></tr>
<tr><td>Salida aire enriquecido O2 (B3)</td><td>429618</td><td>7156378</td><td>Continuo</td><td>7,5</td><td>19,3</td><td>10000</td><td></td><td>ambiente</td><td>5</td><td>200</td><td>Aire ambiente enriquecido en O2 (90% O2; 10% N2; <5%Ar; y trazas de CO2)</td></tr>
<tr><td>Venteo gas proceso NH3 (B4)</td><td>429667</td><td>7156421</td><td>Continuo</td><td>35</td><td>7,1</td><td>8</td><td>5</td><td>30</td><td>ambiente</td><td>20</td><td>53% H2; 43% N2; 2%Ar; y 0,3% de H2O</td></tr>
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</td>
<td>Ammonia Main Torch:
29,626 kg/h*500 h/year = 14,813 t/year (composed mostly of N2)
• 0.076 % (w/w) CO2 = 11.2 t CO2/year
• 0.042 % (w/w) CO = 6.2 t CO2/year
• 7.7e-03 % (w/w) NOx = 1.14 t NOx/year
Ammonia Main and Secondary Torch Pilot Flame:
2*124 kg/h*8,260 h/year = 2,048 t/year
• 18 % (w/w) CO2 = 368.6 t CO2/year
• 0.044 % (w/w) CO = 0.9 t CO/year
• 8.06-03 % (w/w) NOx = 0.16 t NOx/year
Diesel Emergency Generator:
1,244 Nm3/h*500 h/year = 622,000 Nm3/year
• 9 % (v/v) CO2 = 110.05 t CO2/year
• 8.5 % (v/v) CO = 66.15 t CO/year
• <2500 mg/Nm3 NOx = 1.55 t NOx/year
Auxiliary boiler exhaust chimney:
1,078 kg/h*500 h/year = 539 t/year
• 9 % (v/v) CO2 = 74.9 t CO2/year
• 8.5 % (v/v) CO = 44.6 t CO/year
• <2500 mg/Nm3 NOx = 1.05 t NOx/year</td>
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<td>Nitric acid (AN) production</td>
<td>Considering ATOME's nitric acid (AN) plant with dual-pressure production technology, where absorption takes place at a higher pressure than the oxidation stage of NH3 and nitrogen gases, together with a NOx reduction system in the tail gas, the following values are obtained for use in calculations:
• EF = 2.5 kg N2O/t AN produced with dual medium/high pressure technology and NOx reduction technology</td>
<td>N2O emissions from AN production
$E_{N2O} = EF \cdot NAP$
Where:
E_{NO2} = N2O emissions, kg/year
EF = Emission of N2O factor (default), kg NO2/t AN produced</td>
<td>New AN plants (using the emission factor)
$EN2O$ = 380.6 t N2O/year
$ECO2$ = 380.6 t N2O/year
*(296) = 112,664 CO2-eq/year[IX]</td>
<td>2019 IPCC guidelines for national greenhouse gas inventories.</td>
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</table>

[IX] 1 kg N2O = 296 kg CO2-eq; 1kg CH4 = 28 kg CO2-eq. Source: 100-year GWPs from IPCC Fourth Assessment Report (AR4), 2007

Source of Emission	Description	Methodology	Emissions	Reference
	• NAP = 435 t/day * 365 day/year = 152,250 t/year In addition, data provided by the URBAS FEED are used: • Tail gas pre-treated in the NOx reduction system: 58,212 Nm3/h (note[VIII]) • Composition: < 20 ppmv N2O, < 5 ppmv NH3, <10 ppmv NOx For comparison, emission factors are used from plants currently in operation, such as the Borealis plant in Stenungsund, Sweden, which began operating in 1950. = 10 kg N$EF_{2O/t}$ AN (Old AN plants)	NAP = AN production, t/year	Ancient NA plants (using the emission factor) *EN2O* = 1,522.5 t N2O/year *ECO2* = 1,522.5 t N2O/year *(296) = 450,660 t CO2-eq/year ATOME Plant (using FEED data) *EN2O* = 19.22 t N2O/year *ECO2* = 19.22 t N2O/year *(296) = 5,689 t CO2-eq/year	Volume 3 – Industrial Processes and Product Use
Production of SNA and CAN	According to the 2006 IPCC Guidelines and the EMEP/CORINAIR Emission Inventory Guide, NOx, VOC, VOC and SOx emissions from ammonium nitrate solution (ANS) production and calcium ammonium nitrate (CAN) granulation are not expected to be significant. However, emissions from ammonium nitrate production plants typically consist of particulate matter (ammonium nitrate and coating materials), ammonia, and nitric acid. Ammonia and nitric acid are mainly emitted from the formation of solutions and granulators. Table 8.3-2 (English Units). EMISSION FACTORS FOR PROCESSES IN AMMONIUM NITRATE MANUFACTURING PLANTS[a] EMISSION FACTOR RATING: A (except as noted) Particulate Matter: Uncontrolled (lb/ton Of Product); Particulate Matter: Controlled[b] (lb/ton Of Product); Ammonia: Uncontrolled[c] (lb/ton Of Product); Nitric Acid: Controlled[d] (lb/ton Of Product) Neutralizer: 0.09 - 8.6[e]; 0.004 - 0.43[g]; 0.86 - 36.02[g]; 0.084 - 2[e,g] Evaporation/concentration operations: 0.52; ND; 0.54 - 33.4; ND Solids formation operations High density prill towers: 3.18; 1.20; 57.2; ND Low density prill towers: 0.92; 0.52; 0.26; ND Rotary drum granulators: 392; 0.44; 59.4; ND Pan granulators: 2.68; 0.04; 0.14; ND Coolers and dryers[f] High density prill coolers: 1.6; 0.02; 0.04; ND Low density prill coolers: 51.6; 0.52; 0.30; ND Low density prill dryers: 114.4; 1.14; 0 - 3.18; ND Rotary drum granulator coolers: 16.2; 0.16; ND; ND Pan granulator coolers: 56.6; 0.36[g]; ND; ND Coating operations[g]: ≤ 4.0[g]; ≤ 0.04[g]; NA; NA Bulk loading operations[g]: ≤ 0.02[g]; ND; NA; NA [a] Some ammonium nitrate emission factors are based on data gathered using a modification of EPA Method 5 (See Reference 1). ND = no data. NA = not applicable. [b] Based on the following control efficiencies for wet scrubbers, applied to uncontrolled emissions: neutralizers, 95%; high density prill towers, 62%; low density prill towers, 43%; rotary drum granulators, 99.9%; pan granulators, 98.5%; coolers, dryers, and coaters, 99%. [c] Given as ranges because of variation in data and plant operations. Factors for controlled emissions not presented due to conflicting results on control efficiency. [d] Based on 95% recovery in a granulator recycle scrubber. [e] EMISSION FACTOR RATING: B. [f] Factors for coolers represent combined precooler and cooler emissions, and factors for dryers represent combined predryer and dryer emissions. [g] Fugitive particulate emissions arise from coating and bulk loading operations.	CAN Production Emissions: • Without the application of the BATs (Best available technology): [5] Air emissions can be up to 200 mg/particulate matter (PM) and NH3 (2 kg/t of product) • Application of BAT: Production of NA when insoluble solids are present, including the production of CAN: ○ 50 mg PM/Nm3 ○ 50 mg NH3/Nm3 ○ Production of NA when insoluble solids are present, including the production of CAN: ○ Granulation and prill towers with molten NA particles: 15 mg PM/Nm3 and 10 mg NH3/Nm3 ○ Other individual emission points: 30 mg PM/Nm3 and 50 mg NH3/Nm3 ATOME Emissions • SNA Plant ○ Flow rate 220,000 Nm3/h ○ Composition <50 mg/Nm3, <50mg/Nm3 • SNA Plant	*ECO2* = 0 t CO2-eq/year	https://www3.epa.gov/ttnchie1/ap42/ch08/final/c08s03.pdf AP-42, CH 8.3: Ammonium Nitrate

[VIII] Normal cubic meter per hour. Refers to normal conditions of 0°C and 1 atm (1 atmosphere = 101,325 kPa)

Source of Emission	Description	Methodology	Emissions	Reference
	According to the information provided by SNA/CAN plants in Europe, it is estimated that N emissions [4]$_{2O\ from\ nitric\ acid\ production\ accounted\ for\ between\ 60\%\ and\ 78\%\ of\ total\ CO2\ emissions}$-eq from the production of SNA/CAN. It is estimated that the production of 220,750 t/year of 95% SNA and the production of 250,000 t/year of CAN without greenhouse gas emissions into the atmosphere are estimated, according to URBAS/Casale.	○ Flow rate t.b.d ○ Dust content <50 mg/Nm3		
Employee travel for plant operation	The CO2, CH4 and N2O emissions of the transport contracted for the operation of the plant are estimated using the same technologies applied to the mobile sources. The following assumptions are used to calculate emissions: • For ammonia production, 50 contract people directly related to the operational process will be needed, and for producing CAN, an additional 40 contract people will be needed. • Preliminarily, the connection between the Asunción Bus Terminal (Ave Fernando de la Mora, Asunción) and the central one is estimated through the Villeta-Alberdi Route, with intermediate stops to be defined in later phases. The travel distance is 55 km, and another 55 km for the return, totaling 110 km per full trip. • Assuming it runs 24/7 for 12 months of the year, there are 365 trips per vehicle per year. The total distance per vehicle is 110 km/trip * 365 trips per year = 40,150 km per year per vehicle. • In the case of buses, it is estimated that there are 30 seated passengers, requiring 2 buses for ammonia production and 2 additional buses for CAN production expansion at the ATOME plant. • Average fuel consumption is 30 litres per 100 km. The emission factors (FEs) for diesel vehicles are: • *EFCO2* = 74,100 kg/TJ • *EFCH4* = 9.5 kg/TJ • *EFN2O* = 12 kg/T	GHGs emitted by the transport of raw materials. $$Emissions = \sum (Fuel_{ij} \cdot EF_{ij})$$ Where: *Transmissions* = GHG (kg) *Fueli,j* = fuel consumed (TJ) *EFi,j* = emission factor (kg/TJ) i = type of vehicle/machinery j = fuel type Calculation of the estimated fuel for the transport of raw materials. $$Estimaded\ fuel = \sum_{i,j,t} [Vehicle_{i,j,t} \cdot Distance_{i,j,t} \cdot Consumption_{i,j,t}]$$ Where: *Estimated fuel* = estimated total fuel consumption based on distance traveled (KRV) data *Vehiclesi,j,t* = Number of type i vehicles using type j fuel on type $t\ road$ *Distancei,j,t* = Annual kilometres travelled by type i vehicles using type j fuel on type $t\ road$ (km) *Consumptioni,j,t* = average fuel consumption (L/km) of type i vehicles using type j fuel on type $t\ road$ i = type of vehicle (e.g. car, bus) j = fuel type (e.g. gasoline, diesel, natural gas, LPG) t = type of road (e.g. urban, rural)	a) Ammonia Production: *Estimated fuel* = 24,090 L/year *Fuel* = 0.86 TJ/year[X] Emissions: • CO2 = 64.01 t/year • CH4 = 8.17e-03 t/year • N2O = 0.010 t/year *E* = 64.01*(1) + 8.17e-03*(28) + 0.010*(296) = 67.2 t CO2-eq/year 1. CAN Production: *Estimated fuel* = 48,180 L/year *Fuel* = 1.73 TJ/year Emissions: • CO2 = 128.2 t/year • CH4 = 0.016 t/year • N2O = 0.021 t/year *E* = 128.2*(1) + 0.016*(28) + 0.021*(296) = 134.86 t CO2-eq/year	2006 IPCC guidelines for national greenhouse gas inventories. Volume 2 - Energy: Mobile Combustion

[X] 35.86 MJ/L

Scope 2

Indirect emissions from purchased services. Scope 2 emissions are indirect emissions originating from the generation of purchased electric, heating, cooling, gas, steam and purchased electric vehicle services.

Source of Emission	Description	Methodology	Emissions	Reference
Activities that involve the burning of fossil fuels (generation of electricity from stationary combustion)	Ammonia and CAN production plants in European countries, the main consumers and producers of CAN, consume electricity derived from the burning of fossil fuels. Emissions resulting from electricity consumption shall be accounted for according to the quantity and type of fuel used. Using the following estimate of the distribution of electricity consumption at the ATOME plant: • H2 plant, 110 MW • Air Separation Unit, 2 MW • NH3 plant, 8 MW • AN, SNA and CAN plant, 1.4 MW • Turbine, -2.9 MW[XI] • Balance of Plant, 6 MW It can be assumed that European plants do not use electrolysers for hydrogen production, which reduces the electricity consumption of the hydrogen plant to 2 MW (mainly for operation with compressors). When adding the other demands, the total power required amounts to 18 MW. Therefore: • *Fuel consumption* = 18 MW*365 day/year * 24 h/day = 157,680 MWh/year or 567.64 TJ/year for the regular operation of an ammonia and CAN plant. Default emission factors for stationary combustion in energy industries (kg GHG/TJ). Natural gas: • *EFCO2,fuel*= 56,100 kg CO2/TJ • *EFCH4,fuel*= 1 kg CH4/TJ	Total GHG emissions $Emissions_{GHG} = \sum_{fuel} Emission_{GHG,fuel}$ GHG emissions from stationary combustion $Emissions_{GHG,fuel} = Consumption_{fuel} \cdot EF_{GHG,fuel}$ Where: *EmissionsGHG,fuel*= Emissions of a given GHG by fuel type, kg GHG/year *Consumptionfuel* = Amount of fuel burned, TJ/year *EFGHG,fuel* = default emission factor of a given GHG per fuel type, kg GHG/TJ	Annual greenhouse gas emissions from the consumption of fuels for electricity generation • *ECO2,fuel* = 31,844.6 t CO2/year • *ECH4,fuel* = 0.56 t CH4/year • *EN2O,fuel* = 0.056 t N2O/year Total annual CO2-eq emissions from the consumption of fuels for electricity generation. *EmissionsGHG* = 31,884.6*(1) + 0.56*(28) + 0.056*(296) = 31,916.8 t CO2-eq/year	2006 IPCC guidelines for national greenhouse gas inventories. Volume 2 - Energy: Stationary Combustion

[XI] Within the process of the nitric acid plant, it is possible to use the produced water vapor for the generation of electricity and supply the electrical components of the plant, resulting in the self-supply of electrical energy

Source of Emission	Description	Methodology	Emissions	Reference
	• *EFN2O,fuel*= 0.1 kg N2O/TJ			
Fugitive emissions from fossil fuel production	The term "fugitive emissions" is broadly applied, referring to all greenhouse gas emissions originating from the natural gas production and processing system (from the infrastructure necessary to produce, harvest, process, or refine and bring natural gas to market). The most important sources of fugitive emissions include equipment leaks, evaporation and losses from discharge, venting, burning, incineration, and accidental releases. The methodology consists of applying default emission factors corresponding to a representative parameter of activity (usually production) for each segment or subcategory applicable to the natural gas industry of the country/region. More than 40% of Europe's natural gas comes from Russia. To produce 250,000 t CAN/year, 157,680 MWh/year are required, which is equivalent to 13.47e06^{m3} per year[XII] The average emission factors for the most significant industry activities and segments are considered: • Gas production, t/1e06 m3: Fugitive EFCO2 = 4.8e-05, EFCH4 = 1.34e-03, EFCOVDM = 3.2e-04; Torch: EFCO2 = 1.2e-03, EFCH4 = 7.6e-07, EFCOVDM = 6.2e-04, EFNOx = 2.1e-08. • Gas processing, t/1e06 m3: Fugitive EFCO2 = 1.66e-04, EFCH4 = 5.9e-04, EFCOVDM = 3.05e-04; Torch: EFCO2 = 3e-03, EFCH4 = 2.0e-06, EFCOVDM = 1.6e-06, EFNOx = 3.3e-08. • Gas transport and storage, t/1e06 m3: Fugitive EFCO2 = 8.8e-04, EFCH4 = 2.73e-04, EFCOVDM = 7.0e-06; Venting EFCO2 = 3.1e-06, EFCH4 = 4.6e-04, EFCOVDM = 4.6e-06; Storage: EFCO2 = 1.1e-07, EFCH4 = 2.5e-05, EFCOVDM = 3.6e-07. • Gas distribution, t/1e06 m3: EFCO2 = 5.1e-05, EFCH4 = 1.1e-03, EFCOVDM = 1.6e-05.	Estimation of fugitive emissions from an industry segment. $E_{gas,segment} = A_{segment} \cdot EF_{gas,segment}$ Where: *Egas, segment* = annual GHG emission factor, t/year *EFgas, segment* = GHG emission factor, t/activity *Asegment* = type of activity (e.g. annual production of m3) Total Fugitive Emissions from Industries $E_{gas} = \sum_{industry} E_{gas,industry}$	Fugitive emissions of: • Gas production, 0.46 t CO2-eq/year • Gas processing, 0.24 t CO2-eq/year • Gas transport and storage, 0.26 t CO2-eq/year • Gas distribution, 0.37 t CO2-eq/year Total Fugitive Emissions E_{gas} = 1.33 t CO2-eq/year	2019 IPCC guidelines for national greenhouse gas inventories. Volume 2 - Energy: Fugitive Emissions.
Renewable energy	Electricity generation from renewable sources generally has negligible or lower emissions, except in the case of hydropower with large reservoir storage capacity. River waters naturally emit greenhouse gases (GHGs),	GHG from hydroelectric reservoirs: $E_{CO2e}\ (t/año) = Wh \cdot EF$ Where:	E_{CO2e} = 24,228.8 t CO2-eq/year	EIB Project Carbon Footprint

[XII] Each cubic meter (m3) of natural gas corresponds to a Higher Heating Value (HHV) of 11.70 kWh.

Source of Emission	Description	Methodology	Emissions	Reference
	but the construction of reservoirs for hydropower alters carbon emission and storage, releasing CO2 and CH4 generated by the decomposition of submerged organic matter and vegetation. These gases are emitted through diffusion, boiling, and other mechanisms. Hydropower plants with power density indicator, PDI (reservoir capacity/area) in a range of 4 and 10 W/m2 can use current methodologies, with an average emission factor of 24 g CO2-eq/kWh for reservoir emissions[XIII]. The methodology applied is based on the use of emission factors and installed capacity. In this case, the energy required for the normal operation of the ATOME plant will be used. The data used are as follows: • Wh = 120 MW * 24 h/day * 365 day/year = 1,051,200 MWh/year • EF = 24 g CO2-eq/kWh = 0.024 t CO2-eq/MWh Itaipu, with an installed capacity of 14,000 MW, has a reservoir with an area of 1.3e-9 m2 (135,000 ha) [XIV]and its Power Density Index (PDI) is 10.37 W/m2	E_{CO2e} $(t/año)$ = Annual GHG emissions, t/year Wh = Energy produced annually, MWh/year EF = Emission factor, t CO2-eq/MWh		Methodologies – Methodologies for the assessment of project greenhouse gas emissions and emission variations EIB Project Carbon Footprint Methodologies

Scope 3

- Upstream activities: Materials directed to the factory, goods and services purchased, waste generated in operations, transportation and distribution, business travel, employee travel, leased assets, fuel and energy related activities, capital goods.
- Downstream activities: Transportation and distribution, processing of products sold, use of products sold, end-of-life treatment, leased assets, franchising, investments.

Source of Emission		Description	Methodology	Emissions	Reference
Upstream activities: indirect greenhouse gas emissions related to purchased	Emissions from the Construction Phase – Land	CO2 emissions from land-use changes are mainly due to deforestation and land conversion for agriculture, urban areas, urbanization, roads, etc. When large tracts of tropical forests are cleared, the land is often transformed into less productive grasslands with considerably reduced capacity for carbon storage. In the case of ATOME, with 30 hectares of land acquired for the installation of the plant, this does not constitute a significant contribution. In addition, the following methodology is presented which provides a simplified approach to estimating emissions on the basis of cleared area and IPCC default values for above-ground and groundwater carbon stocks in various vegetation types.	The annual loss of carbon in biomass due to disturbances is calculated using the equation: $L_{disturbance} = \{A_{disturbance} \cdot B_W \cdot (1+R) \cdot CF \cdot fd\}$ Where: *L disturbance* = Annual carbon loss, t C/year *Adisturbance* = Area affected by disturbances, ha/year *Bw* = average aboveground biomass of the disturbed land area, t dm/ha	$E_{disturbance}$ = 4,290 t CO2/year $E_{organic}$ = 40.8 t CO2/year Total annual CO2 emissions due to land-use change *E* = 4,330.8 t CO2/year	https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-08-v3.pdf

[XIII] It is stated that "The IPCC states that hydropower has an average greenhouse gas (GHG) emission intensity of 24 g CO_2-eq/kWh" Hydropower.org

[XIV] https://www.itaipu.gov.py/es/sala-de-prensa/itaipu-en-numeros

Source of Emission		Description	Methodology	Emissions	Reference
goods and services	Use Change	• *Adisturbance* = *A* = 30 ha • Soil domain classification: Humid subtropical, body weight = 220 t dm/ha. • *FD* = 1 (plant installation replaces all biomass) • *CF* = 0.5 t C/t d.m. • *R* = 0.3 t d.m. of groundwater biomass (t d.m. aboveground biomass)$^{-1}$ • *EFc* = 1.36 t CO2/ha-year for tropical climate soils	*R* = Ratio of groundwater biomass to aboveground biomass, in t d.m. groundwater biomass (t d.m. aboveground biomass)$^{-1}$ *CF* = carbon fraction of dry matter, t C/t dry matter *fd* = fraction of biomass lost due to disturbances Increased CO2 emissions due to loss of biomass in existing vegetation as a result of site preparation, t CO2/year: $E_{disturbance} = L_{disturbance} \cdot \frac{44}{12}$ The annual loss of soil carbon is calculated using the equation: $L_{organic} = \sum_{c} (A \cdot EF)_c$ Where: *Lorganic* = Annual carbon loss from drained organic soils, t C/year *A* = Soil surface at climate type c, ha *EF* = Emission factor for climate type c, t C/ha-year Increased CO2 emissions due to soil carbon shift as a result of site preparation; t CO2/year. $E_{organic} = L_{organic} \cdot \frac{44}{12}$		2006 IPCC guidelines for national greenhouse gas inventories. Volume 4 - Agriculture, Forestry and Other Land Uses: Chapter: Generic Methodologies Applicable to Multiple Land Use Categories and Chapter: Forest Land Use
	Emissions from the construction stage: materials, assembl	The chosen methodology provides an approach to estimate greenhouse gas emissions from building construction activities as a function of the total area of buildings, using the concept of "embodied carbon". This concept represents the tons of greenhouse gas emissions throughout the life cycle of building materials, including extraction, manufacturing, processing, transportation, construction, disposal, assembly, and the overall life cycle. Concrete, steel, and insulation are examples of materials that contribute to embodied carbon emissions and account for more than 25% of emissions[XV,XVI,XVII] For the ATOME plant, the following buildings have been identified, as well as their estimated surface area[XVIII]:	GHG emissions over the lifetime of each building $ECO_2e(t) = \sum_{i} [AS_i \cdot (EF_i)]$ Where: *ECO2e* = Emission of greenhouse gases emitted during the life cycle of buildings, kg CO2-eq *ASi* = Building area for building type i, m2 *EFi* = Emission factor for the surface area of the type i *building*, kg/m2	Ammonia production • H2 plant, *ECO2ei* = 2,423.86 t CO2-eq • Office building, *ECO2ei* = 153 t CO2-eq • Staff building, *ECO2ei* = 141.12 t CO2-eq • Warehouse, *ECO2ei* = 447.29 t CO2-eq	2006 IPCC guidelines for national greenhouse gas inventories. Volume 1 - General Guidance and Reporting

[XV] Gao, T., Shen, L., Shen, M., Chen, F., Liu, L., Gao, L., 2015. Analysis on differences of carbon dioxide emission from cement production and their major determinants. J. Clean. Prod. 103, 160-170

[XVI] Labaran YH, Mathurb VS, Farouq MM. The carbon footprint of construction industry: A review of direct and indirect emission. J Sustain Const Mater Technol 2021; 6:3:101–115.

[XVII] Sizirici B, Fseha Y, Cho CS, Yildiz I, Byon YJ. A Review of Carbon Footprint Reduction in Construction Industry, from Design to Operation. Materials (Basel). 2021 Oct 15; 14(20):6094. doi: 10.3390/MA14206094. PMID: 34683687; PMCID: PMC8540435.

[XVIII] These values are only approximate estimates and serve only to measure the carbon footprint.

<table>
<tr><th colspan="2">Source of Emission</th><th>Description</th><th>Methodology</th><th>Emissions</th><th>Reference</th></tr>
<tr><td></td><td>y, and construction activities</td><td>

Hydrogen plant, 7,072.5 m2
Office building, 382.5 m2
Staff building, 352.8 m2
Warehouse, 1,118.23 m2
Granulation plant, 2,500 m2
Raw material storage, 2,475 m2
CAN storage, 26,950 m2.

Emission factors were obtained from Life Cycle Assessment (LCA) modelling studies based on databases of industrial buildings with different surfaces. These factors span the entire life cycle of building materials, from their manufacture to their end use or service life. For this analysis, only the following emission factors were considered, focusing on:

Production phase (including procurement of raw materials, transportation to the production plant, and manufacturing of products),
Erection/erection phase (including site preparation, construction of on-site foundations, and assembly of materials/buildings), and
Transport phase (including finished products, raw materials and machinery to/from the assembly site).

The use phase and the end-of-life phase were not considered due to the inclusion of energy and electricity consumption factors. The data covers cases of industrial buildings built in European countries where non-renewable energy sources are commonly used. The inclusion of this phase would affect the overall CO2 balance of the ATOME plant, as this phase would contribute 76% to total GHG emissions. In addition, the dismantling of the structure, which is not included in the useful life of the plant, is also contemplated.
The emission factors related to the surface area of each building in square meters were obtained from the empirical data of the reference[XIX].
<table>
<tr><td>Floor area (m^2)</td><td>1048</td><td>3000</td><td>12,720</td><td>21,910</td></tr>
<tr><td colspan="5">Carbon Footprint (CF) (tCO_{2eq})</td></tr>
<tr><td>1. Plant production</td><td>478.2</td><td>1040</td><td>4216</td><td>5370</td></tr>
<tr><td>2. On-site assembly</td><td>3.035</td><td>7.215</td><td>25.59</td><td>41.54</td></tr>
<tr><td>3. Transportation</td><td>9.974</td><td>21.64</td><td>61.32</td><td>109.0</td></tr>
<tr><td>4. Use</td><td>1,049</td><td>3,004</td><td>12,735</td><td>21,936</td></tr>
<tr><td>5. End-of-life</td><td>−24.77</td><td>−51.87</td><td>−179.9</td><td>−367.8</td></tr>
<tr><td>Total</td><td>1516</td><td>4021</td><td>16,858</td><td>27,089</td></tr>
</table>
</td><td>i= Type of building</td><td>ECO2-eq = 3,165.27 t CO2-eq

Production of AN, SNA and CAN

Granulation plant, ECO2ei = 890.71 t CO2-eq
Feedstock storage, ECO2ei = 881.8 t CO2-eq
CAN storage, ECO2ei = 6,790.44 t CO2-eq

ECO2-eq = 11,728.2 t CO2-eq</td><td></td></tr>
<tr><td></td><td>Transmission Line</td><td>The construction of transmission line infrastructure can lead directly to GHG emissions due to factors such as fuel consumption (gasoline, diesel, etc.) and indirectly through construction materials (cement, steel, etc.) and electrical equipment (cables, transformers, suspension clamp fittings, etc.).</td><td>Greenhouse gas emissions associated with the construction of transmission line infrastructure
$E = EF \times AD$
Where:
E = GHG emissions, t CO2-eq</td><td>E = 159.6 t CO2-eq</td><td>Wei, W., Wang, M., Zhang, P. et al. A 2015 inventory of embodied</td></tr>
</table>

[XIX] Bonamente, E.; Cotana, F. Carbon and Energy Footprints of Prefabricated Industrial Buildings: A Systematic Life Cycle Assessment Analysis. Energies 2015, 8, 12685-12701. https://doi.org/10.3390/en81112333

Source of Emission		Description	Methodology	Emissions	Reference
		In similar large-scale projects, such as the ATOME project, it is observed that emissions indirectly related to materials account for 75% of total emissions, 12% for installation and engineering, and 15% for additional services. Among the construction materials used, steel products for the production and erection of towers, as well as transmission cables, are the largest contributors to indirect emissions, at 59% and 21%, respectively. The emission factor to be used was obtained from an inventory of transmission line projects with similar characteristics to the ATOME project. The following considerations were used for the breakdown of project-related emissions: • Project Land Type: Flat Land • Project voltage: The transmission infrastructure for the project is 220 kV • Transmission Line Circuit Style: There are two types of transmission lines for all voltage classes: single circuit and double circuit. The first option was chosen because of its common use in projects. • Transmission line length: The distance between the Buey Rodeo and Atome substations is < 1 km. The emission factor considering these characteristics is *EF* = 159.6 t CO2-eq/km. Other reports indicate that emissions related to 220 kV transmission line projects have an emission factor of 190 t CO2-eq/km[XX].	*EF* = Emission factor, t CO2-eq/km *AD* = Activity data, km		carbon emissions for Chinese power transmission infrastructure projects. Sci Data 7, 318 (2020). https://doi.org/10.1038/s41597-020-00662-4
	Emissions from vehicles and equipment used during construction	CO2, CH4 and N2O emissions from off-road vehicles and machinery are estimated using the same technologies applied to mobile sources. Types of engines that are typically used include compression-ignition (diesel) engines, spark-ignition (gasoline) engines, 2-stroke engines, and 4-stroke gasoline engines. The following assumptions are made: • A fleet of 25 trucks for transporting material for filling, with a working duration of 40 days, making 8 round trips per truck per day, with total trips equal to 7750. The backfill material will be transported from a quarry in Surubi'y to the plant via the Villeta-Alberdi Route (15 km). • The engine types are compression-ignition (diesel), with an average consumption of 40 L per 100 km. • Emissions are estimated using predetermined fuel-specific emission factors, as shown in the table below: *EFCO2* = 74,100 kg/TJ, *EFCH4* = 1.67 kg/TJ, *EFN2O* = 14.3 kg/TJ	<u>Emissions emitted during the construction and commissioning period of the plant:</u> $$Emissions = \sum (Fuel_{ij} \cdot EF_{ij})$$ Where: *Emissions* = GHG emissions (kg) $Fuel_{ij}$ = Fuel consumed (TJ) EFi,j = Emission factor (kg/TJ) i = Type of vehicle/machinery j = Fuel type <u>Calculation of the estimated fuel for the construction and commissioning period of the plant:</u> $$Estimated\ fuel = \sum_{i,j,t} [Vehicle_{i,j,t} \cdot Distance_{i,j,t} \cdot Consumption_{i,j,t}]$$ Where:	<u>Trucks for backfilling (40 days):</u> *Estimated fuel* = 96,000 L *Fuel* = 3.44 TJ[XXI] *Emissions:* • CO2 = 254.9 t • CH4 = 5.74e-03 t • N2O = 0.049 t Total Emissions: *E* = 254.9*(1) + 5.74e-03*(28) + 0.049*(296) = 269.56 t CO2-eq <u>Container Transport Trucks (Estimated Trips Used):</u> *Estimated fuel* = 2700 L *Fuel* = 0.096 TJ *Emissions:* • CO2 = 239.15 t • CH4 = 0.030 t	IPCC guidelines for 2019 national greenhouse gas inventories. Volume 2 – Energy: Mobile Combustion

[XX] (PDF) Embodied greenhouse gas emissions from building China's large-scale power transmission infrastructure (researchgate.net)

[XXI] 35.8 MJ/L

Source of Emission	Description	Methodology	Emissions	Reference
	CUADRO 3.3.1 **FACTORES DE EMISIÓN POR DEFECTO PARA LAS FUENTES Y MAQUINARIA MÓVILES TODO TERRENO [a]** CO_2 | CH_4 [b] | N_2O [c] **Fuente todo terreno** | **Por defecto (kg/TJ)** | **Inferior** | **Superior** | **Por defecto (kg/TJ)** | **Inferior** | **Superior** | **Por defecto (kg/TJ)** | **Inferior** | **Superior** Diesel Agricultura | 74 100 | 72 600 | 74 800 | 4,15 | 1,67 | 10,4 | 28,6 | 14,3 | 85,8 Silvicultura | 74 100 | 72 600 | 74 800 | 4,15 | 1,67 | 10,4 | 28,6 | 14,3 | 85,8 Industria | 74 100 | 72 600 | 74 800 | 4,15 | 1,67 | 10,4 | 28,6 | 14,3 | 85,8 Hogares | 74 100 | 72 600 | 74 800 | 4,15 | 1,67 | 10,4 | 28,6 | 14,3 | 85,8 Motor de 4 tiempos a gasolina Agricultura | 69 300 | 67 500 | 73 000 | 80 | 32 | 200 | 2 | 1 | 6 Silvicultura | 69 300 | 67 500 | 73 000 | | | | | | Industria | 69 300 | 67 500 | 73 000 | 50 | 20 | 125 | 2 | 1 | 6 Hogares | 69 300 | 67 500 | 73 000 | 120 | 48 | 300 | 2 | 1 | 6 Motor de 2 tiempos a gasolina Agricultura | 69 300 | 67 500 | 73 000 | 140 | 56 | 350 | 0,4 | 0,2 | 1,2 Silvicultura | 69 300 | 67 500 | 73 000 | 170 | 68 | 425 | 0,4 | 0,2 | 1,2 Industria | 69 300 | 67 500 | 73 000 | 130 | 52 | 325 | 0,4 | 0,2 | 1,2 Hogares | 69 300 | 67 500 | 73 000 | 180 | 72 | 450 | 0,4 | 0,2 | 1,2 CO2, CH4 and N2O emissions from heavy-duty trucks are estimated using the same technologies applied to mobile sources. The following assumptions are used to calculate emissions: • A fleet of 5 heavy trucks is used to transport containers with imported goods. The operation is intermittent over 5 months, depending on arrivals at the ports of Villeta. For every arrival, there are 20 truck trips, for a total of 450 trips. These trips are to receive imported goods, traveling from Puerto Terport to the plant through the Villeta-Alberdi Route (15 km). • Another set of at least 5 truck trips per day from various locations within Paraguay for 10 months is considered. The travel distance for each trip is estimated within a range of 15 to 600 km. • The engines are spark-ignition and compression-ignition diesel engines, with an average fuel consumption of 40 L per 100 km. • Emissions are estimated using the default emission factors for diesel engines, as shown in the table below. *EFCO2* = 74,100 kg/TJ, *EFCH4* = 9.5 kg/TJ, *EFN2O* = 12 kg/TJ **CUADRO 3.2.1** **FACTORES DE EMISIÓN DE CO_2 POR DEFECTO DEL TRANSPORTE TERRESTRE Y RANGOS DE INCERTIDUMBRE [a]** **Tipo de combustible** | **Por defecto (kg/TJ)** | **Inferior** | **Superior** Gasolina para motores | 69 300 | 67 500 | 73 000 Gas/Diesel Oil | 74 100 | 72 600 | 74 800 Gases licuados de petróleo | 63 100 | 61 600 | 65 600 Queroseno | 71 900 | 70 800 | 73 700 Lubricantes [b] | 73 300 | 71 900 | 75 200 Gas natural comprimido | 56 100 | 54 300 | 58 300 Gas natural licuado | 56 100 | 54 300 | 58 300 Fuente: Cuadro 1.4 del capítulo Introducción del Volumen Energía. Notas: [a] Los valores representan el 100 por ciento de oxidación del contenido de carbono del combustible. [b] Véase el Recuadro 3.2.4 Lubricantes en la combustión móvil para obtener una orientación acerca de los usos de los lubricantes. **CUADRO 3.2.2** **FACTORES DE EMISIÓN POR DEFECTO DE N_2O Y CH_4 DEL TRANSPORTE TERRESTRE Y RANGOS DE INCERTIDUMBRE [a]** **Tipo de combustible / Categoría representativa de vehículo** | CH_4 (kg/TJ) | | | N_2O (kg/TJ) | | Por defecto | Inferior | Superior | Por defecto | Inferior | Superior Gasolina para motores – sin controlar [b] | 33 | 9,6 | 110 | 3,2 | 0,96 | 11 Gasolina para motores – catalizador de oxidación [c] | 25 | 7,5 | 86 | 8,0 | 2,6 | 24 Gasolina para motores – vehículo para servicio ligero con poco kilometraje, modelo 1995 o más nuevo [d] | 3,8 | 1,1 | 13 | 5,7 | 1,9 | 17 Gas / Diesel Oil [e] | 3,9 | 1,6 | 9,5 | 3,9 | 1,3 | 12 Gas natural [f] | 92 | 50 | 1 540 | 3 | 1 | 77 Gas licuado de petróleo [g] | 62 | na | na | 0,2 | na | na Etanol, camiones Estados Unidos [h] | 260 | 77 | 880 | 41 | 13 | 123 Etanol, automóviles, Brasil [i] | 18 | 13 | 84 | na | na | na	*Estimated fuel* = Total fuel consumption estimated from distance traveled (KRV) data *Vehiclei,j,t* = Number of type *i* vehicles using type *j* fuel on type t road. *Distancei,j,t* = Annual kilometres travelled by type *i* vehicle using type *j* fuel on type t road, km *Consumptioni,j,t* = Average fuel consumption, L/km, per type *i* vehicle using type *j* fuel on type *t highway* *i* = Type of vehicle (e.g. car, bus). *j* = fuel type (e.g. motor gasoline, diesel, natural gas, LPG) *t* = type of road (e.g. urban, rural).	• N2O = 0.038 t *E* = 239.15*(1) + 0.030*(28) + 0.038*(296) = 251.24 t CO2-eq <u>Other trucking activities (a range of estimated trips is used):</u> *Estimated fuel* = 300 – 12,000 L *Fuel* =0.011 – 0.43 TJ *Emissions:* • CO2 = 0.81 – 31.86 t • CH4 = 1.0e-04 – 4.0e-03 t • N2O = 1.32e-04 – 5.16e-03 t *E* = 0.85 – 33.5 t CO2-eq <u>Total GHG emissions:</u> *ECO2e-total* = 521.65 – 554.3 t CO2-eq	

Source of Emission		Description	Methodology	Emissions	Reference
	Employee travel during the construction phase	CO2, CH4 and N2O emissions are estimated from the transport contracted for the operation of the plant using the same technologies applied to mobile sources. The following assumptions are used to calculate emissions: • Approximately 400 contract personnel directly related to the construction phase will be needed to produce NH3 and CAN. • Preliminarily, the connection between the Asunción Bus Terminal (Av. Fernando de la Mora, Asunción) and the plant is estimated through the Villeta-Alberdi Route, with intermediate stops that will be defined in later phases. The distance to be covered is 55 km one way and 55 km back, totaling 110 km per trip. For a total of 22 months of work, an estimated 116 trips are projected – see table below. Total distance of the construction phase: 12,760 km. Autobuses: viajes de autobús ida y vuelta al día: MES 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 Autobuses 1 1 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 Viajes ida y vuelta 1 1 2 4 4 4 5 6 7 7 8 8 8 8 7 6 6 6 6 4 4 4 • Average fuel consumption of 30 litres per 100 kilometres. The emission factors (EFs) of diesel vehicles are: • *EFCO2* = 74,100 kg/TJ • *EFCH4* = 9.5 kg/TJ • *EFN2O* = 12 kg/T	Greenhouse gas emissions emitted from the transport of raw materials $$Emissions = \sum (Fuel_{ij} \cdot EF_{ij})$$ Where: *Emissions* = GHG emissions, kg $Fuel_{ij}$ = Fuel consumed, TJ *EFi,j* = Emission factor, kg/TJ *i* = Type of vehicle/machinery *j* = Fuel type Calculation of estimated fuel consumption for the transport of raw materials $$Estimated\ fuel = \sum_{i,j,t} [Vehicle_{i,j,t} \cdot Distance_{i,j,t} \cdot Consumption_{i,j,t}]$$ Where: *Estimated fuel* = Total fuel consumption estimated from distance traveled (KRV) data *Vehiclei,j,t* = Number of type *i* vehicles using type *j* fuel on the road type *t*. *Distancei,j,t* = Annual kilometres travelled by type *i* vehicle using type *j* fuel on type $t\ road$, km *Consumptioni,j,t* = Average fuel consumption, L/km, per type *i* vehicle using type *j* fuel on type $t\ highway$ *i* = Type of vehicle (e.g., car, bus). *j* = fuel type (e.g. motor gasoline, diesel, natural gas, LPG) *t* = Type of road (e.g., urban, rural).	*Estimated fuel* = 15,312 L *Fuel* = 0.54 TJ[XXII] Emissions: • CO2 = 40.68 t • CH4 = 5.13e-03 t • N2O = 6.48e-03 t *E* = 40.68*(1) + 5.13e-03*(28) + 6.48e-03*(296) = 42.74 t CO2-eq	IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2006. Volume 2 – Energy: Mobile Combustion
	Goods and Services Purchased	Emissions of purchased goods, services and capital goods are a major source of emissions. The scope of this category focuses on the extraction, production, and transportation of goods and services procured or procured by ATOME. For this study, products will only include tangible goods (such as raw materials), and the transportation of purchased products is accounted for separately (upstream transportation and distribution). The following assumptions are used to calculate emissions: • Raw Materials:	GHGs associated with the production of raw materials. $$E = EF \times AD$$ Where: *E* = GHG emissions, kg CO2-eq/year *EF* = Emission factor, kg CO2-eq/kg *AD* = Activity data, kg/year	Results: • PTA & WWTP 322.0 tCO_{2}-eq/year • H2 plant 6.85 tCO2-eq/year • NH3 plant 116.3 tCO2-eq/year • NA Plant 4,055.9 tCO2-eq/year	Ingwersen, W. AND M. Li. Supply Chain Greenhouse Gas Emission Factors for US Industries and Commodities.

[XXII] 35.8 MJ/L

<table>
<tr><th>Source of Emission</th><th>Description</th><th>Methodology</th><th>Emissions</th><th>Reference</th></tr>
<tr>
<td></td>
<td>
<table>
<tr><th>Process</th><th>Raw material</th><th>Value</th><th>Frequency/Years (hours)</th><th>EF (kgCO2-eq/kg)</th></tr>
<tr><td>WWTP</td><td>Sulfuric acid (96-98%)</td><td>2.55 kg/h</td><td>8400</td><td>0.1707</td></tr>
<tr><td></td><td>Sodium hydroxide (50%)</td><td>1 kg/h</td><td>8400</td><td>1.313</td></tr>
<tr><td rowspan="9">PTA</td><td>Coagulant – Aluminum Sulfate</td><td>8 kg/h</td><td>8400</td><td>0.667</td></tr>
<tr><td>Flocculant anionic polyamide</td><td>1.3 kg/h</td><td>8400</td><td>3.778</td></tr>
<tr><td>Sodium hydroxide</td><td>0.3 kg/h</td><td>8400</td><td>1.313</td></tr>
<tr><td>Sodium hypochlorite</td><td>2.3 kg/h</td><td>8400</td><td>2.61</td></tr>
<tr><td>Hydrochloric acid</td><td>0.7 kg/h</td><td>8400</td><td>0.9259</td></tr>
<tr><td>Polyelectrolyte</td><td>7.5 kg/h</td><td>8400</td><td>2.299</td></tr>
<tr><td>Antifouling</td><td>0.19 kg/h</td><td>8400</td><td>2.299</td></tr>
<tr><td>Sodium bisulfite</td><td>0.94 kg/h</td><td>8400</td><td>1.691</td></tr>
<tr><td>H2 Plant</td><td>KOH (30% w/w)</td><td>2,500 kg/year</td><td>1</td><td>2.74</td></tr>
<tr><td>NH3 Plant</td><td>AmoMax © catalyst. Zinc sulfide used as a proxy.</td><td>275,313 kg</td><td>0.2</td><td>2.112</td></tr>
<tr><td rowspan="4">AN & SNA Plant</td><td>Vanadium pentoxide</td><td>1.57 kg/day</td><td>1</td><td>166.16</td></tr>
<tr><td>Platinum Rhodium Base - Pt 29.63 kg</td><td>0.1482 kg/day</td><td>350</td><td>68,758.36</td></tr>
<tr><td>Platinum and rhodium base - Rh 1.56 kg</td><td>0.078 kg/day</td><td>350</td><td>79,687.61</td></tr>
<tr><td>Platinum Rhodium Base - Pd 13.92</td><td>0.0696</td><td>350</td><td>111,143.45</td></tr>
<tr><td rowspan="4">CAN Plant</td><td>Solid Granulating Agent</td><td>201.5 kg/h</td><td>7260</td><td>0.667</td></tr>
<tr><td>Liquid Glazing Agent - Siloxane</td><td>102.2 kg/h</td><td>7260</td><td>3.456</td></tr>
<tr><td>Liquid Coating Agent: Amine</td><td>40.8 kg/h</td><td>7260</td><td>2.784</td></tr>
<tr><td>Dolomite</td><td>173 t/day</td><td>330</td><td>See below</td></tr>
</table>
GHG estimates for limestone and crushed rock mining, based on a study for the U.S. Department of Energy, provide a breakdown of energy use by fuel type and electricity use[XXIII]. The estimates are shown below:
<table>
<tr><th>Power Consumption Unit</th><th>CO2 (g/ton)</th><th>CH4 (g/ton)</th><th>NO2 (g/ton)</th></tr>
<tr><td>Coal</td><td>88.54</td><td>0.099</td><td>0.011</td></tr>
<tr><td>Fuel oil (diesel)</td><td>1,684.2</td><td>1.88</td><td>0.011</td></tr>
<tr><td>Natural gas</td><td>318.8</td><td>0.886</td><td>0.006</td></tr>
<tr><td>Petrol</td><td>131.48</td><td>0.162</td><td>0.005</td></tr>
<tr><td>Net Electricity Purchased</td><td>1,884.16</td><td>0.047</td><td>0.035</td></tr>
</table>
For the calculations of dolomite/limestone mining emissions, only fuel oil and gasoline are considered, as electricity is assumed to be 100% renewable.

• Packaging:
</td>
<td></td>
<td>
• CAN Plant 109,238.5 tCO2-eq/year
• Packaging 354.6 tCO2-eq/year

NH3 Production Scenario
Emissions: 445.15 tCO2-eq/year

CAN Production Scenario
Emissions: 110,026.25 tCO2-eq/year
</td>
<td>U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-20/001, 2020</td>
</tr>
</table>

[XXIII] BCS, Inc. Energy and Environmental Profile of the U.S. Mining Industry. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, 2002.

<table>
<tr><th>Source of Emission</th><th>Description</th><th>Methodology</th><th>Emissions</th><th>Reference</th></tr>
<tr>
<td></td>
<td></td>
<td>
<table>
<tr><th>Process</th><th>Raw material</th><th>Value</th><th>Frequency/Years (hours)</th><th>EF (kgCO2-eq/kg)</th></tr>
<tr><td rowspan="2">CAN Plant</td><td>Polypropylene PP – 100gsm</td><td>0.5 kg/t CAN</td><td>250,000 t CAN</td><td>2.298</td></tr>
<tr><td>PP to Big Bag (Transformation)</td><td>0.5 kg/t CAN</td><td>250,000 t CAN</td><td>0.539</td></tr>
</table>
</td>
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</tr>
<tr>
<td></td>
<td>Transport of raw materials and inputs to the ATOME plant</td>
<td>
Two methodologies were proposed to calculate emissions from the transport and distribution of raw materials and supplies to the ATOME site. The choice between them is based on the complexity of the calculation and the availability of the data.
Raw materials and inputs for the operation
The methodology used consists of the use of a tabulated emission factor related to the emissions generated per tonne of the product transported. The emission factor (EF) was extracted from the Ecoinvent 3 database as follows:
1. 0.173 t CO2-eq/t-km for trucks (16-32 tonne truck, EURO 5),
2. 0.00935 t CO2-eq/t-km for container ships by sea
3. 0.04443 t CO2-eq/t-km for river barges.
Activity Data (AD) is obtained by calculating the annual consumption in tonnes of each raw material and inputs, and then multiplying it by the distance travelled from the point of origin to the ATOME site. The assumptions are summarized in the following table:
<table>
<tr><th>Process</th><th>Raw material</th><th>Value</th><th>Transport</th><th>Way</th><th>Distance, km</th></tr>
<tr><td>WWTP</td><td>Sulfuric acid (96-98%)</td><td>2.55 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td></td><td>Sodium hydroxide (50%)</td><td>1 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td rowspan="9">PTA</td><td>Coagulant – Aluminum Sulfate</td><td>8 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>Flocculant anionic polyamide</td><td>1.3 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>Sodium hydroxide</td><td>0.3 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>Sodium hypochlorite</td><td>2.3 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>Hydrochloric acid</td><td>0.7 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>Polyelectrolyte</td><td>7.5 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>Antifouling</td><td>0.19 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>Sodium bisulfite</td><td>0.94 kg/h</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td>H2 Plant</td><td>KOH (30% w/w)</td><td>2500 kg/year</td><td>Villeta to ATOME</td><td>Truck</td><td>30</td></tr>
<tr><td rowspan="2">NH3 Plant</td><td rowspan="2">AmoMax © catalyst. Zinc sulfide used as a proxy.</td><td rowspan="2">275313 kg</td><td>Guangzhou to Shenzen, Itapoa to Viletta</td><td>Barge (river)</td><td>1236</td></tr>
<tr><td>Shenzen to Itapoa Port</td><td>Vessel (maritime)</td><td>19,000</td></tr>
<tr><td rowspan="2">AN & SNA Plant</td><td rowspan="2">Vanadium pentoxide</td><td rowspan="2">1.57 kg/day</td><td>Prague to Amsterdam, Itapo Port to ATOME</td><td>Barge (river)</td><td>2,000</td></tr>
<tr><td>Amsterdam to Itapoa Port</td><td>Vessel (maritime)</td><td>11,000</td></tr>
<tr><td>Platinum Rhodium Base - Pt 29.63 kg</td><td>0.1482 kg/day</td><td>Prague to Amsterdam, Itapo Port to ATOME</td><td>Barge (river)</td><td>2,000</td></tr>
</table>
</td>
<td>
Raw materials and inputs for the operation
GHG emissions associated with the transport of raw materials and inputs.
$$E = EF \times AD$$
Where:
E = GHG emissions, kg CO2-eq/year
EF = Emission factor, kg CO2-eq/kg
AD = Activity data, kg/year

Raw materials for the production of CAN (limestone/dolomite)
GHG emissions associated with the transport of raw materials.
$$Emissions = \sum (Fuel_{ij} \cdot EF_{ij})$$
Where:
Emissions = GHG emissions (kg)
$_{Fuel,j}$ = Fuel Consumed (TJ)
EFi,j = Emission factor (kg/TJ)
i = Type of vehicle/machinery
j = Fuel type

Calculation of the estimated fuel for the transport of raw materials.
$$Estimated\ fuel = \sum_{i,j,t} [Vehicle_{i,j,t} \cdot Distance_{i,j,t} \cdot Consumption_{i,j,t}]$$
Where:
</td>
<td>
Raw materials and supplies for operation
a) WWTP & WWTP 1.08 t CO2-eq/year
b) H2 plant 0.013 t CO2-eq/year
c) NH3 plant 12.81 t CO2-eq/year
d) AN & SNA plant 0.015 t CO2-eq/year
e) CAN plant 9.53 t CO2-eq/year

Raw materials for the production of CAN (limestone/dolomite)
a) Fluvial:
Estimated fuel = 280,000 L/year
Fuel = 10.04 TJ/year
Emissions:
• CO2 = 744.02 t/year
• CH4 = 0 t/year
• N2O = 0 t/year
E = 744.02 t CO2-eq/year

b) Terrestrial:
Estimated fuel = 10,950 L/year
Fuel = 0.39 TJ/year [XXV]
Emissions:
• CO2 = 28.89 t/year
• CH4 = 3.7e-03 t/year
</td>
<td>IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2006. Volume 2 – Energy: Mobile Combustion.</td>
</tr>
</table>

[XXV] 35.86 MJ/L

Source of Emission		Description					Methodology	Emissions	Reference
					Amsterdam to Itapoa Port	Vessel (maritime)	11,000	*Estimated fuel* = Total fuel consumption estimated from distance traveled (KRV) data *Vehicle,j,t* = Number of type *i* vehicles using type *j* fuel on the road type *t*. *Distancei,j,t* = Annual kilometres travelled by type *i* vehicle using type *j* fuel on type t road (km) *Consumptioni,j,t* = Average fuel consumption (L/km) per type *i* vehicle using type *j* fuel on type *t highway* *i* = Type of vehicle (e.g., car, bus). *j* = Fuel type (e.g. motor gasoline, diesel, natural gas, LPG) *t* = Type of road (e.g., urban, rural).	• N2O = 4.68e-03 t/year *E* = 28.89*(1) + 3.7e-03*(28) + 4.68e-03*(296) = 30.37 t CO2-eq/year	
			Platinum and rhodium base - Rh 1.56 kg	0.078 kg/day	Prague to Amsterdam, Itapo Port to ATOME	Barge (river)	2,000			
					Amsterdam to Itapoa Port	Vessel (maritime)	11,000			
			Platinum Rhodium Base - Pd 13.92	0.0696	Prague to Amsterdam, Itapo Port to ATOME	Barge (river)	2,000			
					Amsterdam to Itapoa Port	Vessel (maritime)	11,000			
		CAN Plant	Solid Granulating Agent	201.5 kg/h	Villeta to ATOME	Truck	30			
			Liquid Glazing Agent - Siloxane	102.2 kg/h	Villeta to ATOME	Truck	30			
			Liquid Coating Agent: Amine	40.8 kg/h	Villeta to ATOME	Truck	30			
		The activity data calculated by site are as follows: a) WWTP & WWTP: 6246 t-km b) H2 plant: 75 t-km c) NH3 plant: 1,046,187.4 t-km by ship and 68,057.37 t-km by barge d) AN and SNA plant: 885 t-km by vessel and 161 t-km by barge e) CAN plant: 54,995 t-km by truck <u>Raw materials for CAN production: Addition of limestone/dolomite</u> The methodology used is to initially calculate the annual fuel consumption required for the transport of raw materials. Subsequently, this value is applied together with a diesel vehicle (*FE)* emission factor to calculate the emissions being as follows: • *EFCO2* = 74,100 kg/TJ • *EFCH4* = 9.5 kg/TJ • *EFN2O* = 12 kg/TJ Additional assumptions for fuel consumption estimation: • For CAN production, 150 tons of rock per day will be used (based on a 22-hour operating day), totaling approximately 54,750 tons per year • Logistics involves transport by river from a port in Vallemi, Concepción to a port in Villeta, and then land transport from the port of Villeta to the ATOME plant: a) River: The transport will be carried out from Vallemi, Concepción, to a port near the Villeta plant, with an extension of 550 km. The type of transport used on this stretch of the river consists of 4x4 convoy tugs with barges, each with a capacity of 1500 tons. In a single trip, it is possible to transport 24,000 tons. The assumed transport efficiency is 245.2 ton-km/L[XXIV]. The emission factor for river transport is *EFCO2* = 74,000 kg/TJ. b) Road: Transport will be carried out from the port of Terport in Villeta to the ATOME plant, covering a distance of 15 km one way and another 15 km back, resulting in each truck travelling 30 km per day. The truck has a capacity of 35 tons of diesel rock, so 5 trucks will								

[XXIV] NATIONAL WATERWAYS FOUNDATION (2017) A modal comparison of domestic freight transportation effects on the general public: 2001–2014 nationalwaterwaysfoundation.org

<table>
<tr><th colspan="2">Source of Emission</th><th>Description</th><th>Methodology</th><th>Emissions</th><th>Reference</th></tr>
<tr><td></td><td></td><td>be needed for daily production. The annual distance is 15 km* (365 days) = 5475 km per vehicle. The average fuel consumption of the vehicle is 40 litres per 100 km.</td><td></td><td></td><td></td></tr>
<tr><td>Downstream activities: These are indirect greenhouse gas emissions related to goods and services sold.</td><td>CO2 and N2O emissions from managed soils. Application of Calcium Ammonium Nitrate (CAN) in Agriculture</td><td>Direct emissions: In most soils, an increase in available nitrogen (N) improves nitrification and denitrification rates, which in turn increases nitrous oxide (N2O) production. Increases in available N may be the result of human-induced N additions or changes in land use and/or management practices that mineralize organic N from the soil. The following data are used for the calculation:
• FSN = 250,000 t CAN/year * 0.27 t N/t CAN = 67,500 t N/year
• EF1 = 0.01 kg N2O–N/kg N
CUADRO 11.1
FACTORES DE EMISIÓN POR DEFECTO PARA ESTIMAR LAS EMISIONES DIRECTAS DE N_2O DE LOS SUELOS GESTIONADOS
<table><tr><th>Factor de emisión</th><th>Valor por defecto</th><th>Rango de incertidumbre</th></tr><tr><td>EF_1 para aportes de N de fertilizantes minerales, abonos orgánicos y residuos agrícolas, y N mineralizado de suelos minerales a causa de pérdida de carbono del suelo [kg N_2O–N (kg N)$^{-1}$]</td><td>0,01</td><td>0,003 - 0,03</td></tr><tr><td>EF_{1FR} para arrozales inundados [kg N_2O–N (kg N)$^{-1}$]</td><td>0,003</td><td>0,000 - 0,006</td></tr><tr><td>$EF_{2\,CG,\,Temp}$ para suelos orgánicos templados de cultivo y con pastizales (kg N_2O–N ha^{-1})</td><td>8</td><td>2 - 24</td></tr><tr><td>$EF_{2\,CG,\,Trop}$ para suelos orgánicos tropicales de cultivo y pastizales (kg N_2O–N ha^{-1})</td><td>16</td><td>5 - 48</td></tr><tr><td>$EF_{2F,\,Temp,\,Org,\,R}$ para suelos forestales templados y boreales ricos en nutrientes orgánicos (kg N_2O–N ha^{-1})</td><td>0,6</td><td>0,16 - 2,4</td></tr><tr><td>$EF_{2F,\,Temp,\,Org,\,P}$ para suelos forestales templados y boreales pobres en nutrientes orgánicos (kg N_2O–N ha^{-1})</td><td>0,1</td><td>0,02 - 0,3</td></tr><tr><td>$EF_{2F,\,Trop}$ para suelos forestales orgánicos tropicales (kg N_2O–N ha^{-1})</td><td>8</td><td>0 - 24</td></tr><tr><td>$EF_{3PRP,\,CPP}$ para vacunos (lecheros y no lecheros, y búfalos), aves de corral y porcinos [kg N_2O–N (kg N)$^{-1}$]</td><td>0,02</td><td>0,007 - 0,06</td></tr><tr><td>$EF_{3PRP,\,SO}$ para ovinos y «otros animales» [kg N_2O–N (kg N)$^{-1}$]</td><td>0,01</td><td>0,003 - 0,03</td></tr><tr><td colspan="3">Fuentes:
EF_1: Bouwman et al. 2002a,b; Stehfest & Bouwman, 2006; Novoa & Tejeda, 2006 en prensa; EF_{1FR}: Akiyama et al., 2005; $EF_{2CG,\,Temp}$, $EF_{2CG,\,Trop}$, $EF_{2F,Temp}$: Klemedtsson et al., 1999, IPCC Good Practice Guidance, 2000; $EF_{2F,\,Temp}$: Alm et al., 1999; Laine et al., 1996; Martikainen et al., 1995; Minkkinen et al., 2002: Regina et al., 1996; Klemedtsson et al., 2002; EF_3 $_{CPP}$, $EF_{3\,SO}$: de Klein, 2004.</td></tr></table>
Indirect emissions: The volatilization of nitrogen compounds and their deposition in soils and water bodies, along with leaching and runoff from fertilizers and agricultural residues, are two main pathways for nitrogen loss in the environment. These nitrogen losses contribute to the emission of nitrous oxide (N2O), which is formed through nitrification and denitrification in groundwater and water bodies. The following data are used for the calculation:
• FSN = 250,000 t CAN/year * 0.27 t N/t CAN = 67,500 t N/year
• FracGASF = 0.10 (kg NH3–N + NOx–N) (kg N added)$^{-1}$
• EF4 = 0.010 kg N2O–N (kg NH3–N + volatilized NOx–N) $^{-1}$
• FracLIXIV = 0.3 kg N (kg of nitrogen added or deposited by grazing animals) $^{-1}$
• EF5 = 0.0075 kg N2O–N (kg nitrogen leaching/runoff) $^{-1}$</td><td>Direct emissions, t N/year
$N_2O - N_{contributions} = F_{SN} \cdot EF_1$
Where:
FSN = Annual amount of nitrogen applied to soils in the form of synthetic fertilizer, t/year
EF1 = Amount of N2O emitted by various applications of synthetic and organic N to soils, including agricultural residues and soil organic carbon mineralization in mineral soils due to changes in land use or management, kg N2O-N (kg N)$^{-1}$
Direct emissions, t N2O/year:
$N_2O_{contributions} = N_2O - N_{contributions} \cdot 44/28$

Direct emissions, t N/year – Volatilization, N2O (ATD)
$N_2O_{(ATD)} - N = F_{SN} \cdot Frac_{GASF} \cdot EF_4$
FSN = Annual amount of nitrogen applied to soils in the form of synthetic fertilizer, t/year
FracGASF = Fraction of nitrogen from synthetic fertilizers that volatilizes as NH3 and NOx, kg N volatilized (kg N added)$^{-1}$
EF4 = Emission factor for N2O emissions from atmospheric deposition of N in soils and water surfaces, kg N–N2O (kg NH3–N + volatilized NOx–N)$^{-1}$
Emissions, t N2O/year:
$N_2O_{(ATD)} = N_2O_{(ATD)} - N \cdot 44/28$

Indirect emissions, t N/year – Leaching/Runoff, N2O(L)
$N_2O_{(L)} - N = F_{SN} \cdot Frac_{LIXIV} \cdot EF_5$
FSN = Annual amount of nitrogen applied to soils in the form of synthetic fertilizer, t N/year
FracLIXIV = Total N fraction aggregated in managed soils in regions where leaching/runoff occurs, kg N (kg N added)$^{-1}$
EF5 = Emission factor for N2O emissions from N leaching and runoff, kg N2O–N (kg N from leaching and runoff)$^{-1}$
Emissions, t N2O/year:
$N_2O_{(LIXIV)} = N_2O_{(LIXIV)} - N \cdot 44/28$</td><td>Direct emissions:
N2Ocontributions = 1060.7 t N2O/year

Indirect emissions:
$N2O_{(ATD)}$ = 106.07 t N2O/year
$N2O_{(LIXIV)}$ = 238.66 t N2O/year

Annual CO2-eq emissions:
416,007 t CO2-eq/year</td><td>IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2006. Volume 4 – Agriculture, forestry and other land uses: N2O emissions from managed soils and CO2 emissions from lime and urea application.</td></tr>
</table>

<table>
<tr><th colspan="2">Source of Emission</th><th>Description</th><th>Methodology</th><th>Emissions</th><th>Reference</th></tr>
<tr><td></td><td></td><td>
CUADRO 11.3
FACTORES DE EMISIÓN, VOLATILIZACIÓN Y LIXIVIACIÓN POR DEFECTO PARA EMISIONES INDIRECTAS DE N_2O DEL SUELO
<table>
<tr><th>Factor</th><th>Valor por defecto</th><th>Rango de incertidumbre</th></tr>
<tr><td>EF_4 [volatilización y re-deposición de N], kg N_2O–N (kg NH_3–N + NO_X–N volatilizado)$^{-1}$ [19]</td><td>0,010</td><td>0,002 - 0,05</td></tr>
<tr><td>EF_5 [lixiviación/escurrimiento], kg N_2O–N (kg N lixiviación/escurrimiento)$^{-1}$ [20]</td><td>0,0075</td><td>0,0005 - 0,025</td></tr>
<tr><td>$Frac_{GASF}$ [Volatilización de fertilizante sintético], (kg NH_3–N + NO_x–N) (kg N aplicado)$^{-1}$</td><td>0,10</td><td>0,03 - 0,3</td></tr>
<tr><td>$Frac_{GASM}$ [Volatilización de todos los fertilizantes de N orgánicos aplicados, y de estiércol y orina depositados por animales en pastoreo], (kg NH_3–N + NO_x–N) (kg N aplicado o depositado)$^{-1}$</td><td>0,20</td><td>0,05 - 0,5</td></tr>
<tr><td>$Frac_{LIXIVIACIÓN-(H)}$ [pérdidas de N por lixiviación/escurrimiento en regiones donde Σ(lluvia en la estación lluviosa) - Σ (EP en el mismo período) > capacidad de retención del agua del suelo, O donde se emplea irrigación (excepto por goteo)], kg N (kg N agregado o por deposición de animales en pastoreo)$^{-1}$</td><td>0,30</td><td>0,1 - 0,8</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td></td><td>CO2 removal through agricultural activity (crop growth)</td><td>The use of fertilizers improves crop productivity, which can promote the uptake or sequestration of CO2 by plants. This could lead to a reduction in the area of land needed for cultivation [XXVI]. Due to the complexity and scope of the IPCC Guidelines, a rough estimate is used for this source of removal. The study is delimited considering two types of crops, sugarcane and soybeans, due to their higher national and regional production (mainly in Brazil).[XXVII] A CO2 removal factor is estimated for these crops of:
• 0.02 g CO2/m2-day for soybean cultivation[XXVIII], and
• 0.66 t CO2/ha-year for sugarcane cultivation[XXIX]
Soybean crop yields are estimated at around 4,000 kg of soybeans/ha used 320 kg of nitrogen fertilizers[XXX]. Studies indicate a 25% increase in sugarcane yield with the use of nitrogen fertilizers at a rate of 150 kg N/ha[XXXI]. With this data, CO2 removal factors are calculated based on the amount of nitrogen that will be used as fertilizer.
• $EF_{soybean} = \frac{0.02\ g\ CO2}{m^2-day} \times \frac{1\ t\ CO2}{10^6\ g\ CO2} \times \frac{1\ m^2}{0.001\ ha} \times 150\ días$[XXXII] $\times \frac{ha}{320\ kg\ N} = 9.375 \times 10^{-6} \frac{t\ CO2}{kg\ N}$</td><td><u>Elimination of greenhouse gases associated with crop growth activity:</u>
$R = -EF \times AD$
Where:
R = GHG emissions, t CO2/year
EF = Emission factor, t CO2 /kg N
AD = Activity data, kg N/year</td><td>R = - 632.8 t CO2 (soybean crops)
E = - 371,250 t CO2 (sugarcane crops)</td><td>2006 IPCC guidelines for national greenhouse gas inventories. Volume 1 - General Guidance and Reporting</td></tr>
</table>

[XXVI] A plant yield of 8 Mg/ha is achieved with the use of 170 kg N/ha, capable of absorbing 12,800 kg CO2/ha, which is equivalent to 75 kg CO2 per kg of N used, e.g. -75 kg CO2-eq/kg N.

[XXVII] FAOSTAT

[XXVIII] Research shows cultivating wheat absorbs more carbon dioxide than it releases - Portal Embrapa

[XXIX] Parr, Jeffrey & Sullivan, Leigh. (2007). Sugarcane the champion crop at carbon sequestration. Jeffrey Parr.

[XXX] Soybeans: Criteria for Crop Fertilization (unc.edu.ar)

[XXXI] Boschiero, B.N., Mariano, E., Torres-Dorante, L.O. et al. Nitrogen fertilizer effects on sugarcane growth, nutritional status, and productivity in tropical acid soils. Nutr Cycl Agroecosyst 117, 367–382 (2020). https://doi.org/10.1007/s10705-020-10074-w

[XXXII] Approximate duration of soybean crops

<table>
<tr><th colspan="2">Source of Emission</th><th>Description</th><th>Methodology</th><th>Emissions</th><th>Reference</th></tr>
<tr><td></td><td></td><td>

- $EFsugar\ cane = \frac{0.66\ t\ CO2}{ha-year} \times \frac{ha}{150\ kg\ N} \times 1.25\ years$[XXXIII] $= 5.5 \times 10^{-3}\ \frac{t\ CO2}{kg\ N}$

With an annual production of 250,000 tons of calcium ammonium nitrate (CAN), a nitrogen composition of 27% is estimated. The activity data to be used is:

- *AD* = 67,500 t N/year * (1000 kg/t) = 67.5e06 kg N /year</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Road transport and distribution of NH3 and CAN</td><td>The mobile fuel consumption method is used, for which the CO2, CH4 and N2O emissions of vehicles used for the transport and distribution of products are estimated. Emissions from the use of fuel from mobile sources are related by type and quantity of fuel or by type of vehicle and total kilometres driven if fuel data are not available.
The emission factors used are as follows:[6]
<table>
<tr><th>Vehicle Type</th><th>CO₂ Factor (kg / unit)</th><th>CH₄ Factor (g / unit)</th><th>N₂O Factor (g / unit)</th><th>Units</th></tr>
<tr><td>Medium- and Heavy-Duty Truck</td><td>1,387</td><td>0,013</td><td>0,038</td><td>vehicle-mile</td></tr>
<tr><td>Passenger Car [A]</td><td>0,313</td><td>0,008</td><td>0,007</td><td>vehicle-mile</td></tr>
<tr><td>Light-Duty Truck [B]</td><td>0,467</td><td>0,013</td><td>0,012</td><td>vehicle-mile</td></tr>
<tr><td>Medium- and Heavy-Duty Truck[C]</td><td>0,170</td><td>0,0016</td><td>0,0047</td><td>ton-mile</td></tr>
<tr><td>Rail</td><td>0,021</td><td>0,0016</td><td>0,0005</td><td>ton-mile</td></tr>
<tr><td>Waterborne Craft</td><td>0,044</td><td>0,0254</td><td>0,0011</td><td>ton-mile</td></tr>
<tr><td>Aircraft</td><td>0,698</td><td>0</td><td>0,0215</td><td>ton-mile</td></tr>
</table>
Converting to kilometers, the factors to use are as follows:

- *EFCO2* = 0.1056 kg CO2/t-km
- *EFCH4* = 9.94e-07 kg CH4/t-km
- *EFN2O* = 2.92e-06 kg N2O/t-km

Two study frameworks are distinguished, each with its possible scenarios:

1. <u>NH3 Production:</u>
   a) Land transport of green ammonia from the Plant to the Villeta Industrial Zone for the production of ammonia-based fertilizers, 30 km.
   b) Land transport of grey ammonia from the Port of Villeta to the Villeta Industrial Zone for the production of ammonia-based fertilisers, 15 km.
2. <u>CAN Production:</u>
   a) Road transport of green CAN from the Plant to the ports of Villeta for export, 25 km.
   b) Green CAN road transport from the Plant to the final destinations in Brazil:
      i. 1488 km Villeta – São Paulo,
      ii. 1778 km Villeta – Miras Gerais,
      iii. 1200 km Villeta – Rio Grande do Sul.</td><td><u>Total annual emissions from the transport and distribution of the final product</u>

$$Emissions = \sum_{a}[Product \cdot Distance \cdot EF_a]$$

Where:
Emissions = GHG emissions, kg/year
Product = Quantity of product transported annually, t/year
Distance = Distance traveled per trip, km
EFa = Emission factor, kg GHG/t-km.
a = GHG type (e.g. CO2, CH4, N2O)</td><td><u>Ammonia production, 100,000 t/year</u>
Scenario (a):
Emissions = 316.8 t CO2/year*(1) + 6.21e-03 t CH4/year*(28) + 0.0182 t N2O/year*(296) = 322.36 t CO2-eq/year

Scenario (b):
Emissions =159.74 t CO2-eq/year

<u>CAN production, 250,000 t/year</u>
Scenario (a):
Emissions = 660 t CO2/year*(1) + 2.98e-03 t CH4/year*(28) + 8.76e-03t N2O/year*(296) = 662.67 t CO2-eq/year
Scenario (b):
i. *Emissions* = 39,284.65 t CO2-eq/year
ii. *Emissions* = 47,335.76 t CO2-eq/year
iii. *Emissions* = 31,947.64 t CO2-eq/year</td><td>GHG Emission Factors Hub | US EPA

GHG Protocol. Technical Guidance for Calculating Scope 3 Emissions Supplement to the Corporate Value Chain (Scope 3) Accounting & Reporting Standard</td></tr>
<tr><td></td><td>River and sea transport and</td><td>The methodology covers maritime and river transport, ranging from recreational activities to large cargo ships powered primarily by low-, medium- and high-speed diesel engines, as well as steam or gas turbines. Maritime and river transport generates emissions of CO2, CH4 and N2O, as well as CO, volatile organic compounds other than methane (VOCs), SO2, particulate matter</td><td><u>Equation for Maritime and Inland Waterway Navigation</u>

$$ECO2_a = AD \cdot EF_a \cdot D \cdot 10^{-6}$$

Where:
ECO2 = CO2 emissions by type of transport, t CO2/year</td><td><u>Ammonia, *AD* = 100,000 t/year</u>
<u>Scenario 1 & 2:</u> Transport of NH3 from the Port of Rotterdam to the Port of Villeta</td><td>IPCC (Intergovernmental Panel on Climate Change)</td></tr>
</table>

[XXXIII] Approximate Duration of Sugarcane Crops from Planting to Harvest Stages of Sugarcane Cultivation | Ministry of Agriculture and Rural Development | Government | gob.mx (www.gob.mx)

Source of Emission		Description	Methodology	Emissions	Reference
	distribution of NH3 and CAN	(PM) and NOx. The following study frameworks are distinguished, along with their possible scenarios: Ammonia Production: Scenarios: 1. Sea route: Transport from the Port of Rotterdam to the Port of Nueva Palmira, Uruguay, 14,500 km. 2. River route: Transport from Nueva Palmira, Uruguay, to the Port of Villeta, 1,593 km. CAN Production: Scenarios: 1. River route: Transport from Puertos de Villeta to the Port of Nueva Palmira, Uruguay, 1,593 km. 2. Sea route: Transport from the Port of Nueva Palmira to the Port of Santos, São Paulo, Brazil, 1,800 km. 3. Sea route: Transport from the Port of Rotterdam to the Port of Santos, São Paulo, Brazil, 24,550 km The emission factors to be used are related in terms of CO2 emissions per tonne of cargo transported per kilometre, using the following values for the calculation:[7] • Ocean freight, *EF* = 3 g CO2/t-km • River transport, *EF* = 7.9 g CO2/t-km	*EF* = emission factor per type of transport a, g CO2/t-km *D* = Distance travelled per trip, km *AD* = Activity data, in this case, the quantity of product to be transported annually, t/year a = Type of transport, river or sea	• *ECO2* = 4350 + 1258.5 = 5608.5 t CO2/year CAN, *AD* = 250,000 t/year Scenario 1 and 2: Transport of the CAN from Villeta to the Port of Santos, SP-BR • *ECO2* = 4496.17 t CO2/year Scenario 3: Transport of the CAN from the Port of Rotterdam to the Port of Santos, SP-BR • *ECO2* = 18,412.5 t CO2/year	Guidelines for National Greenhouse Gas Inventories, 2006. Volume 2 – Energy: Mobile Combustion.
	Wastewater treatment and disposal	The most widespread wastewater treatment methods in developed countries are centralized facilities for aerobic wastewater treatment and lagoons for domestic and industrial wastewater. In nitrogen fertilizer plants, the wastewater generated contains ammonia nitrogen (NH3-N and NH4+-N), nitrates ($NO3^-$-N), and organic nitrogen (Org-N). Under normal production conditions, organic nitrogen is not expected to be found in wastewater from ammonium nitrate plants. Direct emissions resulting from nitrification and denitrification in wastewater treatment facilities can be considered minor sources. [1] Continuous emissions to water can be up to 5,000 mg AN-N per liter and 2,500 mg NH3-N/L (equivalent to 6 and 3 kg/t of product, respectively). Applying best available techniques (BAT) would result in 100 mg N/L (0.2 kg N/t AN) The IPCC 2019 introduces new methodologies and values for effluents generated by industries. These are the characteristic values of the effluents generated by the nitrogen fertilizer industry: • $_j$ = secondary (biological) effluent treatment system and discharge to aquatic systems • *Pi* = 250,000 t CAN/year • *Wi* = 2.89 m3/t (2.66 m3/t for ATOME plant)[XXXIV] • *TNi* = 0.5 kg N/m3 • *Tj* = 0% as the treatment plant will be operating continuously	Total Nitrogen in Industrial Effluents $TN_{IND_i} = P_i \cdot W_i \cdot TN_i$ *TNINDi* = Total nitrogen in the influent entering industrial treatment, kg N/year. i = Industrial sector *Pi* = Annual production of industry i, t/year. *Wi* = Effluent generated by industry i, m3/tonne of product. *TNi* = Total nitrogen in effluent generated by the industrial sector i, kg N/m3 N2O emissions from industrial effluent treatment plants $N2O\ Plants_{IND} = \left[\sum_i \left(T_{i,j} \cdot EF_j \cdot TN_{IND_i}\right)\right] \cdot 44/28$ Where: *N2OPlants,IND* = N2O emissions from industrial effluent treatment plants, kg N2O/year *TNIND,i* = total nitrogen in the influent entering the treatment for the industrial sector i, kg N/year	Total Nitrogen in Industrial Effluents *TNINDi* = 332,500 kg N/year N2O emissions from industrial effluent treatment plants *N2OPlants,IND* = 8,882.5 kg N2O/year Total nitrogen in industrial effluent treated for discharge *NEffluent,IND* = 49,875 kg N/year N2O emissions from the discharge of treated effluents *N2OEffluent,IND* = 391.88 kg N2O/year	IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories, 2019. Volume 5 – Waste: Wastewater treatment and disposal.

[XXXIV] Production of 250,000 tons/year of CAN and generation of 658,976 m3/year of industrial effluents, especially wastewater.

Source of Emission		Description	Methodology	Emissions	Reference
		• *NREM,j* = 85% • *EFEffluents* = 0.005 kg N2O/kg N • *EFj* = 0.017 kg N2O/kg N [XXXV] **TABLE 6.12 (NEW)** **EXAMPLES OF INDUSTRIAL WASTEWATER DATA** **Industry Type** | **Wastewater Generation W (m³/tonne)** | **Range for W (m³/tonne)** | **Total Nitrogen (TN) (kg/m³)** | **TN Range (kg/m³)** Alcohol refining | 24[2] | 16 – 32[2] | 2.4[2] | 0.94 – 3.86[2] Beer & malt | 6.3[2] | 5.0 – 9.0[2] | 0.055[3] | 0.025 – 0.08[3] Fish processing | 5[2] | 2 – 8[2] | 0.60[2] | 0.21 – 0.98[2] Iron and steel manufacturing | 5[1] | 0.004 – 10.4[4] | 0.25[1] | 0.0004 – 0.524[4] Meat & poultry | 13[2] | 8 – 18[2] | 0.19[2] | 0.17 – 0.20[2] Nitrogen fertiliser | 2.89[2] | 0.46 – 8.3[2] | 0.5[2] | 0.1 – 0.8[2] Plastics & resins | 0.6[5] | 0.3 – 1.2[5] | 0.25[6] | No range provided Starch production | 9[2] | 4 – 18[2] | 0.9[2] | 0.8 – 1.10[3] [1] Based on expert judgment by Lead Authors of this section. [2] IPCC (2014) [3] Simate *et al.* (2011) [4] US EPA (2002a) [5] Doorn *et al.* (1997) [6] Li *et al.* (2016)	*Ti,j* = Degree of use of the treatment/discharge system *j*, for the industrial sector *i* *i* = Industrial sector *j* = Type of treatment/discharge system *EFj* = Emission factor for treatment/discharge system *j*, kg N2O/kg N Total nitrogen in industrial effluent treated for discharge $$N_{Effluent,IND} = \left[\sum_j TN_{IND_i} \cdot T_j \cdot (1 - N_{REM_i})\right]$$ *NEffluent,IND* = Total nitrogen content in treated industrial effluent, kg N/year *TNIND,i* = Total nitrogen in industrial effluent entering treatment, kg N/year *Tj* = Degree of utilization of the treatment/discharge system *j* = Type of treatment/discharge system *NREM,j* = Fraction of total nitrogen removed during treatment by treatment type *j* N2O emissions from the discharge of treated effluents. $$N_2O\ Effluents_{IND} = N_{Effluent,IND} \cdot EF_{Effluent} \cdot 44/28$$ *N2OEffluent,IND* = N2O emissions from industrial effluent discharge, kg N2O/year *NEffluent,IND* = Total nitrogen content in treated industrial effluent discharged into aquatic systems, kg N/year *EFEffluent* = Emission factor for N2O emissions from treated industrial effluents discharged into aquatic systems, kg N2O-N/kg N	Total N2O emissions Total N2O = 9.27 t N2O/year Total CO2-eq = 2745.2 t CO2-eq/year	
	End-of-life treatment of the product sold	This category includes emissions from the disposal and treatment of waste from products sold by ATOME at the end of their useful life. Fertilizer itself is a consumer product in crops, so disposal emissions are associated with packaging waste. It was assumed that CAN is packaged in 1000 kg polypropylene bags, commonly known as big bags, and the weight of each bag was estimated. In addition, it was assumed that all packaging waste is recycled by the end consumer. The following data and assumptions are used for the calculation: • Total mass of products sold: 250,000 t CAN/year	GHGs associated with end-of-life treatment of the product sold (big bag recycling) $$E = EF \times AD$$ Where: *E* = GHG emissions, kg CO2-eq/year *EF* = Emission factor, kg CO2-eq/kg *AD* = Activity data, kg/year	Emissions from the recycling of polypropylene big bags: • *E* = 34.6 t CO2-eq/year	GHG Protocol. Technician. Category 12: End-of-life treatment of products sold

[XXXV] EFDB - Basic Search (iges.or.jp) Emission Factor for Industrial Wastewater Treatment Facilities: Manufacture of Chemicals and Related Products.

Source of Emission		Description	Methodology	Emissions	Reference
		• Packaging mass used to transport the can from the point of sale to the end of its shelf life after use by the consumer: 0.5 kg/big-bag • Activity data, *AD* = 250,000 t CAN/year * 1 big-bag/ 1 t CAN * 0.5 kg/big-bag = 125,000 kg big bags/year (125 t/year) • Assuming recycling as waste treatment, the average specific emission factor is *EF* = 0.277 kg CO2-eq/kg			Life Cycle Assessment (LCA) Database (Ecoinvent 3, version 3.8) AECOM Document: "ATOME Comparative Product CAN Carbon Footprint Fertilizer"

Annex 13 – Public Consultation Report

ATOME

ATOME PARAGUAY S.A.

Free Trade Zone and Hydrogen, Ammonia and Green Fertilizer Production Plant of ATOME Paraguay S.A.

Report of the Public Consultation

December/2023

JGP

Free Trade Zone and Hydrogen, Ammonia and Green Fertilizer Production Plant of ATOME Paraguay S.A.

Report of the Public Consultation

December/2023

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1.0
Introduction

This document is the report on the consolidation of the planning, dissemination and execution of the Public Consultation on the Free Trade Zone Project and Hydrogen, Ammonia and Green Fertilizer Production Plant ATOME Paraguay S.A.

The Public Consultation seeks to expose to the public the content of the EsIA developed for the Project, and to open a channel of direct dialogue between Atome and the interested parties and affected by the Project, providing mechanisms to clarify doubts and collect applicable criticisms and suggestions from interested parties.

The aim of this report is therefore to show the actions taken before and on the day of the event.

2.0
Disclosure

As proposed in the Consultation Plan prepared and approved by Atome, various means of dissemination and invitation were used for the Public Consultation, informing of the date, time and place of the event. Activities included radio outreach, transportation and the distribution of invitations.

Radio

The call for Public Consultation was broadcast on radio 5 de Marzo (90.3 FM) from 06 to 13/12/2023. Five (5) daily insertions were made throughout the program.

Car with loudspeaker

A car with a loudspeaker was hired to publicize the Public Consultation, indicating the place, date and time.

The car toured the areas of Villeta, Puerto Lobato (Ypeka'e) and Surubiy in the morning and afternoon between 06 and 13/12/2023. The **Photo Record** in **Exhibit 1** includes a photo of the car with a loudspeaker. Also attached are some videos showing the car in different places and times of the disclosure.

Invitations

Invitations were sent via email and WhatsApp to all stakeholders and affected by the Project listed in the expanded Stakeholder Map, which was submitted as an annex to the Consultation Plan. Among the invited stakeholders were the Mayor of the Municipality of Villeta, the Municipal Board and the Volunteer Firefighters of the
city of Villeta, as well as the Ministries of Environment and Sustainable Development (MADES), Industry and Commerce (MIC), Public Works and Communications (MOPC), Labor, Employment and Social Security (MTESS).

Invitations were also sent by email and WhatsApp to the owner of a rice mill located in the AID, to residents of Estancia Lola, also in the AID, to the Ypeka'e Fishermen's Association, to the 49 Surubiy Police Station and to the owners of the affected land and to the neighbors of the land. Some invitations were personally delivered to residents of Villeta, as shown by some photos from the **Photographic Record** in **Annex 1**.

3.0
Transport for Public Consultation

Free transportation was provided to residents of the Ypeka'e community interested in participating in the Public Consultation. A **photo of the bus used in this transport is shown** in the Photographic Record **of** Annex 1.

The vehicle was available at 4:00 p.m. in front of the Ypeka'e police station. He arrived at the Public Consultation site at 5:00 p.m. and returned to the community after the event.

4.0
Public Consultation

The Public Consultation took place in person on December 13, 2023 at 6:00 p.m. in the event room of the River Hotel, located on General Díaz Street, Villeta. Before entering the room, all participants signed the attendance list (see photos in **Annex 1**) and received a brochure with information about the Project. The list of assistance can be found in **Annex 2** and the booklet in **Annex 3**.

Both on arrival and at the end of the event, refreshments were offered to the attendees (see photos in **Annex 1**).

The Photographic Record in **Annex 1** shows photos of the event, including some that show the characteristics of the venue and the structure set up for the Consultation, the participants, the preparation of the minutes, the presenters, the participants asking their questions and the representatives of Atome Paraguay and the environmental consultancy (JGP Consultoria) answering the questions.

The Public Consultation was opened by Viviana Brun, environmental coordinator of Atome Paraguay, who thanked everyone for their presence, explained the dynamics of the meeting, the objectives and the expected results, highlighting that the contributions of those present will be taken into account in the final version of the ESIA. Viviana formed the table with Juan Pablo Nogues, Project Manager of ATOME Paraguay and [redacted], geographer and consultant of JGP Consultoria, the company responsible for the preparation of the Environmental and Social Impact Study – ESIA of the project.

The cycle of presentations (see copy of the presentation in **Annex 4**) began with Juan Pablo Nogues, Project Manager of Atome Paraguay, who thanked those present, and continued to

present information about the company Atome and details of the Project, including the location and its components, information about hydrogen, ammonia and green fertilizer and their advantages, the main and auxiliary facilities of the Plant, the operation and maintenance aspects and the environmental controls that will be adopted to avoid and minimize impacts.

Next, Juan Pablo introduced [redacted], consultant and specialist in physical environment at JGP Consultoria, who participated in the preparation of the ESIA. [redacted] began the presentation with the studies of locational and technological alternatives carried out for the Plant, the power transmission line (LT) and the water and effluent pipes, and that the objectives of these studies were to achieve a Project with the best possible technology and to seek the most suitable location for its construction and operation. in order to cause the least possible environmental and social impact.

He also presented succinct information on the baseline made for the areas of indirect and direct influence and the area directly affected by the Project. He explained the studies and data collection on climate, water resources, geology, geomorphology and soils, environmental noise and air quality, flora and fauna, and socioeconomic data of the municipality of Villeta and the area surrounding the Plant land, through the investigation of secondary data in official sources and fieldwork with surveys and interviews.

[redacted] then explained the methodology used to identify and evaluate the environmental and social impacts of the Project and the main impacts and risks evaluated for the Project in its construction and operation phases, highlighting that the main ones will be of low magnitude due to the technology adopted for the Plant and the environmental controls that will be applied by the operation and maintenance company to be contracted by Atome. He also described the main measures envisaged in the Environmental and Social Management Plan (ESMP) to prevent, mitigate, control and compensate for the impacts and risks identified and evaluated. The ESMP includes a set of 12 Programs, which [redacted] briefly presented below, highlighting that the measures established in the Programs will be implemented during the construction and operation of the Project as a commitment by Atome to achieve a Project with minimal environmental and social impacts.

Once the presentation was over, Juan Pablo took the floor again and opened the question and answer session.

In general, the main questions and comments related to the following issues:

- Impacts of the Project on the quantity and quality of water in the Paraguay River
- Impacts of the Project on the fishing activity of the Ypeka'e community
- Cumulative impacts of the project, considering other industries installed and planned in the area of influence
- Risks to the population related to hydrogen and ammonia

The full description of the questions and comments made in the Consultation can be found in the Minutes presented in **Annex 5**.

5.0
Conclusion

Considering the proposal presented in the Consultation Plan, it is considered that the general and specific objectives established for the Public Consultation were met.

All stakeholders were informed in advance about the Project and the Public Consultation, through radio disclosures, car with loudspeakers and invitations sent via email and WhatsApp. The presence of a considerable number of people (55 in total), including the important and active participation of residents of the community of Ypeka'e and representatives of the Councillor of Villeta, among other stakeholders from the Project's area of influence, with numerous statements and questions (18 in total), demonstrates the full scope of the outreach activities of the Public Consultation.

The dialogue channel with Atome was established through the availability of email and WhatsApp, and it is expected that the population will use these channels in the next phases of the Project.

6.0
Technical Team

Responsible Directors:	
Juan Piazza	Managing Partner
Ana Maria Iversson	Sociologist
Coordination:	
Renata Cristina Moretti	
Bruno Del Grossi Michelotto	
JGP Technical Team:	
Ana Paula de Azevedo Lima	Technical support / Coordination of the organisation of the public consultation
Renata Michelle A. Oliveira	Visual programming of outreach material

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ANNEXES

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Annex 1 – Photographic Record

JGP	Public Consultation – Free Trade Zone and Green Hydrogen, Ammonia and Fertilizer Production Plant PHOTOGRAPHIC RECORDS	ATOME



Photo 1: Car with loudspeaker doing outreach.



Photo 2: Personal handing out invitations to the residents of Villeta.



Photo 3: Personal handing out invitations to the residents of Villeta.



Photo 4: Free bus provided for the transfer of interested parties from Ypeka'e.

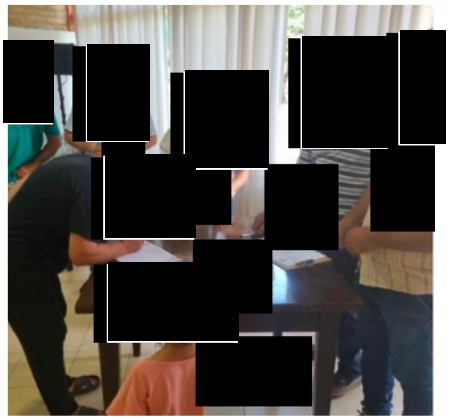




Photo 5 and 6: Participants signing a list of attendance at the event.



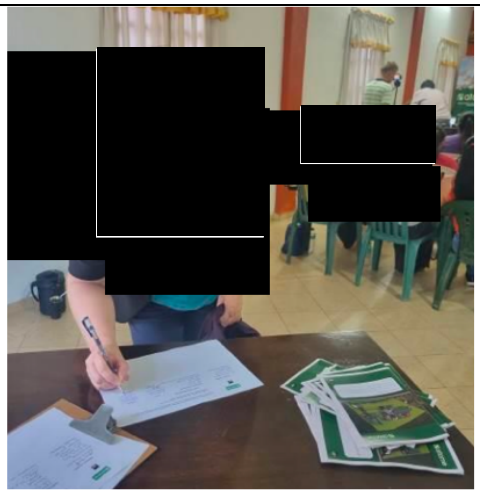


Photo 7 and 8: Participants signing a list of attendance at the event.



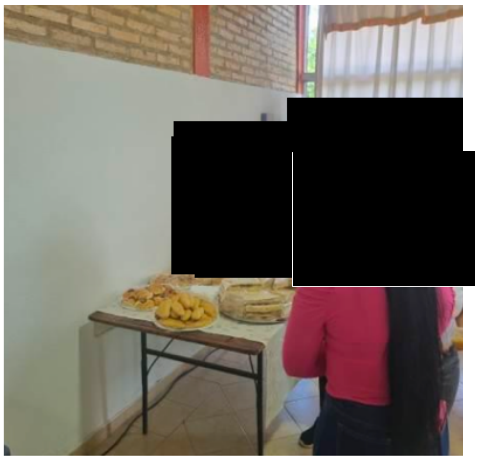


Photo 9 and 10: Refreshments served to participants before and after the Public Consultation.





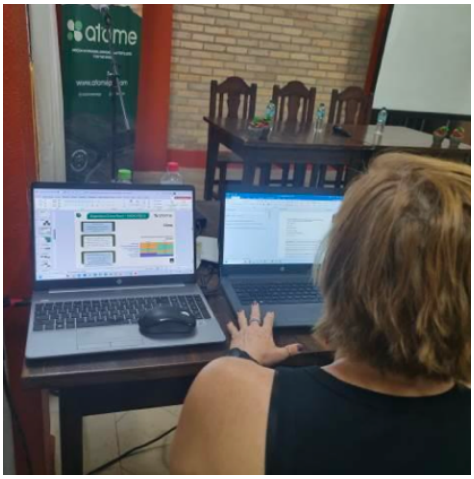
Photo 11: General view of the room where the Public Consultation was held.

Photo 12: Detail of the exterior available.





Photo 13 and 14: Visión general de la asistencia durante la Consulta Pública.



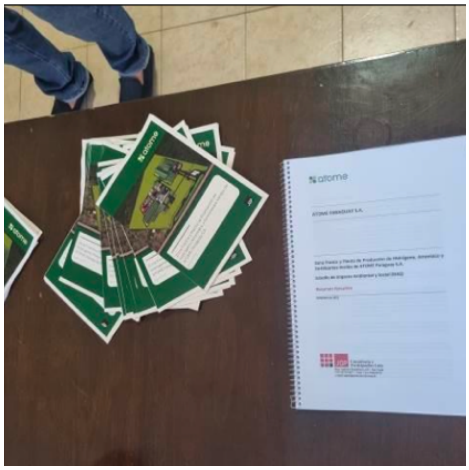


Photo 15: Details of the preparation of the minutes of the Public Consultation

Photo 16: Executive summary of the ESIA available during the event.





Photo 17: Presentation of the project by Juan Pablo Nogués, from ATOME Paraguay.

Photo 18: Presentation of the ESIA by Bruno Michelotto, JGP Consultoria.



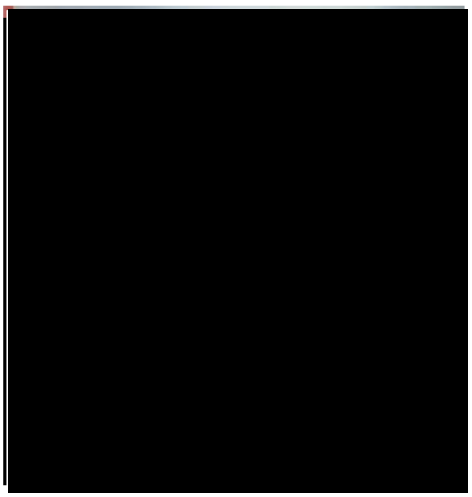
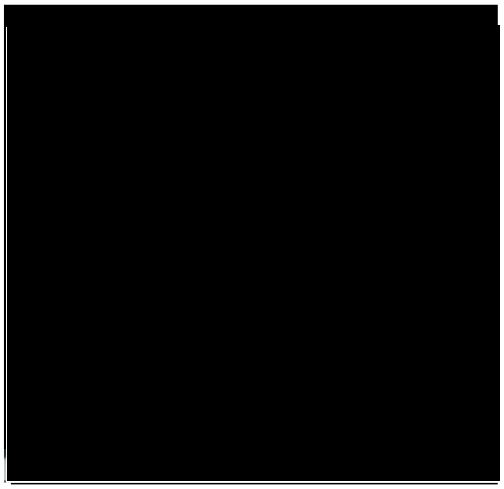


Photo 19 and 20: Participants asking questions orally.



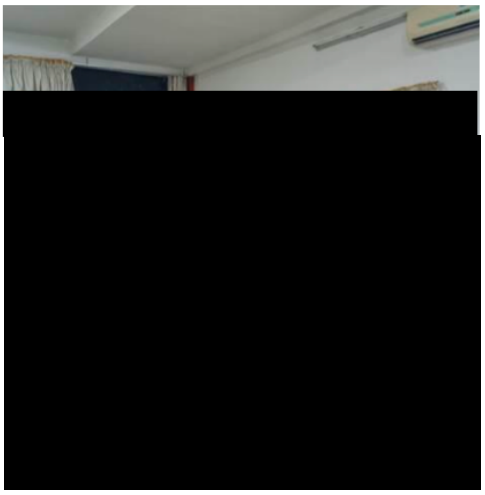


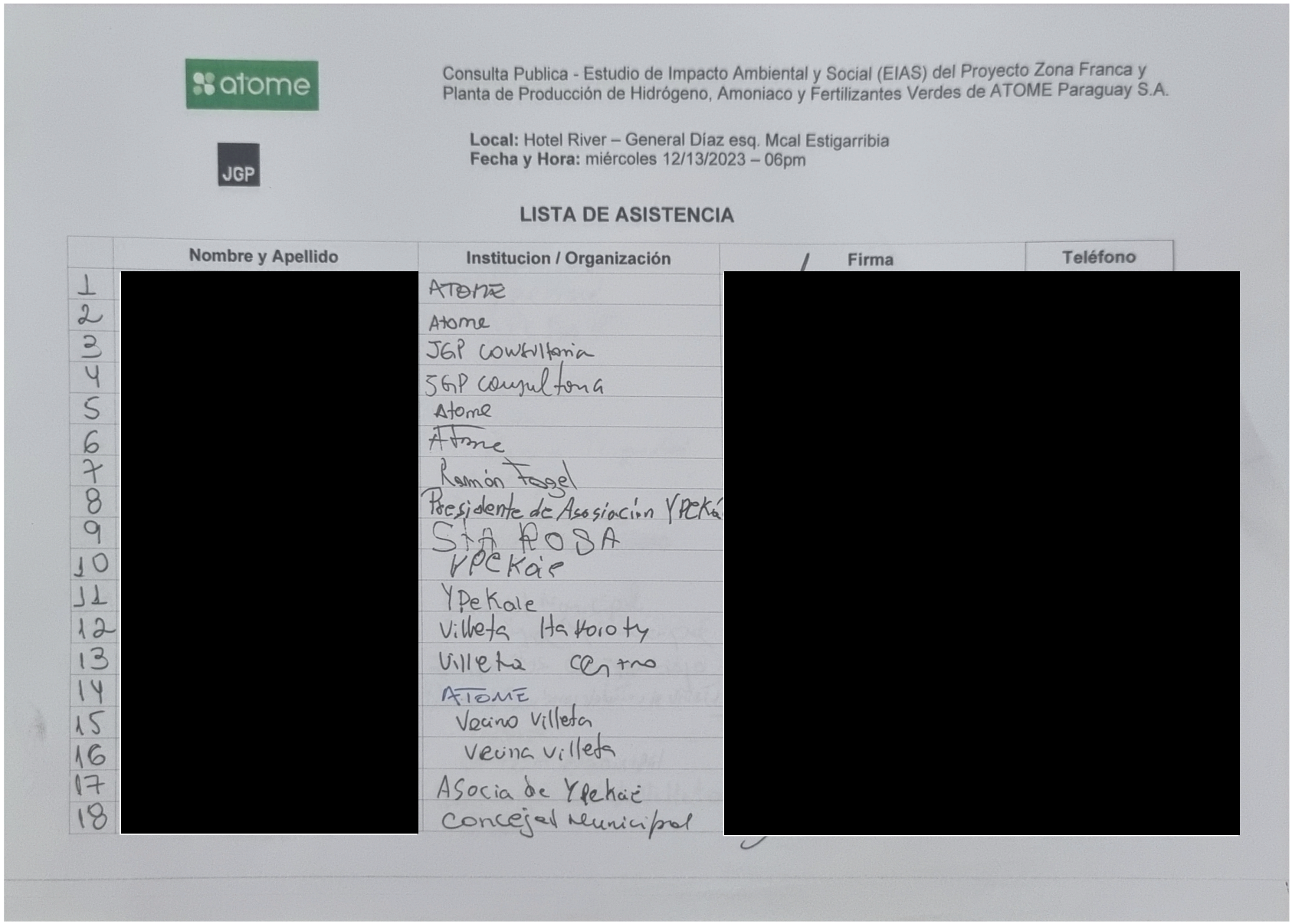
Photo 21 and 22: Participants asking questions orally.





Photo 23 and 24: ATOME and JGP representatives answering questions.

Annex 2 – Attendance List



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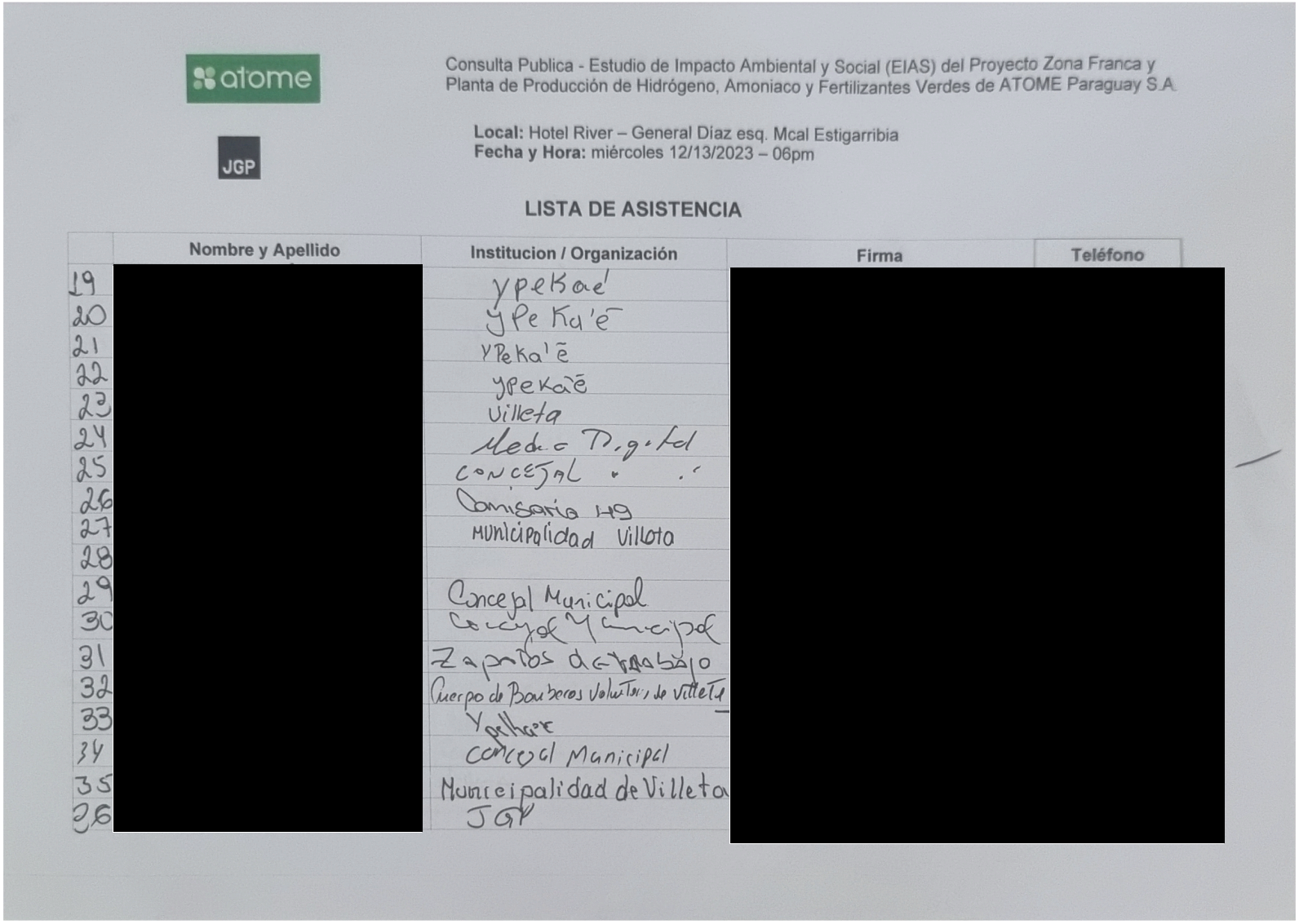
Consulta Publica - Estudio de Impacto Ambiental y Social (EIAS) del Proyecto Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizantes Verdes de ATOME Paraguay S.A.

Local: Hotel River – General Díaz esq. Mcal Estigarribia
Fecha y Hora: miércoles 12/13/2023 – 06pm

LISTA DE ASISTENCIA

	Nombre y Apellido	Institucion / Organización	Firma	Teléfono
1	[redacted]	ATOME	[redacted]	
2		Atome		
3		JGP consultoria		
4		JGP consultoria		
5		Atome		
6		Atome		
7		Ramón Fogel		
8		Presidente de Asociación YPEKAÍ		
9		Sta ROSA		
10		YPEKAÍ		
11		YPEKAÍ		
12		Villeta Hatoroty		
13		Villeta Centro		
14		ATOME		
15		Vecino Villeta		
16		Vecina Villeta		
17		Asocia de YPEKAÍ		
18		Concejal Municipal		



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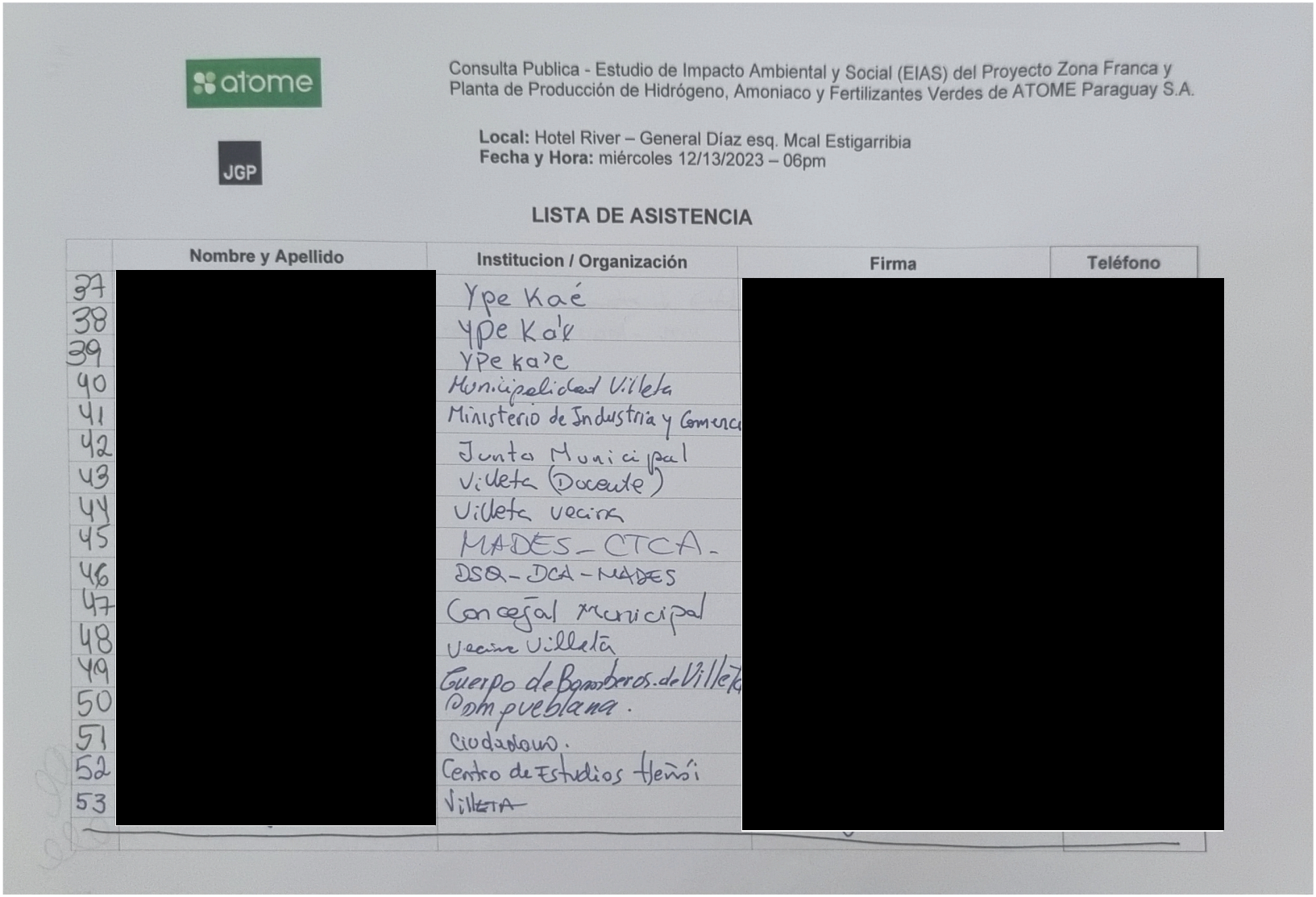
Local: Hotel River – General Díaz esq. Mcal Estigarribia
Fecha y Hora: miércoles 12/13/2023 – 06pm

LISTA DE ASISTENCIA

	Nombre y Apellido	Institucion / Organización	Firma	Teléfono
19	[redacted]	ypekaé	[redacted]	
20		ypeka'é		
21		ypeka'ẽ		
22		ypekaẽ		
23		villeta		
24		Medio Digital		
25		CONCEJAL		
26		Comisaria 19		
27		Municipalidad Villeta		
28				
29		Concejal Municipal		
30		Concejal Municipal		
31		Zapatos de trabajo		
32		Cuerpo de Bomberos Voluntarios de Villeta		
33		Ypekaé		
34		Concejal Municipal		
35		Municipalidad de Villeta		
36		JGP		



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Consulta Publica - Estudio de Impacto Ambiental y Social (EIAS) del Proyecto Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizantes Verdes de ATOME Paraguay S.A.

Local: Hotel River – General Díaz esq. Mcal Estigarribia
Fecha y Hora: miércoles 12/13/2023 – 06pm

LISTA DE ASISTENCIA

	Nombre y Apellido	Institucion / Organización	Firma	Teléfono
37	[redacted]	Ype Kaé	[redacted]	
38		Ype Ka'e		
39		Ype ka'e		
40		Municipalidad Villeta		
41		Ministerio de Industria y Comercio		
42		Junta Municipal		
43		Villeta (Docente)		
44		Villeta vecina		
45		MADES - CTCA.		
46		DSA - DCA - MADES		
47		Concejal municipal		
48		Vecina Villeta		
49		Cuerpo de Bomberos de Villeta		
50		Pompueblana.		
51		Ciudadana.		
52		Centro de Estudios Heñoi		
53		VILLETA		

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Consulta Publica - Estudio de Impacto Ambiental y Social (EIAS) del Proyecto Zona Franca y Planta de Producción de Hidrógeno, Amoniaco y Fertilizantes Verdes de ATOME Paraguay S.A.

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Fecha y Hora: miércoles 12/13/2023 – 06pm

LISTA DE ASISTENCIA

	Nombre y Apellido	Institucion / Organización	Firma	Teléfono
54	[redacted]	Heñoi Centro de Estudios	[redacted]	[redacted]
55		Concejal Municipal - JMV		

Annex 3 – Prospectus

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Free Trade Zone and Hydrogen, Ammonia and Green Fertilizer Production Plant of ATOME Paraguay S.A.

December 2023

JGP

PRESENTATION

This brochure provides information to the population of the area of influence about the ATOME Hydrogen, Ammonia and Green Fertiliser Production Plant Project.

THE PROJECT

The Project consists of a Hydrogen, Ammonia and Green Fertilizer production plant to be built in the city of Villeta, Paraguay, at km 29 of the Villeta- Alberdi road, near the ANDE's Buey Rodeo substation (SE).

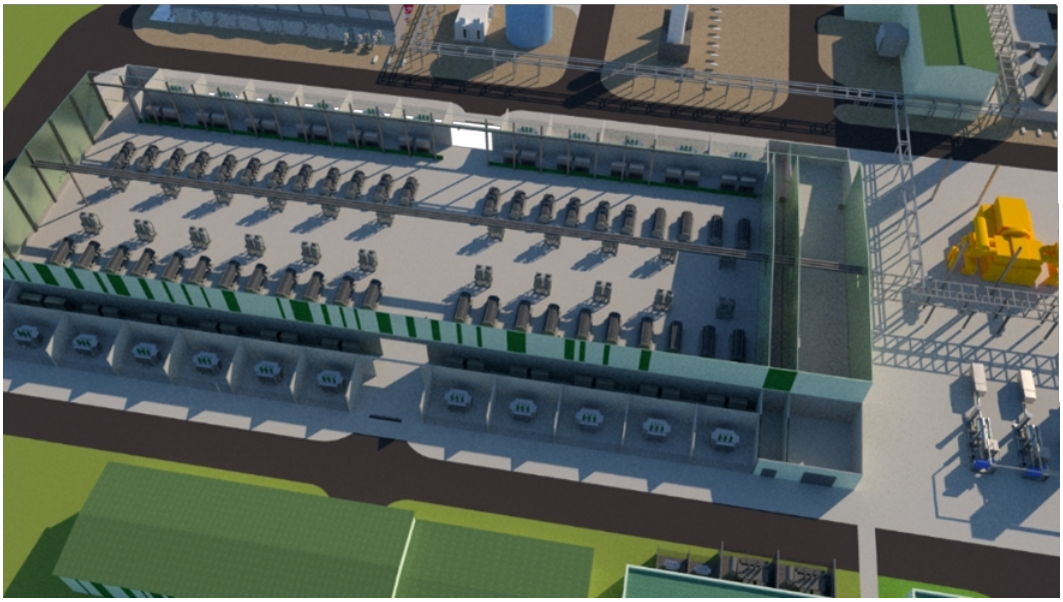
The following components are also part of the project:

- A 220 kV power transmission line (TL) of about 550 m in length.
- Catchment, pumping and piping for water supply from the Paraguay river to the ATOME plant and effluent discharge piping.

The project includes the word green in its name because the production of hydrogen from water will use electricity from a renewable energy source, in this case hydroelectricity (energy produced at the Itaipu power plant).

MAIN PLANT FACILITIES

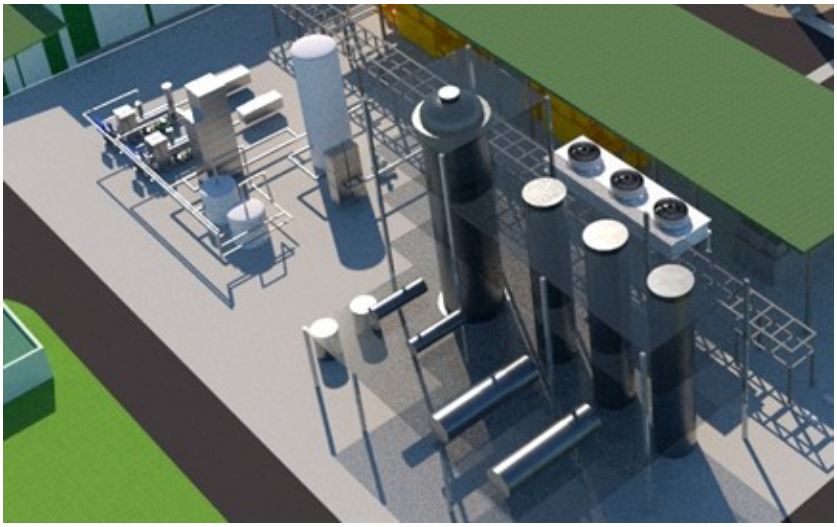
Green Hydrogen Plant (H_2) - Houses electrolysers that produce hydrogen using electrical energy coming from ANDE's Buey Rodeo Substation (SE) through a transmission line (TL). The TL will also be built as part of the project.



View of the hydrogen production plant.

Air Separation Unit - captures air and separates nitrogen from other gases that make up the air. The nitrogen is then used to produce ammonia.

Ammonia Synthesis Unit - houses the reactor where ammonia is produced from the mixture of hydrogen and nitrogen.



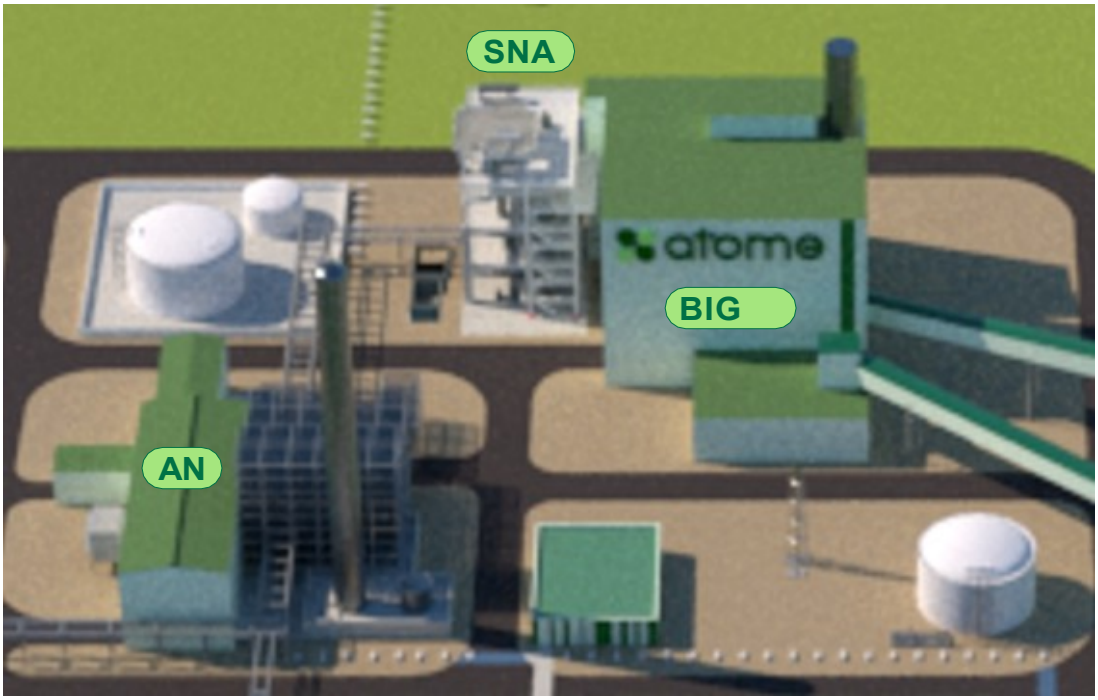
Areas of the plant occupied by the air separation unit (left) and the ammonia synthesis unit (right).

Approximately half of the ammonia produced is sent to the Nitric Acid (NA) Plant and the other half to the Ammonium Nitrate Solution (ANS) Plant. The AN and ANS will be used to make fertiliser.

Nitric Acid Plant (NA) - In this plant, ammonia is transformed into nitric acid by the double pressure process.

Ammonium Nitrate Solution (ANS) Plant - In this plant the nitric acid formed in the AN Plant reacts with ammonia in a reactor, producing ammonium nitrate.

Granulation Plant (GRAN) - This is the last stage of the ATOME Plant, where the Ammonium Nitrate Solution is converted into a type of granular nitrate-based fertiliser (CAN fertiliser).



View of the Nitric Acid (NA) Plants,
Ammonium Nitrate Solution (ANS) and Granulator (GRAN).

Flaring System - The ATOME Plant will include a flaring system to burn hazardous or flammable gases in cases of emergency or specific process conditions, discharging them afterwards to the atmosphere. The system will comply with the limits established by Paraguayan environmental legislation and international standards.

AUXILIARY PLANT INSTALLATIONS

Raw Water Collection System - The water to be used for process, service, fire fighting, cooling and drinking water will be collected from the Paraguay River and pumped to the plant. The estimated flow will be 242.70 m³/h and the flow returned to the river will be 77.30 m³/h, being the total water consumption 165.4 m³/h equivalent to 0.008% of the lowest flow of the river.

Raw Water Treatment Plant - In this plant the water will be pre-treated and then part of it will be made potable and part demineralised.

Wastewater Treatment Plant (WWTP) - This plant will treat the effluent from the pre-treatment and demineralisation system, oily network, non-oily network and sanitary effluent. The treated effluent will be conducted to the Paraguay River through a buried pipeline, parallel to the raw water pipeline. The effluent will comply with the quality established in Paraguayan legislation and international standards, returning water to the river with a better quality than the existing one.

Plant Substation and High Voltage Transmission Line - The 220 kV, 550 m long transmission line will carry power from ANDE's Buey Rodeo Substation to the Plant, connecting this substation to the Plant's internal substation.

Plant Production Capacity

Hydrogen production rate	1,802.0 kg/h
Ammonia production rate	10,165 kg/h
Fertiliser production rate	31,958 kg/h

Area Directly Affected by the Project: 30 ha of plant land, the easement strips of the TL (3.30 ha or 33,000 m²) and of the water and effluent pipelines (1.15 ha or 11,500 m²).

Number of workers:

- Construction phase: 461 workers at the peak of the works, with a proportion to be recruited locally.
- Operation phase: 240 direct jobs, 195 permanent and 45 temporary.
  In addition, some 874 indirect jobs will be generated.

Construction schedule: The plant will be built in approximately 31 months, with 6 months for commissioning and testing.

Positive impacts of the Project: Generation of direct and indirect jobs during construction and operation; Improvement of the economy of Villeta; Reduction of Greenhouse Gas (GHG) emissions and carbon footprint.

DO YOU HAVE ANY QUESTIONS OR WOULD YOU LIKE TO MAKE A REQUEST/COMMENT?

www.atomeplc.com/projects/paraguay/
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021 664 493

Annex 4 – Presentation of the Project and ESIA

Annex 5 – Minutes of the Public Consultation

Minutes of the Public Consultation of the Project "Free Trade Zone and Hydrogen, Ammonia and Green Fertilizer Production Plant" of ATOME Paraguay S.A.

Date: 13/12/2023
Time: 6 p.m.
Location: Villeta, Paraguay

The event kicked off at 6:07 pm.

Viviana Brun, environmental coordinator of Atome Paraguay S.A., welcomed everyone to the event, explained the dynamics of the meeting and the objectives and expected results, highlighting that the contributions of those present will be taken into account in the final version of the ESIA.

Next, Juan Pablo Nogues, Project Manager of Atome Paraguay, thanked those present, and continued to present information about the Atome company and details of the Project, including the location and its components, information about hydrogen, ammonia and green fertilizer and their advantages, the main and auxiliary facilities of the Plant, the operation and maintenance aspects and the environmental controls that will be adopted to avoid and minimize impacts.

Juan Pablo then gave the floor to [redacted] consultant and specialist in Physical Environment at JGP Consultoria, the Brazilian company responsible for the preparation of the ESIA, to continue the presentation, summarizing the main points of the studies.

[redacted] began the presentation with the studies of locational and technological alternatives carried out for the Plant, the power transmission line (LT) and the water and effluent pipes, and that the objectives of these studies were to achieve a Project with the best possible technology and to seek the most suitable location for its construction and operation. in order to cause the least possible environmental and social impact.

He also presented succinct information on the baseline made for the areas of indirect and direct influence and the area directly affected by the Project. He explained the studies and data collection on climate, water resources, geology, geomorphology and soils, environmental noise and air quality, flora and fauna, and socioeconomic data of the municipality of Villeta and the area surrounding the Plant land, through the investigation of secondary data in official sources and fieldwork with surveys and interviews.

[redacted] then explained the methodology used to identify and evaluate the environmental and social impacts of the Project and the main impacts and risks evaluated for the Project in its construction and operation phases, highlighting that the main ones will be of low magnitude due to the technology adopted for the Plant and the environmental controls that will be applied by the operation and maintenance company to be contracted by Atome. He also described the main measures envisaged in the Environmental and Social Management Plan (ESMP) to prevent, mitigate, control and compensate for the impacts and risks identified and evaluated. The ESMP includes a set of 12 Programs, which [redacted] briefly presented below, highlighting that the measures established in the Programs will be implemented during the construction and

operation of the Project as a commitment by Atome to achieve a Project with minimal environmental and social impacts.

Once the presentation was over, Juan Pablo took the floor again and opened the question/comment and answer session.

Question 1:

Ms. [redacted] from the Ypeka'e Community, began her question by commenting on the importance of fishing for the community, and that she feared the impact of the Project on the quantity and quality of water in the Paraguay River, considering the other current and future uses of the river, and the consequences of this cumulative impact on the community's fishing activity.

Answer:

The answer was given by [redacted], who mentioned that JGP has conducted a cumulative impact study, which was not on the slides, but is listed in the ESIA. The study found that the magnitude of the impact of the Atome Project on water quality and quantity is much smaller than the impact of the other planned projects and those already occurring in the area of influence. According to him, the cumulative effect of the projects is important, but the expected effect of the Atome Plant is very, very low. He spoke about the wastewater treatment planned at the Plant, which will comply with Paraguayan and international legislation.

Viviana, from Atome, added that, in addition to mitigation and prevention measures, it is important to know that compliance with Paraguayan and international legislation has already been taken into account from the design stage, so that the technologies chosen for the Project are the best in terms of prevention and mitigation of impacts. Thus, it is expected that what is discharged into the river will be of better quality than the water we have today.

Question 2:

Mr. [redacted], from the Municipal Council of Villeta - Councilor, mentioned that the importance of Paraguay is well known due to the availability of energy and fresh water. He said that this type of project posed a great risk of reducing water flow and impacting water quality. He asked if a project could be rejected by the environmental agency if the impacts were high. It is also concerned about the cumulative effect of the Atome Project with those already in place and the effect over time.
Another positive comment by [redacted] concerns the jobs that will be created.

Answer:

[redacted] began his response by mentioning that the study could indeed have a negative conclusion on the part of the consultancy and the environmental agency, and he recounted an example that occurred in Brazil. However, in the case of Atome, the ESIA team is very confident in the impacts that have been identified, the proposed control measures, and the capacity to support the environment. As for the long-term effect, 20 years from now, for example, he

assumed that there is no way to know if the environment will be able to withstand it, among other things because it will depend on future projects that are approved in the area of influence.

Juan Pablo, from Atome, complemented the answer by giving an idea of the volume of water that the Plant will capture and the minimum percentage it represents in relation to the flow of the river. He also stressed that Atome will have to comply with national and international legislation. In the event of a drought, you will have to respect the permitted collection volumes, even if they are lower than the needs of the Plant. Juan Pablo mentioned that today they do not need to pay the fee.

Comment 3:

Another representative of the Ypeka'e Community mentioned that there will be two associations affected by the Project and the residents are very concerned because fishing is the only livelihood of the families and they are not included in the company's program.

Answer:

[redacted] gave the answer, mentioning that the Project is in a very early phase. A stakeholder relations program is planned, and the Ypeka'e community will be one of the main focuses of social communication to be carried out as part of this program, as it is the main community located downstream of the project. Communication has already begun with the ESIA social surveys, but will intensify during construction and operation.

They may not have been seen in the presentation (in fact, the community is mentioned in the Nearby Communities slide), but they are in the ESIA.

Viviana stressed that the stakeholder relations program is one of the most important for Atome and will begin immediately, including not only the Ypeka'e community, but also residents neighboring the Plant site and other stakeholders. He insisted once again that the project also includes effluent and water quality control measures, and that the community can rest assured that the company will share the results of the measures with the community.

Question 4:

A representative of the Center for Heñoi Studies asked what the implications of the name Free Trade Zone are.

Answer:

Juan Pablo, from Atome, explained that it was mainly a tax issue. Free Trade Zone is established by decree and has tax benefits for the purchase of equipment and services during the works. He also explained the benefits of a free zone that can be returned to the country.

Comment 5:

Mr. [redacted] from Concejal, continuing with the issue of taxes, commented that even though it is a free zone, Villeta has a municipal tax on construction.

Comment 6:

One participant commented that mitigation measures are super important and need to be worked on very carefully. The measures must be explained in detail, mainly the treatment of water for return to the river and for cases of leakage of by-products and products, which are very volatile.

Answer:

Juan Pablo explained that they are doing everything very carefully, both the design and the preparation of environmental and social control measures. No one but Atome is interested in the project being as good as possible from a socio-environmental and economic point of view. They are using all the technologies and based on international standards. And you can go into more detail about the measurements and design another time.

Question 7:

One participant asked about the impact on air quality. It called for a better explanation of the modelling carried out and the expected impacts. He also asked if JGP has experience in this type of H2 project, and if it is in a position to know and predict the impacts and risks to the population.

Answer:

[redacted] replied that, knowing that the Project could emit pollutants, an atmospheric dispersion modelling was carried out, based on the plant's emissions and climatic conditions. He explained that in Paraguay there is a preferential natural path of the wind through the valley. The modelling showed that there is a risk of impact on air quality, but that it will be of low magnitude. He explained in much more detail the dispersal conditions in winter and how this can influence the dispersion of pollutants, explaining that this would be the worst period. During the summer, the risk of impact on air quality is lower.

He mentioned again what Viviana had already said, that the technology adopted and designed for the Plant aimed to use equipment that emitted the lowest levels of pollutants into the atmosphere to comply with national and international legislation.

He mentioned that there may be periods of critical events, such as droughts. However, the Project provides for air quality monitoring, which will indicate the eventual need to intensify mitigation measures.

[redacted] reviewed JGP's experience, of the different projects that the company has already carried out, but that the modelling of an H2 plant is in fact the first to be carried out.
Juan Pablo mentioned that this plant is the first in Latin America and that it will be installed in Paraguay mainly because the country has renewable energy. He mentioned the gases that will be vented, mainly oxygen, which is not polluting. And that there will be emissions of NOx, SO2 and particulate matter, but they will be minimal, and mitigation measures are planned. Viviana re-emphasized the adoption of technology to comply with international measures, including those of the WHO, to guarantee the integrity of the population's health.

Comment 8:

Another representative of the Villeta Council said that she had many questions that would be impossible to answer in the two-hour duration of the Public Consultation. That they should form a working group to discuss the Project. That the H_2 production project has been presented in the Consultation as a very nice project that uses renewable energy, but that it does not know all the uses that H2 can have and that it is a highly explosive product. That in Villeta there are industries that use H2 and have a product storage system in which a lot of investment is made to comply with safety standards. He also highlighted the risks and problems of liquid ammonia. The third product, fertilizer, doesn't worry him.

He wants to dig deeper into these risks to the community. He says that the company should sit down with the municipality to look at the expected impacts and study the measures together, especially to provide previous experiences to improve the project. He believes that it is good that Villeta continues to grow, but that there must be a balance between economic growth and the preservation of the environment.

He praised the initiative to carry out the Public Consultation and to make a contact number and an email available to the population.

Answer:

Juan Pablo de Atome thanked them and said they would organize a more technical presentation for the Councilman.

He clarified that

That the final product of the plant is fertilizer, which is very stable and everyone knows how to handle.

they will not store H2 or NH3, and that these hazardous products will go directly through the production chain to make fertilizer. The plant will link all production chains.

Comment 9:

Mr. [redacted] from the Heñoi Study Center, mentioned that it has been pointed out during the presentation that the Project site has no neighbors, that it is a place where there is nothing around. However, in front of the Buey Rodeo substation, a mine is being built, and next to the project, the Omega Green biofuels plant is going to be built. All of these projects together will have impacts. He also mentioned that the wetlands that occur in the area where the projects will be built are the ecosystem that captures the most carbon. That it has been said that the Atome Project will reduce the carbon footprint, but that this is not credible, since the construction of large factories in a place where it will be necessary to remove native vegetation and impact wetlands, should result in an increase and not a reduction in the carbon footprint.

Answer:

[redacted] responded by highlighting [redacted] observation on the characteristics of wetlands and their importance to the carbon chain. However, he clarified that the Atome project does not foresee any intervention in this type of land.

He confirmed that native vegetation will be cut down for the Project and that carbon will be released. However, there will be a compensation program that includes the planting of native vegetation.

He again mentioned the studies of alternatives that had been carried out. And the compensatory measures envisaged for impacts that cannot be avoided, such as the removal of vegetation. And that based on all of the above, the reduction of the Project's carbon footprint in the long term is positive.

Juan Pablo complemented by giving more details about the accounts of the carbon balance and highlighting that the calculations are not made for the project area, but in a broader way, considering the entire chain.

Viviana also pointed out that there is compensation for the environmental services that the Project will fulfill, and based on this, they will have to compensate even more than the impact. And what is affected by forest must be compensated with forest; What is affected by Savannah must be compensated with Savannah. In addition, Villeta is demanding a compensatory planting for the felled trees. They will comply with everything that the city council asks of them. He also mentioned the measures to repel and rescue fauna and rescue germplasm and that the aforementioned measures are only part of the set of measures that Atome will implement not only to comply with Paraguayan legislation, but also with international legislation.

[redacted] responded again, emphasizing that a cumulative impact study has been conducted for the Project and that it has been evaluated and approved by the top cumulative impact specialist at present. There is a cumulative impact management program that provides for collective management of these impacts by all Project promoters.

Comment 10:

Once again, Mr. [redacted], from Councillor, also insisted on the importance of wetlands, and that he is also concerned that the Project will exploit groundwater.

Answer:

He was told that the project will only use water from the Paraguay River. They will not collect groundwater. The quality of the groundwater from an existing well on the Plant's land has been studied, but it is brackish, which would be harmful to the machines and would require a very sophisticated treatment.

Comment 11:

Despite having her question answered, Ms. [redacted], from the Ypeka'e Community, again expressed that the fishermen of Ypeka'e are very concerned and asked when the project is expected to start impacting the water and fish.

Answer:

[redacted] responded again by sizing the flow that the Project will capture in comparison to the flow of the river. And that this represents a low risk that the Project will affect the river in terms of flow reduction, water pollution and impact on fish.

Juan Pablo complemented by clarifying that the project will not begin to pollute the water. That measures and controls are being planned so that the treated effluent returned to the river is even better than the water collected. He also explained that the treated effluent will be discharged into the river at a point near the catchment, through a subfluvial pipe, which will discharge the effluent in a place away from the shore.

This again explains that the project is not expected to have a significant impact on the quantity and quality of water or fish. He again explained how the water will be captured and how much will be collected, and that the treated wastewater will be returned near the catchment, which means that the water will be collected.

Regarding the start date of the Project, he explained that it is not yet defined. That the company expects that work can begin in the first months of 2024, that the construction will last 2 years and therefore the operation is expected for 2026.

Viviana added that all stakeholders interested in the project will be informed of the planned dates. The communication strategy must ensure the transparency of the Project.

Comment 12:

Another participant mentioned the time it takes to carry out and see the results of renewable resource recovery measures, such as reforestation, flora and fauna recovery, wastewater treatment, and water quality monitoring. He says this based on the experience they have of the construction of the hydroelectric plant, since the works are carried out very quickly compared to the time needed for reforestation and other recovery measures.

The concern is because there is a population that depends on the resource, and the water is already heavily polluted and temperatures are very high. That is why they have to continue monitoring to see if everything is being executed as planned and if the measures applied are having an effect.

Question 13:

One participant commented on the more than 30 years of experience [redacted] had mentioned JGP had. He asked what environmental problems the company had in its different projects over the

past 30 years and whether the company had received any major wake-up calls from the environmental authorities in that time.

Answer:

[redacted] mentioned that the company has seen numerous problems and gave as an example the Belo Monte hydroelectric project, which has some threatened fish species that exist only there. That we have already seen the sale of rare species. However, JGP is a consulting company that does not carry out the work, it is not the cause of the impact. It is a company that is contracted to evaluate the impacts of projects, advising private, public or intergovernmental clients on how to carry out projects in the best possible way, based on the best performance standards.

Comment 14:

Another participant mentioned that the population's fear is the added impacts, taking into account other industries. That the problem is not the Atome project, but the combined effect of all the projects. However, it trusts that social responsibility measures will be applied during the execution and operation to communicate, involve communities and reduce impacts.

Answer:

[redacted] agreed and stressed that this is the case. That is the objective of this Public Consultation. For problems to be mentioned and discussed, and for solutions to be discussed together.

Comment 15:

Another participant mentioned that he was concerned about the issue of public health. The Project should provide for follow-up in this regard, as many outsiders are likely to be interested in the Project. He also mentioned the need to provide clear information to the population.

Answer:

Juan Pablo responded, pointing out that Atome has made available contact channels (email and phone) for doubts and queries, and showed them in the ppt presentation that was still on the big screen. He clarified that the work will not begin tomorrow and that Atome has a direct line to the municipality and the Councilor, and that they will continue to meet to answer any questions and answer them as far as possible. And that, if another hearing is necessary, they can hold it.

Comment 16:

Another participant again congratulated the company for carrying out the public consultation and opening the communication channel for the population to express their concerns. He said it was good to know the commitments that Atome was going to make. He thanked the company for getting the community involved now.

Answer:

Viviana responded, highlighting that the company has an Environmental, Social and Health and Safety Management System, which must prepare monthly and quarterly reports on the implementation of the measures, and that within a ESMP Program it is planned to share with the municipality a quarterly bulletin to report on the progress and results of the application of the measures. including a summary of the monitoring to be carried out. This will give people peace of mind, who will be able to accompany if the company is meeting its commitments.

Comment 17:

Another participant mentioned that during the Consultation there was a lot of talk that the project would comply with international standards, but that municipal ordinances would have to be consulted. That there is one that deals with the issue of odour control, an issue that is not dealt with in national legislation.

He added by congratulating the company for carrying out the consultation and that he hopes that this practice will be applied to all projects, allowing the population to get to know them and express their concerns.

Comment 18:

Another participant also congratulated the company on the hearing. However, she agreed with the other Ms. that another public consultation should be held to deal with the issues more calmly. He mentioned again that the flow that will be extracted for the Project will be small, but that there are large rice companies in the city and that the sum of water uses will be important. He also mentioned that there are nearby communities, Ypeka'e and Santa Rosa, where several of those present at the hearing were from, although the studies had not mentioned them. Finally, he said that Councilman participants should discuss whether to approve or reject the project.

Answer:

[redacted] mentioned that the communities had been identified in the studies. They may not have been included in the submission, but they are in the ESIA, which will be made public.
That this meeting is being recorded in minutes and on a recording, and that all the information discussed today will be incorporated into the study. This consultation is one of the tools to develop the project in the best possible way.

Juan Pablo said he would be available to continue discussing questions and comments in private. As there were no further questions or comments, he adjourned the meeting.

The consultation ended at 8:07 pm.

Annex 14 – Risk Area Figures

Public Consultation

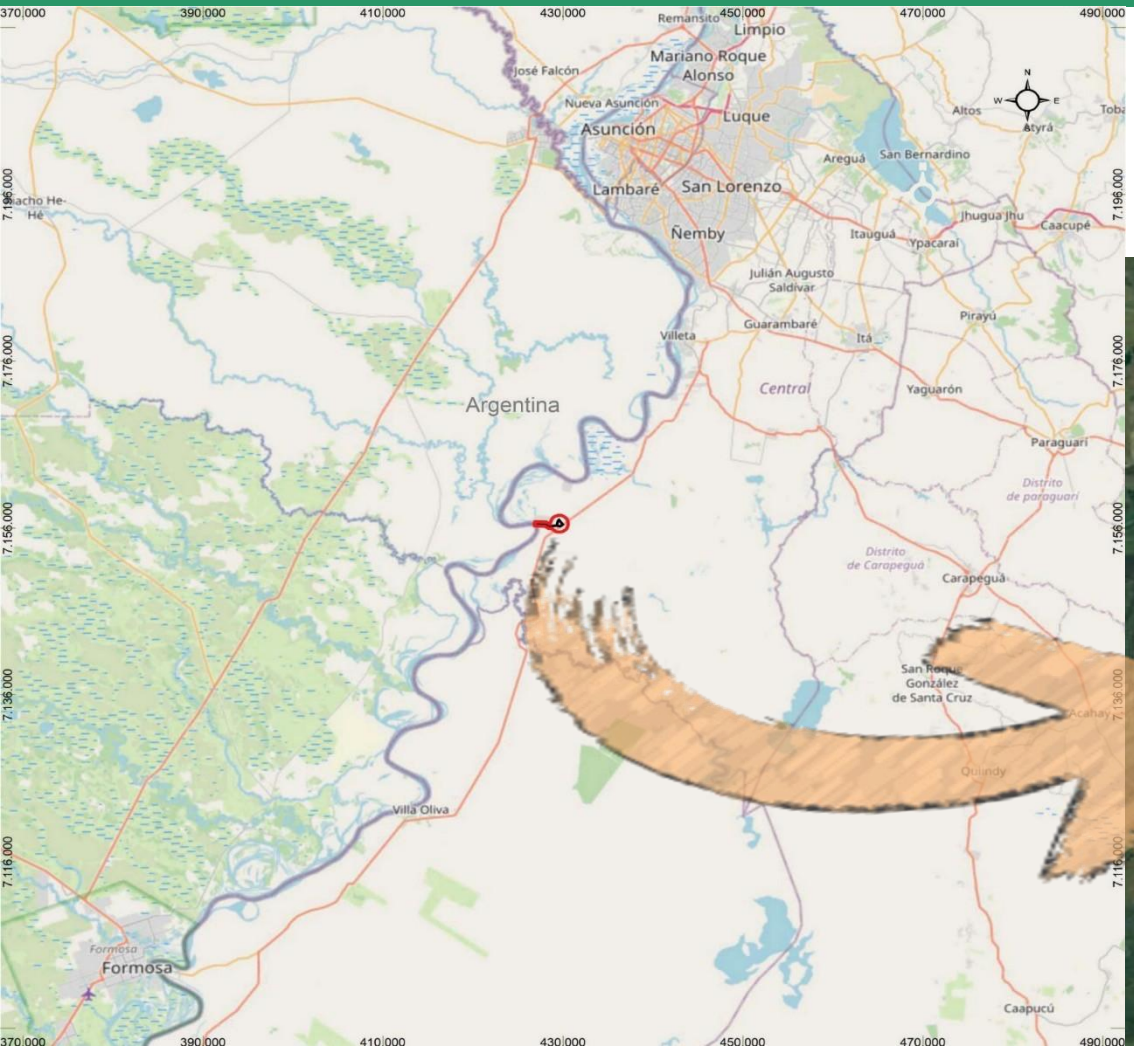
Green Hydrogen, Ammonia and Fertilizer Production Plant by ATOME Paraguay S.A.

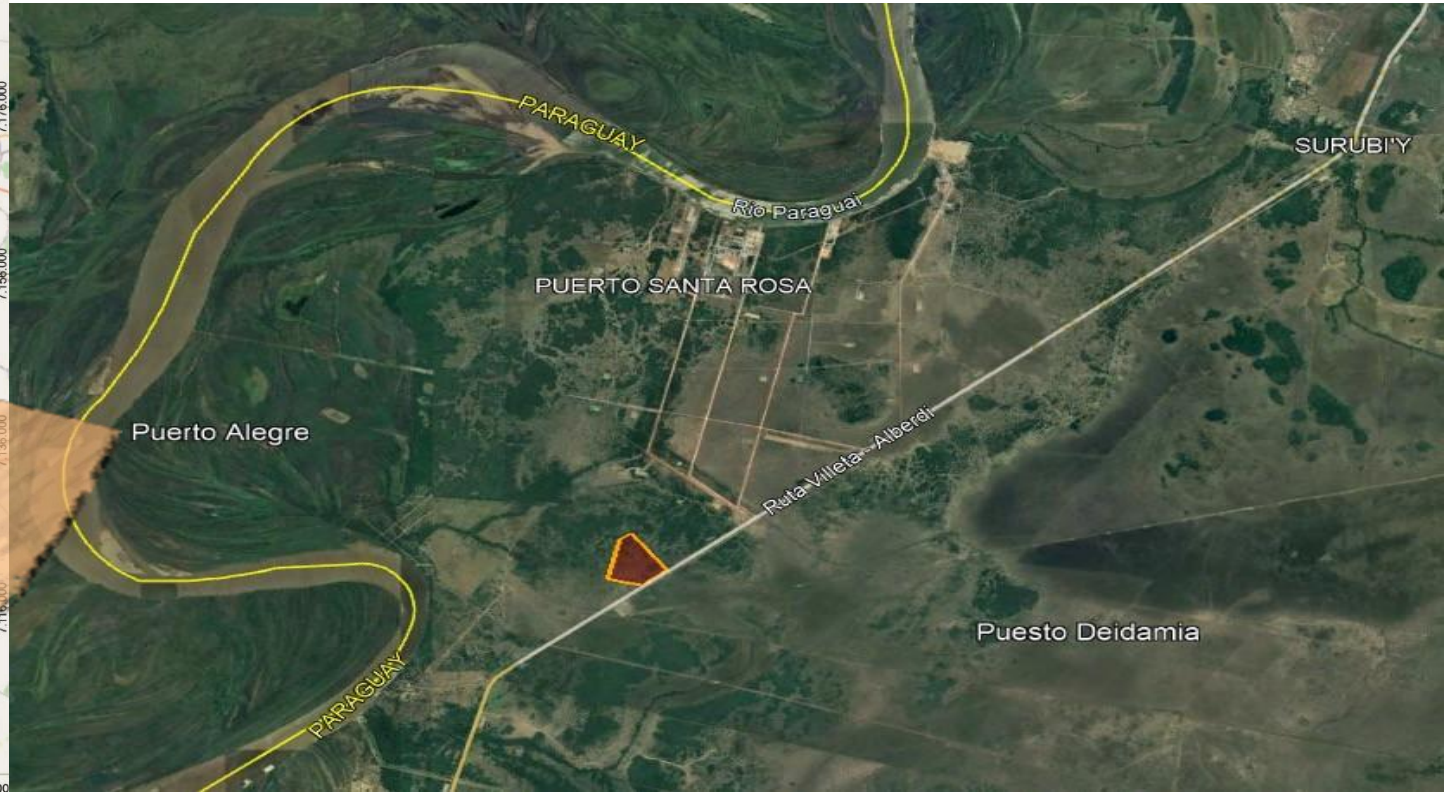


December/2023

Location

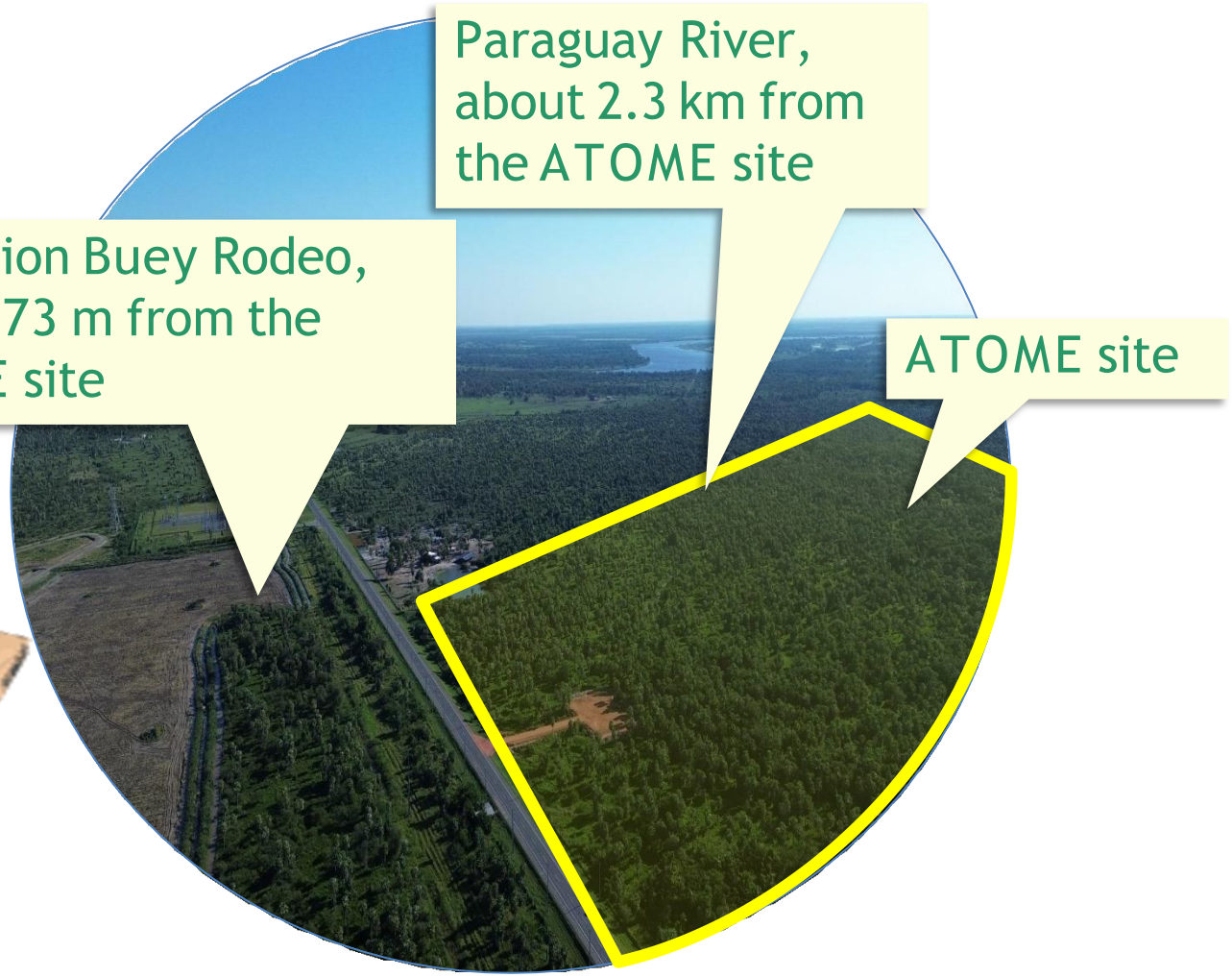
City of Villeta, Paraguay, km 29 of the route Villeta Alberdi, close to the ANDE's Substation (SE) Buey Rodeo.





Location


Limpio
Mariano Roque Alonso
José Falcón
Nueva Asunción
Asunción
Luque
Altos
Atyrá
Areguá
San Bernardino
Lambaré
San Lorenzo
Ñemby
Itauguá
Ypacaraí
Jhugua Jhu
Caacupé
Julián Augusto Saldívar
Guarambaré
Villeta
Itá
Pirayú
Central
Yaguarón
Argentina
Distrito de paraguari
Distrito de Carapeguá
Carapeguá
San Roque González de Santa Cruz
Acahay
Quiindy
Villa Oliva
Formosa
Caapucú

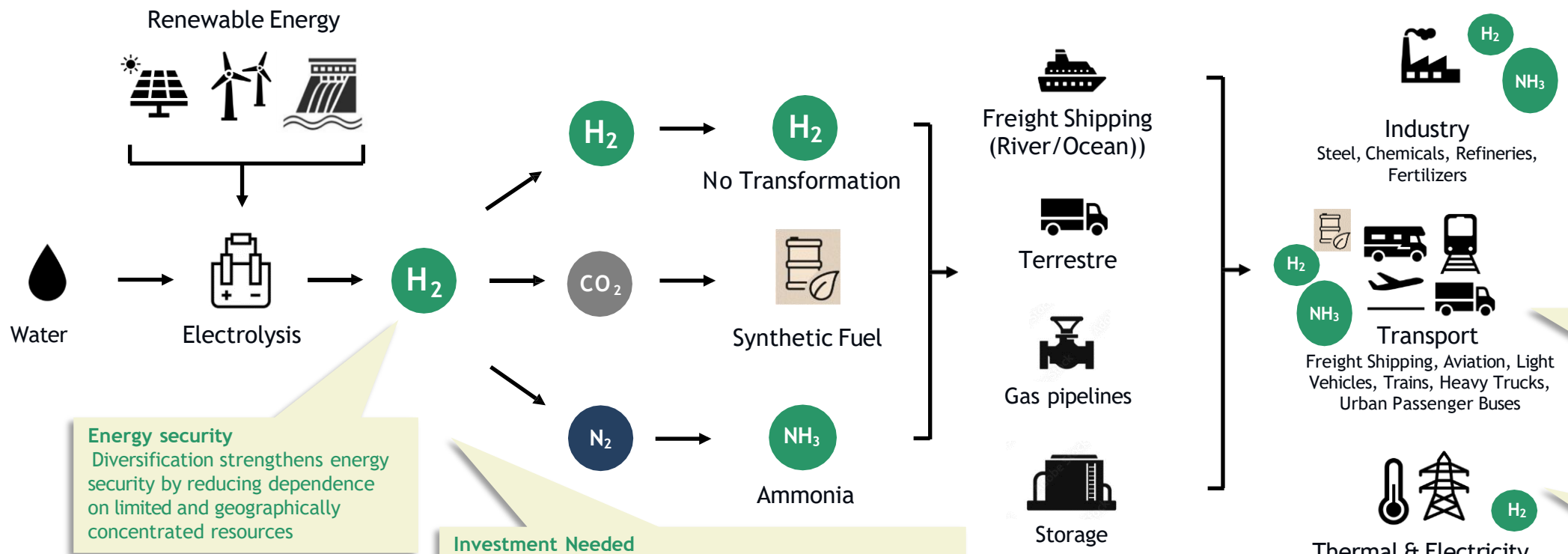

Paraguay River, about 2.3 km from the ATOME site
Substation Buey Rodeo, about 273 m from the ATOME site
ATOME site

Green Hydrogen (H2)

Green Hydrogen Value Chain

Global contribution to the Paris Agreement
Mass adoption of green H2 will contribute to the global goal of limiting global warming to 1.5°C

Production | **Transformation** | **Transport** | **Final Use**



Promotion of green jobs
Creating employment opportunities in sustainable industries and developing a workforce focused on clean technologies.

Clean Fuel
Decarbonisation of the transport, heating and industrial production sector, reducing dependence on fossil fuels.

Energy Storage
On a large scale and over long periods of time, it solves the intermittency of renewable sources

Energy security
Diversification strengthens energy security by reducing dependence on limited and geographically concentrated resources

Investment Needed
Goldman Sachs – Global Investment Research estimates that $5 trillion of investment in the low-carbon hydrogen supply chain is needed to achieve net-zero emissions by 2050 [3]

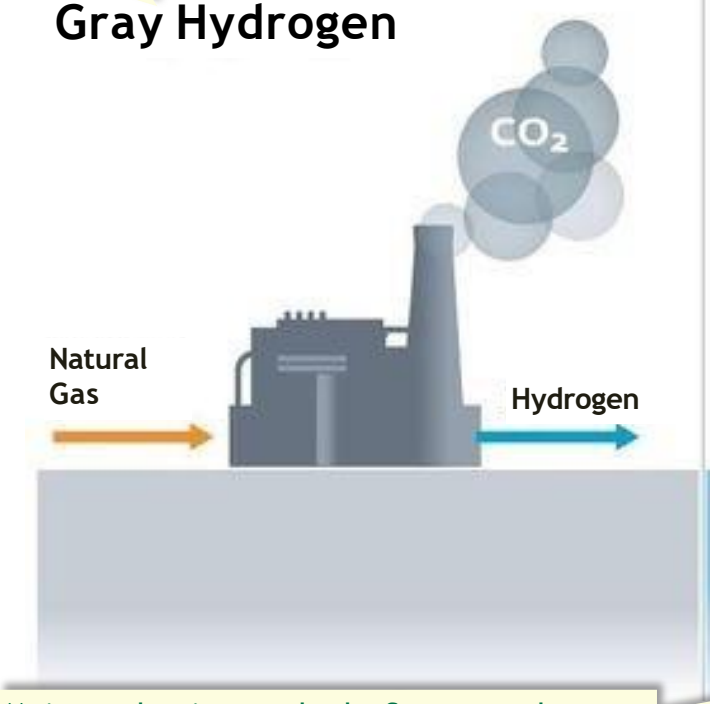
1 Reuters - Ten clean hydrogen policies and initiatives from across the globe 2. Goldman Sachs - estimates of possible future scenarios 3. Goldman Sachs - Global Investment Research

Green Hydrogen (H_2)

A key element for the energy transition

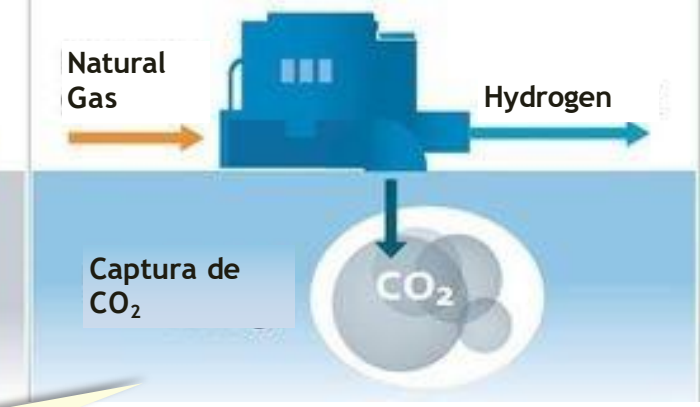
More than 95% of today's hydrogen is produced from fossil fuels

Gray Hydrogen

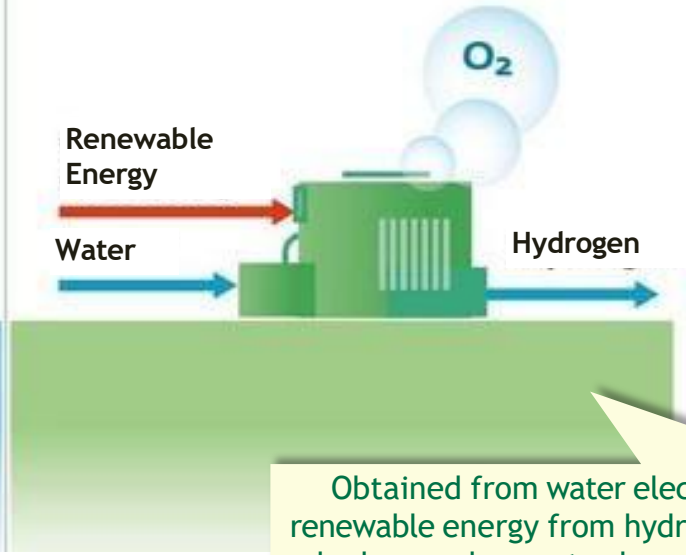


Main production methods: Steam methane reforming and coal gasification.
Both processes release carbon dioxide (CO2)

Blue Hydrogen



Green Hydrogen



Obtained from water electrolysis and renewable energy from hydropower, green hydrogen does not release greenhouse gases

Green Hydrogen H_2

For the production of ammonia and green fertilizer

Raw Materials
- Renewable energy
- Water
- Aiir

Electrolysis

Green Hydrogen
- For ammonia production
- Zero emission transport (**Mobility Project**)

Ammonia Synthesis

Ammonia
- Fertilizer Production (**Latin America**)
- Marine Fuel(**Island**)

Nitric Acid Limestone

CAN+
- Green Fertilizer (**Villeta Project**)

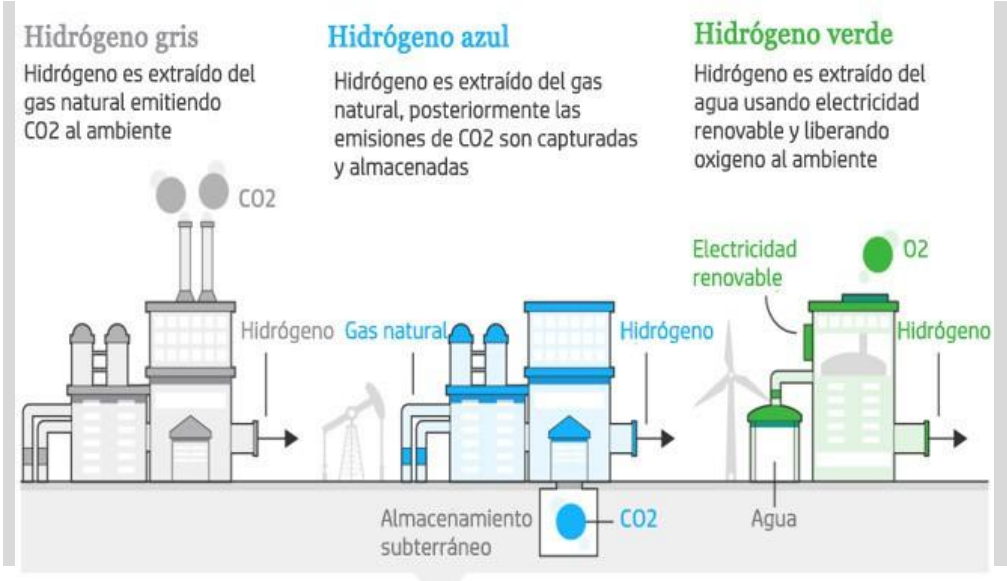
Displacement of grey hydrogen: More than 95% of today's hydrogen is produced from fossil fuels.

Transition to green energy: Low-carbon hydrogen could supply up to 25% of the world's energy by 2050, with a global use of 450 million tonnes of green hydrogen [1] Hydrogen is considered the green fuel of the future and a potential substitute for fossil fuels, making it one of the key strategies to achieve "decarbonisation" by 2050 as encompassed in international agreements.

Economy of scale: The low-carbon or clean hydrogen sector is expected to generate $2.5 trillion in revenue by 2030, creating 30 million jobs [2].

Government Support: $370 billion IRA investments in the U.S. for climate and clean energy. The EU's €800 million Green Deal. The UK's Net Zero Hydrogen Fund.

Investment needed: $5 trillion of investment in the low-carbon hydrogen supply chain is required to achieve the goal of zero emissions [3].



1. Reuters - Ten clean hydrogen policies and initiatives from across the globe, 2. Goldman Sachs – estimates of possible future scenarios 3. Goldman Sachs - Global Investment Research

The Project

Green Fertilizer (CAN)

Project Components

- Hydrogen, Ammonia and Green Fertilizers production plant.
- 220 kV electrical transmission line (LT) and about 550 m long.
- Water catchment system from the Paraguay River to the ATOME Plant and effluent discharge pipes.

¿Why the Plant Is Considered Green?

The production of hydrogen from water will use electricity from a renewable energy source, in this case hydroelectric (energy produced at the Itaipu plant).

By not using fossil fuels as raw materials and for electricity generation, the Project foresees a reduction in greenhouse gas (GHG) emissions and their contribution to climate change.

The Project

Green Fertilizer (CAN)

Transporte

CAN – Nitrato de amonio y calcio 250.000 t/año - (757 t/dia)

Consumo nacional:

- Transporte terrestre en camiones pesados de 30 t/viaje de capacidad.
- 700 viajes/mes previsto con una flota de 15 camiones pesados (~2 viajes por día)

Exportación:

- 170 barcazas fluviales anuales desde Puerto de Villeta hasta Puerto de Montevideo.
- Transporte marítimo desde Montevideo hasta Puertos de Sao Paulo, Rio Grande, Camacari.



Desarrollo de la economía del hidrógeno verde

Generación de empleos verdes

- Capacitación en nuevos procesos industriales, mantenimiento, gestión, administración, logística.

Nuevas cadenas de valor

- Desarrollo industrial en la zona con nuevas plantas de transformación y empresas de servicio.

Distribución y logística

- Alcance al consumo final en el país, nuevos almacenes y centros de distribución.

Agricultura local

- Menores costos e independencia del mercado internacional.

Uso del CAN

Superficie de cultivos en Brasil

- 43 mill ha. de Soja
- 21,9 mill ha. de Maiz
- 8,32 mill ha. de Caña de Azúcar
- 3 mill ha. de Trigo
- 1,5 mill ha. de Arroz

Superficie de cultivos en Paraguay

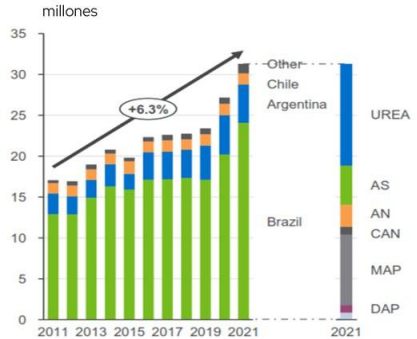
- 3,7 mill ha. de Soja
- 800.000 ha. de Maíz
- 450.000 ha. de Trigo
- 170.000 ha. de Arroz
- 105.000 ha. de Caña de azúcar

Superficie cubierta por ATOME (promedio)

- Maíz 450.000 ha*
- Caña de azúcar 1.270.000 ha**
- Arroz 2.500.000 ha***

Mercado de Fertilizantes

- LatAm depende en gran medida de las importaciones de fertilizantes nitrogenados para respaldar sector agrícola.
- Brasil es el 4to mayor importador en el mundo y es responsable del 8% del consumo global.
- Paraguay es importador neto con alta fuga de divisa de más US$ 600 mill.



Consumo fertilizantes nitrogenados

Emisiones por uso

- El reemplazo de urea por CAN verde reducirá las emisiones de NOx y CO2 relacionadas a su uso en cultivos (lixiviación de nitrógeno, volatilización, nitrificación

The Project

Green Fertilizer (CAN)

Investment & Impact

$ >400 mill
Capital investment for the production plant of Hydrogen, Ammonia and Green Fertilizers

+1300
Direct and indirect jobs generated in the construction phase

+1100
Direct and indirect jobs generated in the operational phase

Fertilizer market

27 Mt
Annual fertilizer imports in the Mercosur region

$600 mill
Paraguayan market covered entirely by imports with foreign exchange outflows

1,2 mill
hectares of sugarcane can be fertilized with the ATOME product

Environment & Society

~500.000
t CO_2 eq/year avoided by ATOME s green fertilizer production

160.000
ton/year of medical oxygen that will be available to the local market

100%
Renewable energy for the production of hydrogen, ammonia and green fertiliser

ATOME will be one of the first companies in the world to use green ammonia to produce 100% green products on an industrial scale and reduce emissions in the fertilizer sector

The Project

Green Fertilizer (CAN)

Use of CAN

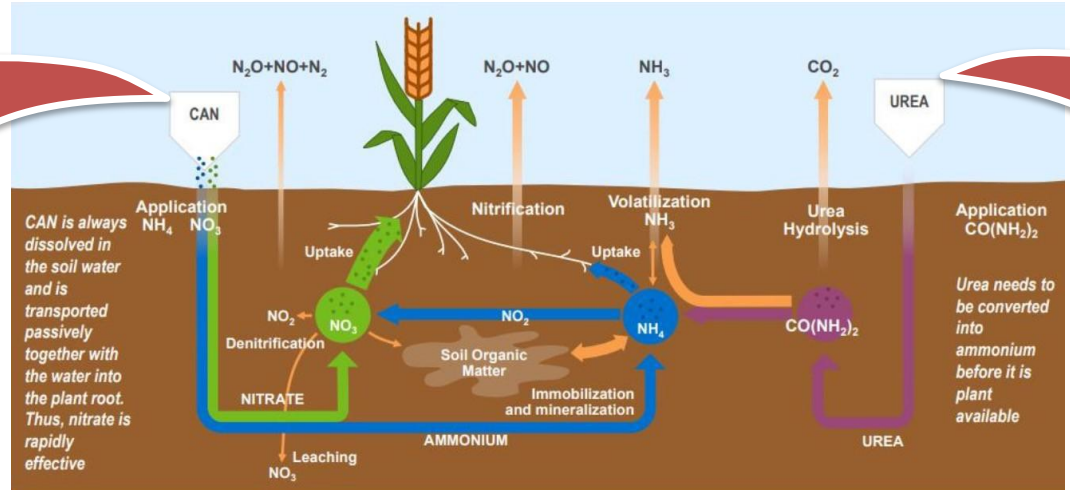
- The replacement of urea with green CAN will reduce NOx and CO2 emissions related to its use in crops (nitrogen leaching, volatilization, nitrification and hydrolysis of urea).

Comparison with other fertilizers

Annual emissions avoided

473,753 t CO2e/año

CAN always dissolves in soil water and is passively transported along with the water to the root of the plant. Therefore, nitrate is quickly effective



Urea CO(NH2)2 must be converted to ammonium before it is available to the plant

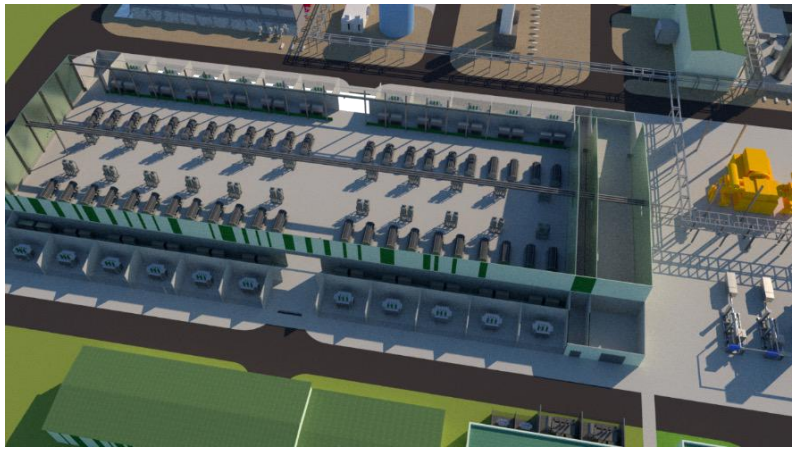
Main Plant Facilities

Green Hydrogen (H2) Plant
It will produce hydrogen using energy that comes from the ANDE's Buey Rodeo Substation (SE), through a transmission line that is also part of the Project.

Air Separation Unit
It captures air and separates nitrogen from other gases that make up the air. The nitrogen is then used to produce ammonia.

Ammonia Synthesis Unit
This part of the plant houses the reactor where ammonia is produced from the mixture of hydrogen and nitrogen.

~50% of the ammonia goes to the Nitric Acid (AN) Plant and the other half to the Ammonium Nitrate Solution (AN) Plant. The NA and SNA will be used to make the fertilizer.



Hydrogen Production Plant



Haber-Bosch Reactor

Main Plant Facilities

Nitric Acid Plant (AN)

In this plant, ammonia is transformed into nitric acid using the double-pressing process.

Ammonium Nitrate (SNA) Solution Plant

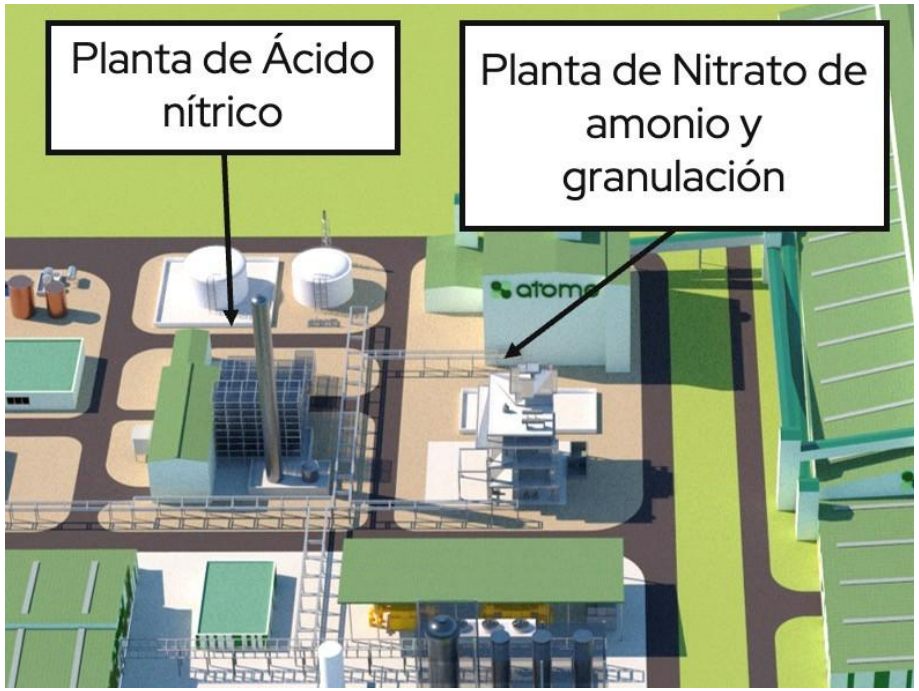
In this plant, nitric acid formed at the AN plant reacts with ammonia in a reactor, producing ammonium nitrate.

Granulation Plant (GRAN)

This is the last phase of the Atome Plant, where the Ammonium Nitrate Solution is converted into a type of nitrate-based granular fertilizer (CAN fertilizer).

Flare System

The flare system is used to burn hazardous or flammable gases in cases of emergency or specific process conditions, and then discharge them into the atmosphere. The system will comply with the limits established by Paraguayan environmental legislation and international standards.



Nitric Acid (AN), Ammonium Nitrate Solution (ANS) and Granulator (GRAND) Plants)

Auxiliary Plant Facilities

Raw Water Intake System

The water will be used for processing, firefighting, refrigeration and drinking water. It will be taken from the Paraguay River and pumped to the plant. The total consumption will be 165.4 m^3/h, equivalent to 0.008% of the lowest flow of the river.

Raw Water Treatment Plant

In this plant, the water will be pre-treated and then part will be purified and part will be demineralized.



Raw Water Treatment Plant and WWTP

Wastewater Treatment Plant (WWTP)

The effluents will comply with the quality established in Paraguayan legislation and international standards, returning water to the Paraguay River with a better quality than the existing one, through a buried pipe, parallel to the raw water pipe.

High Voltage Transmission Line and Plant Substation

The 220 kV transmission line with a 550 m extension will carry power from ANDE's Buey Rodeo Substation (SE) to the Plant, connecting this SE to the internal SE of the Plant.



Internal SE and LT 220 kV input

Operation and maintenance aspects

Productive Capacity of the Plant

Production rate of CAN fertilizer	250.000 ton/year

Raw Materials and Inputs

Raw Materials	Source	Quantity
Water (net consumption)	Paraguay River. Option: Paraguay River and deep wells (fire fighting system only)	165.4 m3/h (0.008% of the lowest flow of the Paraguay River)
Ambient air	Air Separation Unit	201 ton/day
Electric power (hydropower)	ANDE's Buey Rodeo substation through a 220 Kv LT	Total electrical power consumption 112.9 MW
Limestone	Existing quarries under evaluation	173 ton/day



Granulated Calcium Ammonium Nitrate (CAN) Fertilizer



Environmental Controls During Operation

Liquid Effluents

The effluents will be treated in a Wastewater Treatment Plant (WWTP) to comply with national and international standards.

Solid Waste

Sludge, waste oils, polluted process water, worker-generated waste, electrical waste and mechanical waste will be collected, separated, sorted, stored and disposed of.

Atmospheric Emissions

Part of the continuously emitted gases are non-polluting and will be vented to the atmosphere = H_2, N_2, H_2O, O_2 and Argon.

The volumes of air pollutants are very small, including CO_2, NO_x, N_2O, CO, SO_2, NH_3, particulate matter for which there will be control mechanisms such as the flare system.

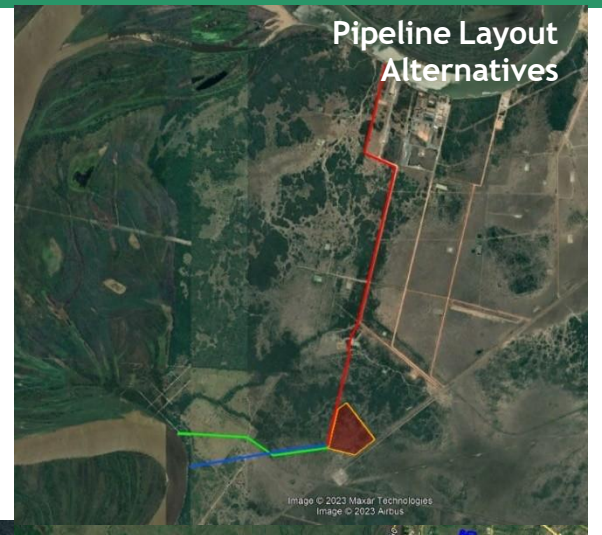
All national and international standards for emissions and air quality will be complied with, in addition to constant monitoring.

Noise

The equipment will be designed to comply with Paraguayan and international legislation.

Alternatives Analysis

The studies of alternatives were carried out with the aim of achieving a Project with the best possible technology and seeking the most suitable location for its construction and operation, in order to cause the minimum environmental and social impact.

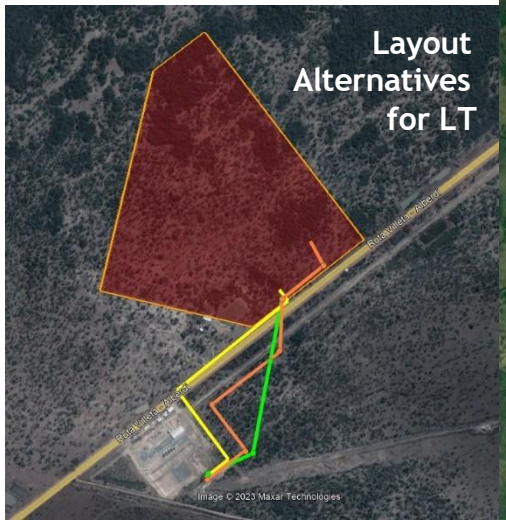


Location Alternatives

- Land alternatives for the implementation of the Plant
- Transmission Line Layout Alternatives
- Routing Alternatives for Water and Wastewater Pipelines

Economic and Technological Alternatives

- H2 Electrolysis
- Recovery of products from the air
- NH3 Synthesis
- CAN Storage
- Cooling system
- Water Treatment
- Water source for the process





Alternative without Project

Diagnosis (baseline) Physical Environment

Clima

Clima subtropical

Verano caluroso, con temperatura promedio del mes más caluroso por encima de los 22ºC.

Temperatura Promedio anual en la zona

22ºC con amplitud de 10ºC. Verano - puede superar los 40ºC, con promedio de 27ºC y humedad relativa de ~ 80%. Invierno y primavera - promedio de 17ºC.

Precipitación promedia anual en la zona

~ 600 mm por la distancia del océano. Meses más secos - julio y agosto, con precipitación < 60 mm. Meses más lluviosos - noviembre y diciembre, con precipitación > 170 mm.

Acontecimientos extremos y desastres naturales

	Amenaza	Riesgo
Déficit Hídrico	Media	Media
Inundación (precipitación excesiva)	Media	Baja
Inundación (desbordamiento)	Media	Baja
Inundación (conjunta)	Baja	Baja
Heladas	Media	Media
Incendios Forestales	Alta	Baja
Tormenta Severa	Alta	Alta

Diagnosis (baseline) Physical Environment

Recursos Hídricos

Río Paraguay
Caudal medio anual - 3,279 m^3/s (caudal a captar por el Proyecto = 0.0021% de este total)
Caudal mínimo - 2,701 m^3/s (caudal a captar por el Proyecto = 0.0025% de este total)

Usos del Agua en el AII
53.07% - fuente subterránea (caudal de 15,069 m^3/s)
28.62% - fuente superficial (caudal de 8,126 m^3/s)
18.31% - otros (caudal de 5,199 m^3/s)

13,325 m^3/s, distribuidos para industrias (60.35%, caudal de 8,042 m^3/s); usos agropecuarios, incluyendo arroceros (29.25%, caudal de 3,898 m^3/s), y estaciones de servicios y lavaderos (10.39%, caudal de 1,385 m^3/s).





Calidad del agua en el río Paraguay
Muestreo en dos campañas marzo (C1) y junio (C2) de 2023
Algunos valores superan los límites de la Resolución Nº 222/2002: cor aparente, Nitrógeno total, Fósforo total, Aceites y grasas, Aluminio, Hierro soluble, Cromo hexavalente (en C1 y C2), y Oxígeno disuelto y Manganeso (en C1).

Calidad de los sedimentos de fondo
Muestreo en una campaña septiembre de 2023
Casi todos los parámetros cumplen el valor inferior de los dos límites de la norma canadiense (Paraguay no tiene norma de calidad de sedimentos). Sólo el Níquel está en el intervalo de valores en el que ocasionalmente pueden producirse efectos adversos en la biota acuática.



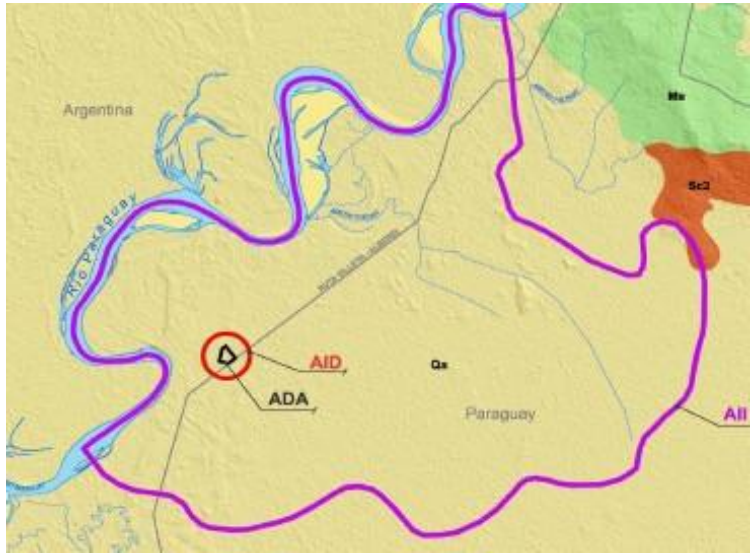
Puntos de muestreo de agua y sedimentos

Diagnosis (baseline) Physical Environment

Geología

Unidades geológicas en el AII:

Grupo Caacupé y Sedimentos Cuaternarios



Mapa de Geología



Bloques de areniscas gruesas a medias y bien estratificadas, relacionadas con el Grupo Caacupé



Depósitos aluviales entre la desembocadura del Arroyo Zanja Mercedes y Amarradero Cargil Ypekae

Diagnosis (baseline)
Physical Environment

Geomorfología

Tipos de relieve en el AII:

Cerros, Llanuras Bajas y Llanuras de Inundación



Cerros ubicados en el Distrito de Nueva Italia, conformados por areniscas del Grupo Caacupé



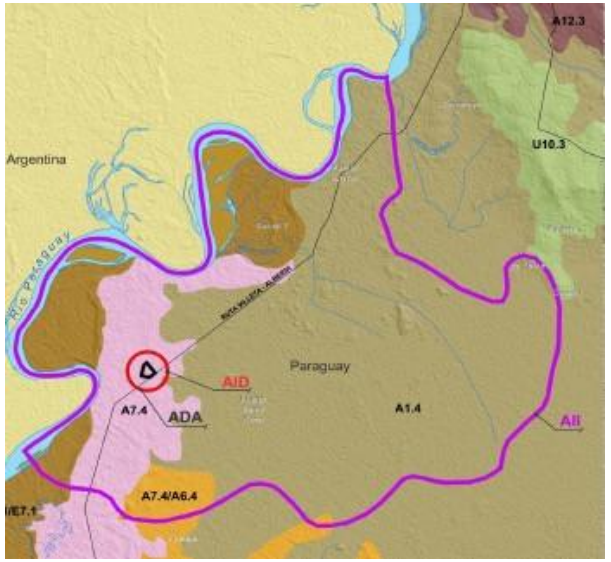
Relieve plano a semiplano del terreno "llanuras bajas". A la derecha se ve el cultivo de arroz



Relieve de llanuras de inundación, visto a partir del río Paraguay, aguas abajo del Puerto Londrina

Diagnosis (baseline)
Physical Environment

Tipos de suelos en el AII: Alfisol, Entisol y Ultisols



Mapa de Suelos

Suelos



Exposición de suelo del grupo Alfisol a orillas del río Paraguay, cerca de Puerto Londrina



Suelo del grupo Entisol a orilla del río Paraguay, cerca de la localidad de Puerto Alegre, sobre depósitos aluviales

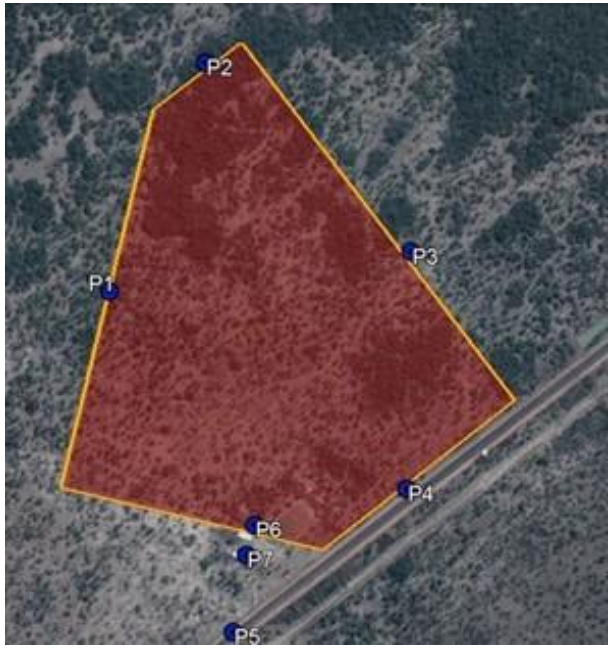
Diagnosis (baseline) Physical Environment

Ruido

Línea base de ruido en tres campañas

- 1ª campaña - Mediciones diurnas y nocturnas de 15 min.
- 2ª campaña - Medición en P6 por 4 horas consecutivas.
- 3ª campaña - Mediciones de 20 horas continuas en los 4 puntos.

Resultado de las mediciones: el área ya presenta un ruido ambiental superior a los estándares establecidos para áreas residenciales, que es la situación actual (sin la planta en funcionamiento).



Puntos 1ª y 2ª campañas



Puntos 3ª campaña

Diagnóstico (línea de base) Medio Físico

Calidad del Aire

Línea base de calidad del aire en tres campañas, durante 24 h, realizadas entre agosto y septiembre de 2022

- Parámetros medidos: Material Particulado (PM10 y PM2.5), monóxido de carbono (CO), óxido de nitrógeno (NO_2), ozono (O_3) y óxido de azufre (SO_2).



Equipo utilizado en la medición



Lugar de instalación de la estación de monitoreo de la calidad del aire

Resultado de las mediciones: los niveles ambientales de los contaminantes atmosféricos monitoreados estuvieron siempre por debajo de los estándares de calidad del aire establecidos por la Resolución SEAM Nº 259/2015, la OMS 2021 - Directrices Mundiales de Calidad del Aire y las Guías generales sobre medio ambiente, salud y seguridad de la CFI.

Diagnosis (baseline) Biotic Environment - Flora

Área	% de vegetación nativa	% de Sabana	% de Bosque
AID	65.2	42.9	22.3
Terreno de la Planta	99.2	78.8	22.4
Franja de servidumbre de la LT	23.7	23.3	0.4
Franja de servidumbre de las tuberías de agua y efluentes LT	60.0	48.4	11.6

Muestreo realizado en el ADA:

- Bosque: 26 especies entre arbóreas, arbustivas y palmeras, de 14 familias.
- Sabana: 72 especies pertenecientes a 29 familias.

Especies amenazadas presentes en el sitio

Especie	Nombre común	Estado de conservación (MADES)	Estado de conservación (IUCN)
Cohniella jonesiana (Rchb. f.) Christenson	Orquídea	En Peligro de extinción	-
Cynophalla retusa (Griseb.) X. Cornejo & H.H. Iltis	Arbusto	-	Casi amenazada (NT)
Libidibia paraguariensis (D. Parodi) G.P. Lewis	Guayacán	En Peligro de extinción	Vulnerable (VU)
Monteverdia ilicifolia (Mart. ex Reissek) Biral	Kangorosa	En Peligro de extinción	-
Prosopis nigra (Griseb.) Hieron	Algarrobo negro	Amenazada de extinción	Deficiente de datos (DD)



Vista del mosaico bosque/sabana palmar

Diagnosis (baseline) Biotic Environment - Fauna

Muestreo realizado en el ADA (2 campañas):

- Aves: 2,140 registros, 138 especies, 22 órdenes y 43 familias.
- Herpetofauna: 27 especies, 21 de anfibios y 6 de réptiles.
- Mamíferos medianos y grandes: 85 registros, 12 taxones, 7 órdenes y 9 familias.
- Murciélagos: 591 registros, 14 taxones, 3 familias.

Especies amenazadas presentes en el sitio

	Especie / Nombre común	Estado de conservación (MADES)	Estado de conservación (IUCN)
Aves	*Amazona aestiva* / loro manchado menor	-	Casi amenazada (NT)
Herpetofauna	-	-	-
Mamíferos medianos y grandes	-	-	-
Murciélagos	*Peropteryx macrotis*	En Peligro de extinción	-
	Myotis ruber	-	Casi amenazada (NT)
	Myotis simus		Deficiente de datos (DD)
	Cynomops abrasus		Deficiente de datos (DD)

Búsqueda de rastros de anfíbios y réptiles



Equipo para muestreo de murciélagos



Tangará



Rana, Ju'i



Corzuela parda



Diagnosis (baseline) Protected Areas

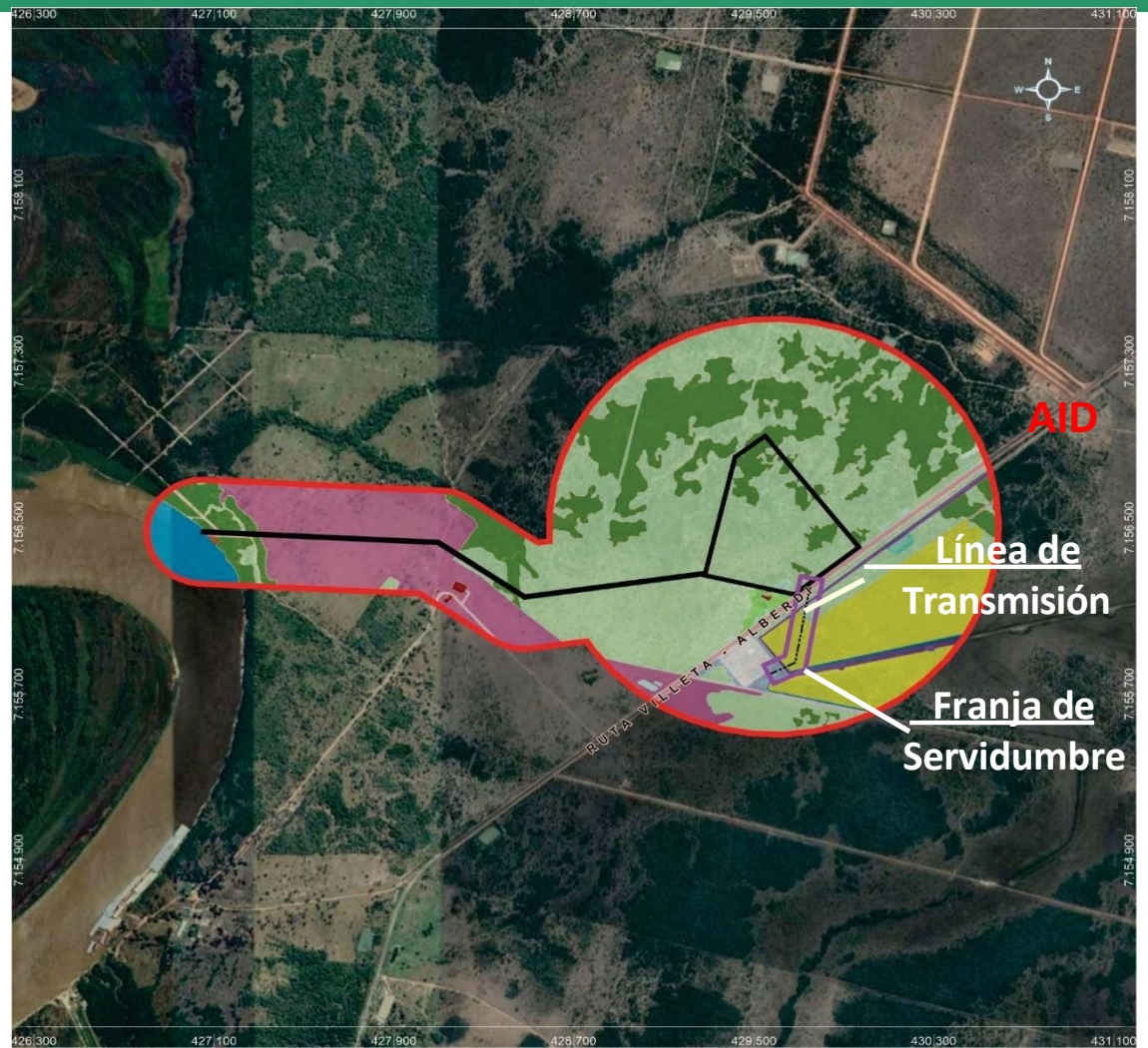
Áreas Protegidas

El proyecto no interfiere con Áreas Silvestres Protegidas (ASP).

ASP más cercanas: Reserva Natural Guyrati y Parque Nacional Lago Ypoá, que se encuentran a unos 3 km del límite del AII.



Diagnosis (baseline)
Land Use and Vegetation Cover



Uso Actual

- Río Paraguay
- Pastizal inundable
- Línea de transmisión
- Construcción rural
- Canales
- Suelo
- Bosque sub-húmedo
- Sabana
- Cultivo
- Pasto
- Uso silvopastoril
- Áreas Antrópicas
- Caminos
- Subestación
- Tajamar

Diagnosis (baseline)
Land Use and Vegetation Cover

Categorías de Uso del Suelo

Sabana

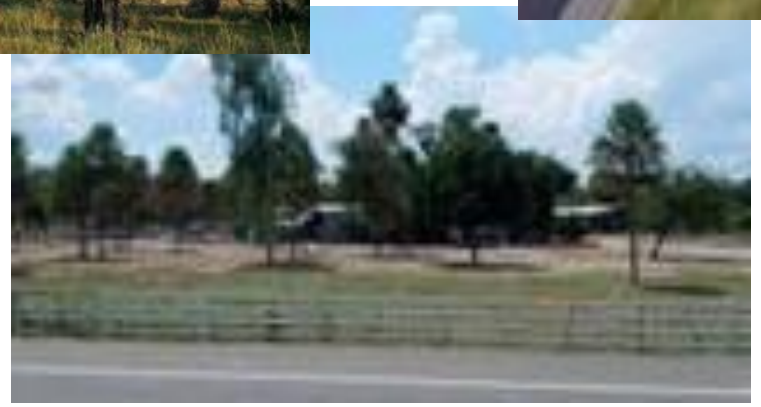


Pasto



Bosque





Uso Silvopastoril



Cultivo

Diagnosis (baseline)
Socio-economic environment

Neighboring property



Propiedad vecina al terreno de ATOME

Límites del terreno de ATOME y la propiedad vecina



Diagnosis (baseline)
Socio-economic environment

Comunidades cercanas

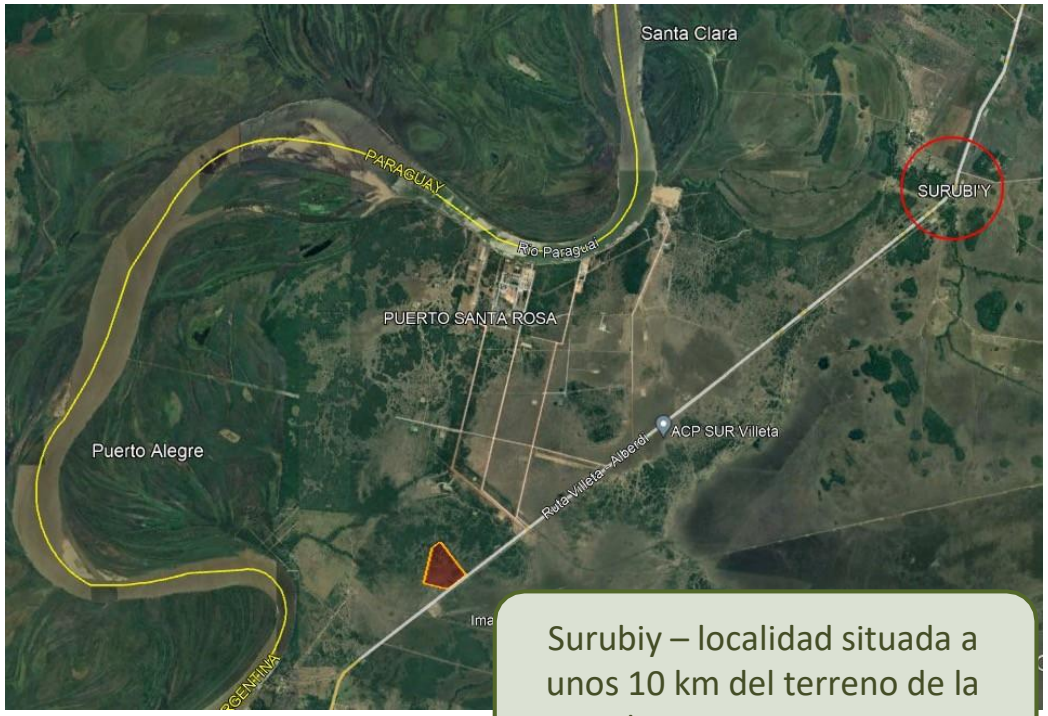
Ubicación de Puerto Lobato / Ypeka'e en relación con el terreno de la Planta



Puerto Lobato / Ypeka'e – localidad ubicada a orillas del río Paraguay, ~ 3 km de la Ruta Villeta Alberdi (PY19) y a 11 km del Proyecto de ATOME por carretera.

En este lugar se pesca con fines deportivos, comerciales y de subsistencia.

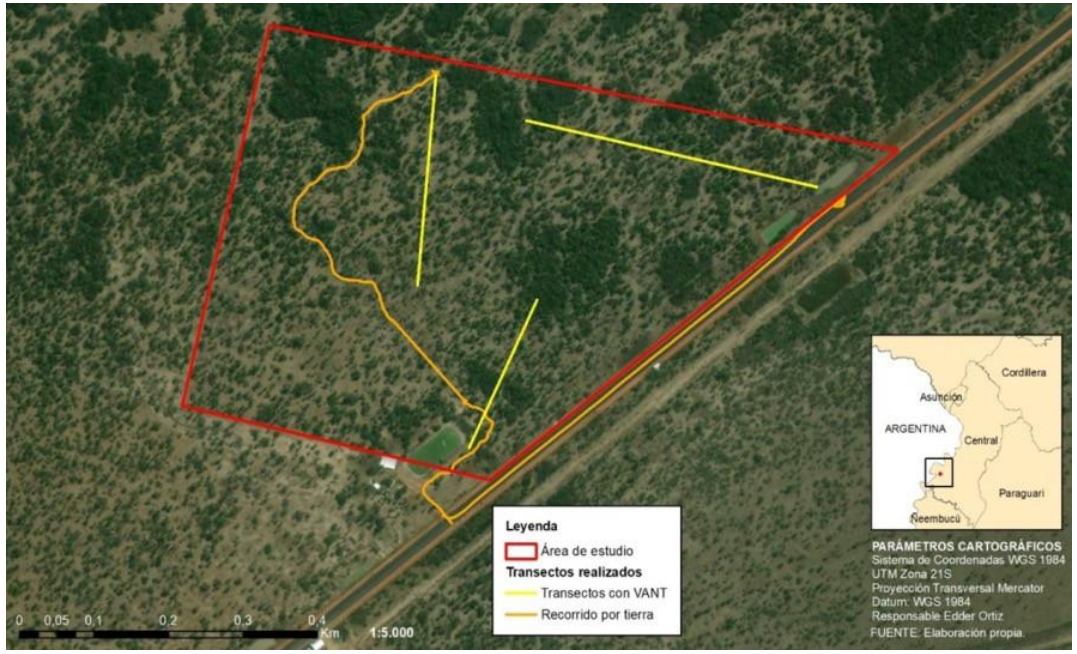
Ubicación de Surubiy en relación con el terreno de la Planta



Surubiy – localidad situada a unos 10 km del terreno de la Planta por carretera.

Diagnosis (baseline)
Socio-economic environment

Patrimonio Arqueológico



Zonas de muestreo arqueológico y recorridos en el ADA



Recorridos y prospección arqueológica de superficie en sabana palmar con uso de dron

No se encontraron elementos o vestigios culturales, debido a la vegetación presente, además de presentar modificaciones en el uso del suelo y remoción. Sin embargo, se visualizaron áreas de potenciales usos humanos.

Environmental and Social Impact Assessment

Metodología

Acciones impactantes **x** Componentes impactables de los Medios Físico, Biótico y Socioeconómico

↓

Impactos potenciales y riesgos **x** Medidas de prevención, control, mitigación y compensación de impactos (Plan de Gestión Ambiental y Social – PGAS)

Atributos de Calificación:

- Naturaleza (positivos o negativos)
- Localización (AII, AID o ADA)
- Etapa (planificación, construcción o operación)
- Incidencia (directo o indirecto)
- Inducción (Inmediato, Corto, Medio o Largo Plazo)
- Duración (Corto, Medio o Largo Plazo, Permanente)
- Reversibilidad (Reversible, Parcial o Irreversible)
- Probabilidad (Baja, Media o Alta, Cierto)
- Magnitud (Alta, Media, Baja)
- Importancia (Alta, Media, Baja)

Importancia del impacto resultante **x** Grado de mitigabilidad

↓

Importancia residual

Identification of Main Impacts

Construcción: impactos temporales, incluyendo aparición o aumento de erosiones, potencial contaminación del agua y del suelo, aumento del ruido y las vibraciones y de las emisiones atmosféricas.

Para evitar y minimizar estos, se tienen medidas de prevención, mitigación y monitoreo durante las obras, como:

- control de las actividades de movimiento de tierras, prevención y control de procesos erosivos;
- tratamiento de efluentes en fosas sépticas, gestión de residuos sólidos y de materiales peligrosos;
- monitoreo de emisiones de los vehículos y maquinaria de construcción (visual);
- monitoreo de emisiones atmosféricas de fuentes fijas;
- supervisión de obras.

Medio Físico

Operación: aumento del consumo de agua del río Paraguay y potencial contaminación por el vertido de aguas residuales tratadas, además del deterioro de la calidad del aire por las emisiones de los equipos de la Planta.

Se estima un consumo neto de 165.4 m3/h equivalente al 0.008% del caudal mínimo del río. Además, el efluente a retornar al río será tratado en una Estación de Tratamiento de Aguas Residuales, retornando agua con mejor calidad que la existente en el río.
Se monitoreará el caudal de agua utilizado, la calidad de los efluentes y la calidad del agua del río para asegurar el cumplimiento de las normas nacionales e internacionales ambientales.

Identification of Main Impacts

Medio Físico

Los resultados de la modelización de dispersión de contaminantes atmosféricos muestran que las emisiones de CO, NO_2 y NH_3 están muy por debajo de los límites fijados por la legislación paraguaya e internacional. Sólo en el caso del material particulado, cuando se consideran los valores diarios de calidad objetivo propuestos por la CFI, se puede observar que la calidad actual (línea de base) influye en el nivel de cumplimiento futuro.

Mapas de isoconcentraciónes de contaminantes



CO – operación de 24 h



NO_2 – operación de 24 h



NH_3 – operación de 1 h

- Medidas de gestión y monitoreo durante la operación:
  - ❖ monitoreo del efluente tratado en la Estación de Tratamiento de Aguas Residuales – ETAR de la Planta y monitoreo de la calidad del agua y caudales;
  - ❖ especificaciones de diseño de los equipos de la planta para cumplir con los límites establecidos por la legislación paraguaya e internacional;
  - ❖ monitoreo de emisiones atmosféricas y de la calidad del aire.



PM10 – operación de 24 h



PM2.5 – operación de 24 h

Identification of Main Impacts

Medio Físico

Es en el Medio Físico donde se espera el mayor impacto positivo del Proyecto, que es la Reducción de las emisiones de Gases de Efecto Invernadero (GEI) y de la huella de carbono.

Considerando los totales de t CO_2-eq/año para la producción y distribución del fertilizante CAN estimados para la Planta verde de ATOME y para una Planta gris, se observa que el total de la verde corresponde al 37.7% del valor total en la gris.

Teniendo en cuenta estas cifras, se observa que el proyecto de ATOME tiene una capacidad de desplazamiento de alrededor de 525,000 t CO_2-eq/año, con un total de 13,125,000 t CO_2-eq si se tiene en cuenta la vida útil del Proyecto de 25 años.

Identification of Main Impacts

Pérdida de vegetación.

Previsión de desbroce de:

- 29.85 ha para la instalación de la Planta: 6.14 ha son bosques y 23.7 ha son sabanas;
- 0.07 ha de sabanas para implantación de la LT;
- 0.69 ha para la instalación de las tuberías subterráneas de agua y efluentes: 0.56 ha de sabanas y 0.13 ha de bosques.

Medidas de mitigación y monitoreo durante las obras:

- ❖ control de actividades de supresión de vegetación;
- ❖ rescate de germoplasma (semillas y plántulas);
- ❖ recuperación de áreas degradadas por las obras;
- ❖ supervisión de las actividades;
- ❖ capacitación y educación ambiental de trabajadores;
- ❖ monitoreo de la flora.

Medio Biótico

Medidas de compensación:

- ❖ Plan de Acción de Biodiversidad (PAB): compensación ambiental mediante conservación de bosques, compensación ambiental mediante adquisición de Certificados de Servicios Ambientales y compensación ambiental por árboles taladas.

Pérdida de hábitats de la fauna.

- ❖ Ahuyentamiento previo y rescate de fauna durante la fase de construcción.
- ❖ monitoreo de la fauna.

Identification of Main Impacts

Medio Socioeconómico

Construcción: impactos temporales, incluyendo molestias causadas por las actividades de construcción y aumento de tráfico especialmente durante la entrada y salida de camiones y autobuses de trabajadores.

- Medidas de prevención, mitigación y monitoreo durante las obras:
  - ❖ control y monitoreo de emisiones atmosféricas;
  - ❖ control y monitoreo de ruido y vibraciones;
  - ❖ mantenimiento de equipos;
  - ❖ supervisión de obras;
  - ❖ gestión del tráfico de construcción: capacitación de conductores, cumplimiento de límites de velocidad, elección de las mejores rutas;
  - ❖ código de conducta de trabajadores;
  - ❖ mecanismo de manejo de reclamos.

Impacto positivo: creación de empleos durante las obras. Se prevé la contratación de 461 trabajadores directos para la construcción y montaje de la Planta (en el pico) y otros cerca de 30 trabajadores para la LT.

- ❖ medidas de potenciación de la contratación de trabajadores locales;
- ❖ capacitación laboral.

Riesgos de accidentes con trabajadores durante la construcción (.

- ❖ Programa de Salud y Seguridad Laboral en la Fase de Construcción (procedimientos de trabajo seguro, supervisión de salud y seguridad, capacitación en salud y seguridad, gestión de la salud del trabajador);
- ❖ Plan de Acción de Emergencia para incendios / explosiones durante la construcción.

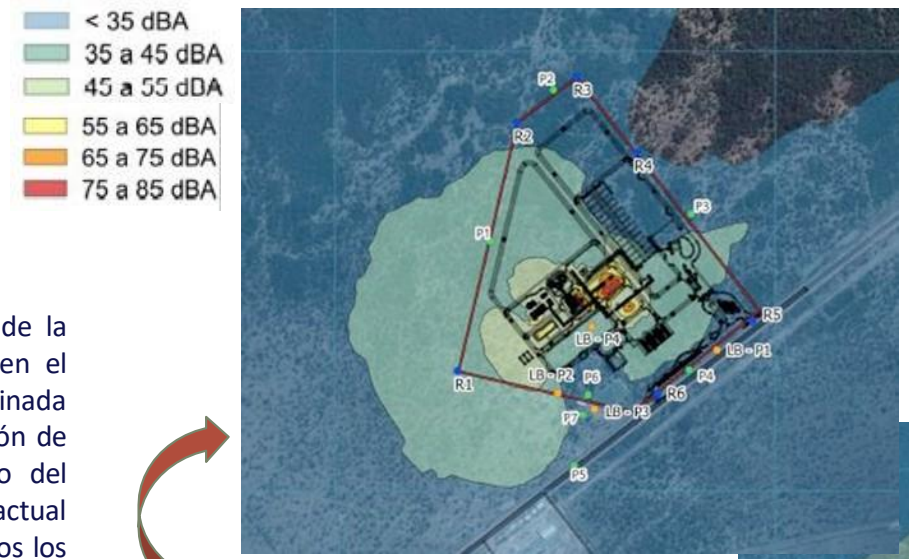
Identification of Main Impacts

Medio Socioeconómico

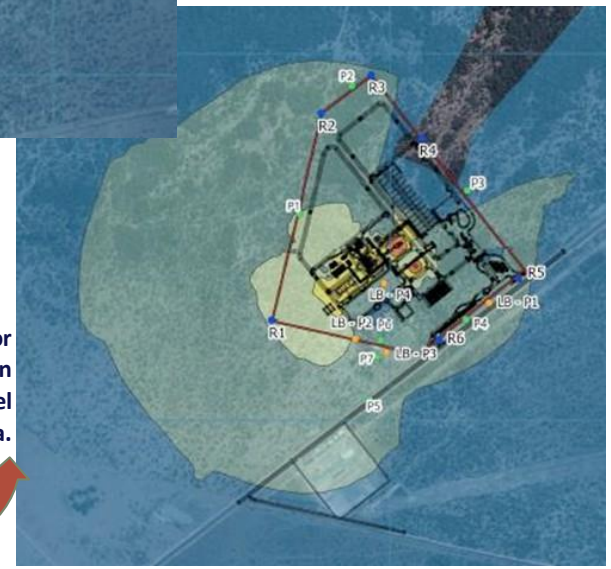
Operación: molestias por ruido en la fase de operación.

Conclusiones de la modelización: la futura operación de la Planta no generará un impacto negativo significativo en el entorno. La calidad acústica continuará siendo determinada por la condición actual (de línea de base). La contribución de nivel de presión sonora producto del funcionamiento del proyecto es sustancialmente menor a la condición actual (línea de base), con valores de menos de 10 dBA en todos los receptores puntuales evaluados.

- Medidas de prevención, mitigación y monitoreo:
  - ❖ especificaciones de diseño de los equipos de la planta para cumplir con los límites establecidos por la legislación paraguaya e internacional;
  - ❖ monitoreo de ruido en la operación.
  - ❖ mecanismo de manejo de reclamos.



Escenario 1 - ruido exclusivo de la operación del Proyecto basándose en las especificaciones de emisión sonora de los equipos (funcionamiento 24 horas y simultáneo).



Escenario 2 - escenario anterior sumado a las medidas de mitigación del impacto de ruido definidas en el diseño de ingeniería de la Planta.

Modelización del ruido de la Planta utilizando el modelo CadnaA.

Identification of Main Impacts

Medio Socioeconómico

Operación: molestias por olores en la fase de operación, causados por el funcionamiento de la Planta de Tratamiento de Aguas Residuales (ETAR), Planta de síntesis de NH_3 y Tanque principal de NH_3.

- Medidas de prevención, mitigación y monitoreo:
  - ❖ medidas de control de emisiones atmosféricas;
  - ❖ especificaciones de diseño de los equipos de la planta para cumplir con los límites establecidos por la legislación paraguaya e internacional;
  - ❖ mecanismo de manejo de reclamos.

Impacto positivo: creación de empleos durante la operación. Se prevé la contratación de 240 puestos directos, de los cuales 195 son puestos fijos y 45 son temporales. Además, se generarán unos 874 puestos de trabajo indirectos.

- ❖ medidas de potenciación de la contratación de trabajadores locales;
- ❖ capacitación laboral.

Riesgos de accidentes con trabajadores durante la operación: incendio, explosión, fuga de amoníaco, ácido nítrico y nitrato de amonio.

- ❖ Programa de Salud y Seguridad Laboral en la Fase de Operación (procedimientos de trabajo seguro, supervisión de salud y seguridad, capacitación en salud y seguridad, gestión de la salud del trabajador);
- ❖ Plan de Acción de Emergencia en caso de explosión;
- ❖ Plan de Acción de Emergencia en caso de incendios;
- ❖ Plan de Acción de Emergencia en caso de fugas de sustancias.

Environmental and Social Management Plan

- **Programa de Control Ambiental de la Construcción**
  - ✓ Medidas de gestión de:
    - ❖ actividades de movimiento de tierras
    - ❖ actividades de supresión de vegetación
    - ❖ agua y efluentes
    - ❖ emisiones atmosféricas
    - ❖ residuos sólidos
    - ❖ materiales peligrosos
    - ❖ ruido y vibraciones
    - ❖ campamento de construcción
  - ✓ Medidas de monitoreo de:
    - ❖ emisiones atmosféricas
    - ❖ ruido
  - ✓ Recuperación de áreas degradadas por las obras

- **Programa de Gestión Ambiental**
  - ✓ Supervisión de la construcción
  - ✓ Coordinación de Programas del PGAS
  - ✓ Promoción y desarrollo de proveedores locales
  - ✓ Gestión de las emisiones de GEI
  - ✓ Negociación y adquisición de tierras

- **Programa de Participación de las Partes Interesadas**
  - ✓ Consulta pública
  - ✓ Divulgación continua de información a las partes interesadas
  - ✓ Mecanismo de gestión de quejas, consultas y sugerencias

- **Programa de Salud y Seguridad Laboral**
  - ✓ Procedimientos de Trabajo Seguro
  - ✓ Capacitación en seguridad ocupacional
  - ✓ Supervisión de salud y seguridad
  - ✓ Gestión de salud del trabajador

- **Programa de Gestión del Trabajo y Condiciones Laborales**
  - ✓ Política de Recursos Humanos
  - ✓ Contratación y capacitación laboral
  - ✓ Condiciones de trabajo y de empleo
  - ✓ Mecanismo de manejo de reclamos para trabajadores
  - ✓ Código de conducta para trabajadores
  - ✓ Educación ambiental y Social de trabajadores

- **Programa de Respuesta a Emergencias para la Fase de Construcción**
  - ✓ Planes de Acción de Emergencia para casos de derrame de productos peligrosos; incendios / explosiones; eventos extremos, como tormentas severas y sequías

Environmental and Social Management Plan

- **Programa de Prevención de Impactos en Fauna y Flora**
  - ✓ Rescate de germoplasma
  - ✓ Ahuyentamiento previo y rescate de fauna
- **Plan de Acción de Biodiversidad (PAB)**
  - ✓ Subprograma de Conservación de Biodiversidad
    - ❖ Monitoreo de la fauna y flora
    - ❖ Compensación ambiental mediante conservación de bosques
    - ❖ Compensación ambiental mediante adquisición de Certificados de Servicios Ambientales
    - ❖ Compensación ambiental por árboles taladas
- **Programa de Respuesta a Emergencias para la Fase de Operación**
  - ✓ Planes de Acción de Emergencia para casos de explosión física / incendios / fugas de gases / derrames de productos peligrosos / accidentes con barcazas eventos extremos, como tormentas severas y sequías
- **Programa de Conservación del Patrimonio Arqueológico y Cultural del ADA**
  - ✓ Acompañamiento arqueológico
  - ✓ Procedimiento en caso de hallazgos fortuitos

- **Programa de Gestión Ambiental y Social de la Fase Operación**
  - ✓ Supervisión del cumplimiento de medidas ambientales y sociales de la fase de operación
  - ✓ Capacitación ambiental y social del equipo de O&M
  - ✓ Gestión de residuos sólidos
  - ✓ Medidas de monitoreo de:
    - ❖ calidad del agua
    - ❖ ruido
    - ❖ calidad del aire
    - ❖ olores
  - ✓ Supervisión de empresas contratadas
  - ✓ Mantenimiento de la franja de servidumbre
- **Programa de Gestión del Transporte en la Fase de Operación**
  - ✓ Mantenimiento rutinario
  - ✓ Inspección de las carreteras e implantación de mejoras

Conclusions

- El EIAS desarrolló una amplia **línea de base** del área de influencia del proyecto.
- Se identificaron algunos impactos de la fase de construcción, que serán **temporales y podrán prevenirse y mitigarse** con el amplio conjunto de medidas propuestas en el PGAS ya descrito, y que serán adoptadas por los Contratistas como parte de sus contratos y supervisadas por Atome.
- En la operación, los principales impactos negativos están relacionados con el ruido y emisiones atmosféricas de la Planta, la captación de agua y la descarga de efluentes tratados en el río Paraguay, **todos considerados de baja magnitud con la aplicación de las medidas de prevención incorporadas en las tecnologías, medidas de mitigación y control**. Como ya se mencionó, la especificación de diseño de los equipos ya tiene en cuenta los niveles de ruido y emisiones para cumplir con la legislación, y también está previsto el monitoreo. En cuanto al agua, la captación será irrisoria en relación con el caudal del río, y el tratamiento de los efluentes garantizará el vertido al río de un agua tratada que cumpla las normas de la legislación nacional e internacional.
- Los riesgos de **explosión, incendio y fugas de contaminantes** estarán restrictos a las instalaciones de la Planta, previéndose Planes de Acción de Emergencia para todos estos escenarios de emergencia.
- Como **impactos positivos**, se puede mencionar la **generación de empleos** en las fases de construcción y operación y la **dinamización de la economía**, especialmente de Villeta.
- El principal impacto positivo del Proyecto es la **reducción de las emisiones de gases de efecto invernadero – GEI y de la huella de carbono** de la cadena de producción agrícola y de alimentos.

Free Trade Zone and Production Plant for Hydrogen, Ammonia and Green Fertilizers of ATOME Paraguay S.A.

Public Consultation

atome

Gracias!

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Figure 6.4.1.3.b-1
Flash fire *hazard areas* in the H2 Separators (SEP1, SEP2, SEP3 and SEP4) of the Electrolysis Building

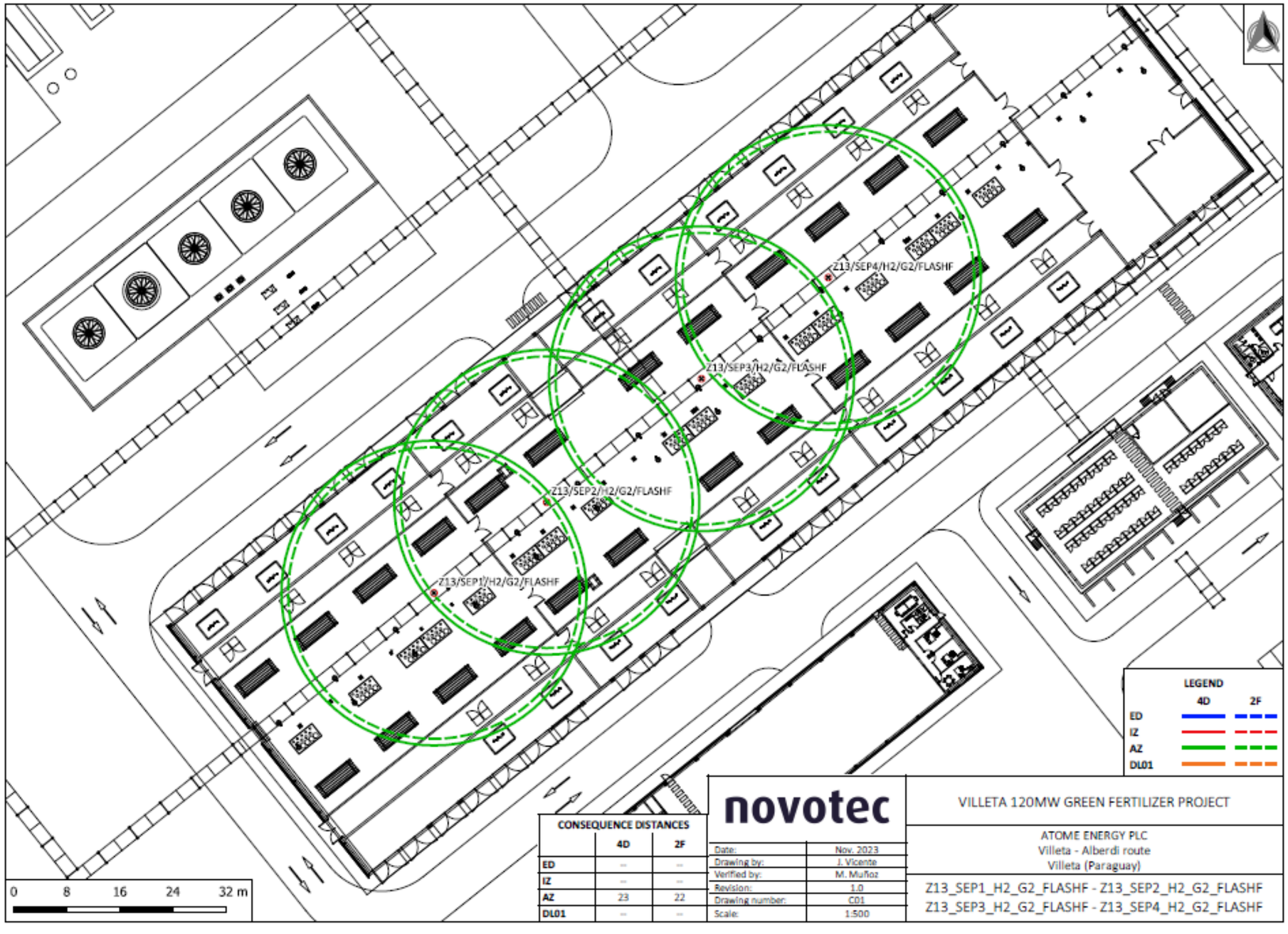

Figure 6.4.1.3.b-2
Physical Explosion Hazard Areas (ECVs) in the H2 Separators (SEP1, SEP2, SEP3 and SEP4) of the Electrolysis Building

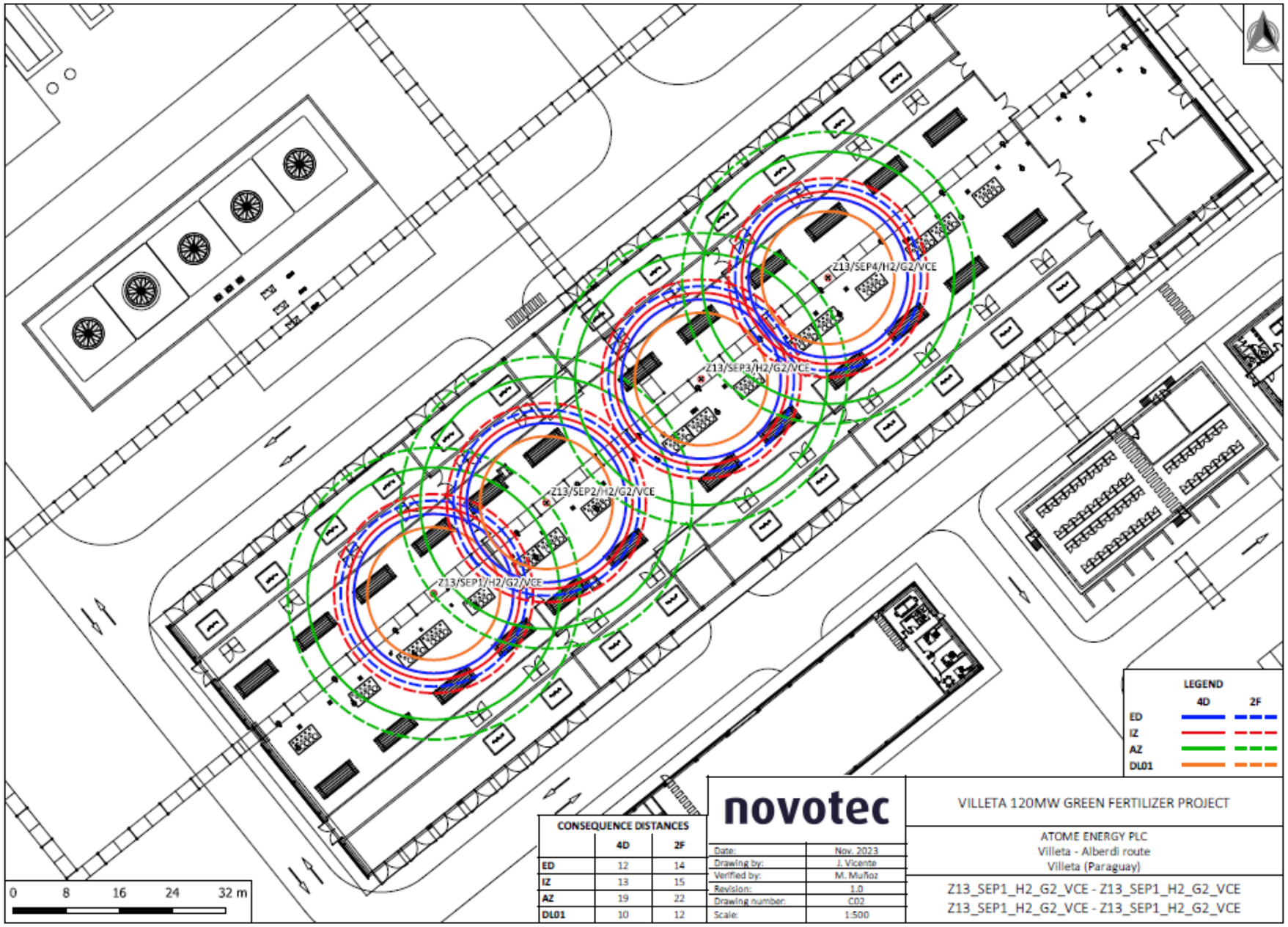

Figure 6.4.1.3.b-3
Jet Fire *Risk Areas* in H2 Separators (SEP1, SEP2, SEP3 and SEP4) of the Electrolysis Building

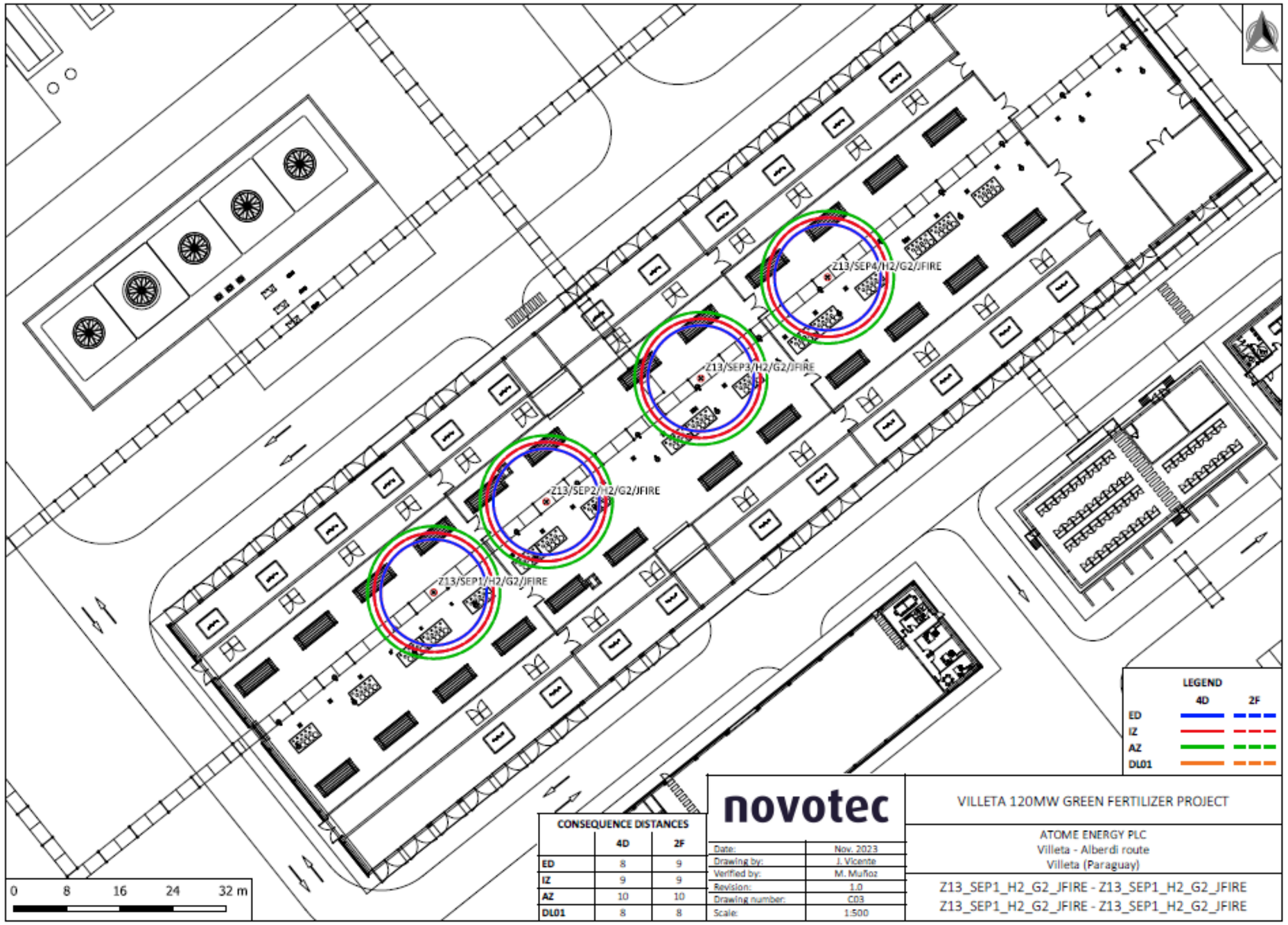

Figure 6.4.1.3.b-4
Jet *fire* on the line of the Electrolysis Building

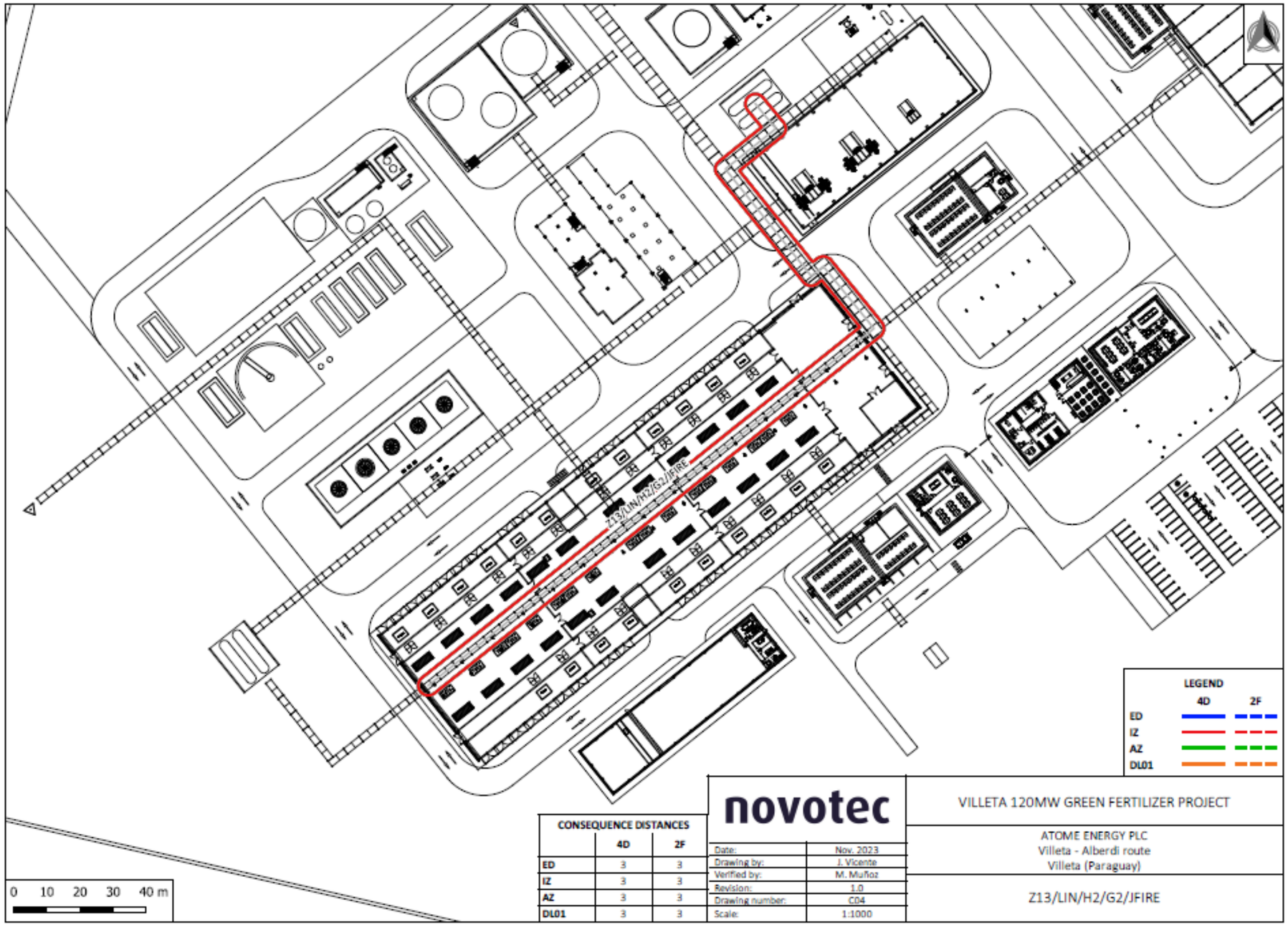

Figure 6.4.1.3.b-5
Physical Explosion (VCE) on the Line of the Electrolysis Building

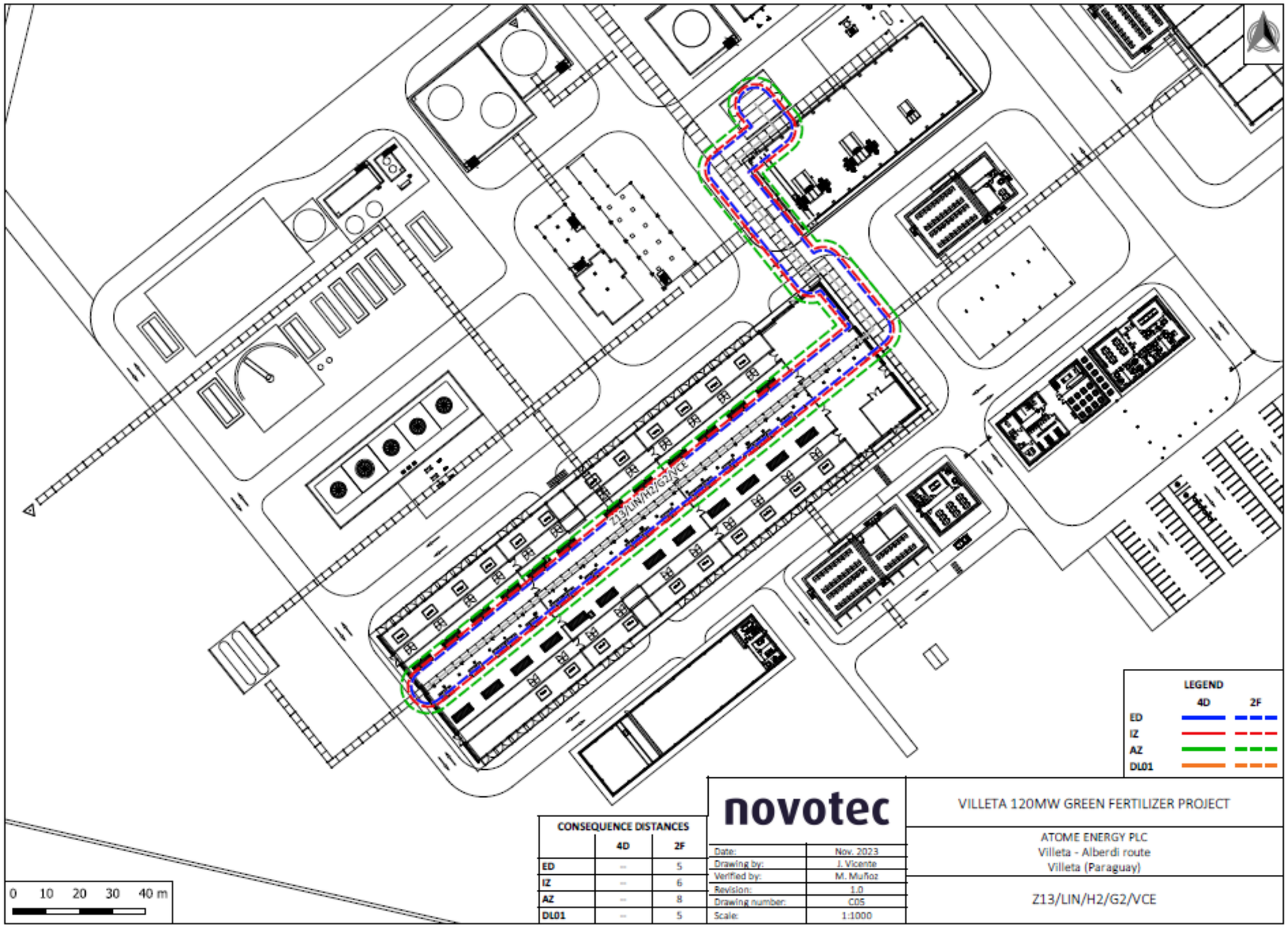

Figure 6.4.1.3.b-6
Jet Fire *Risk Areas* in H2 Tanks

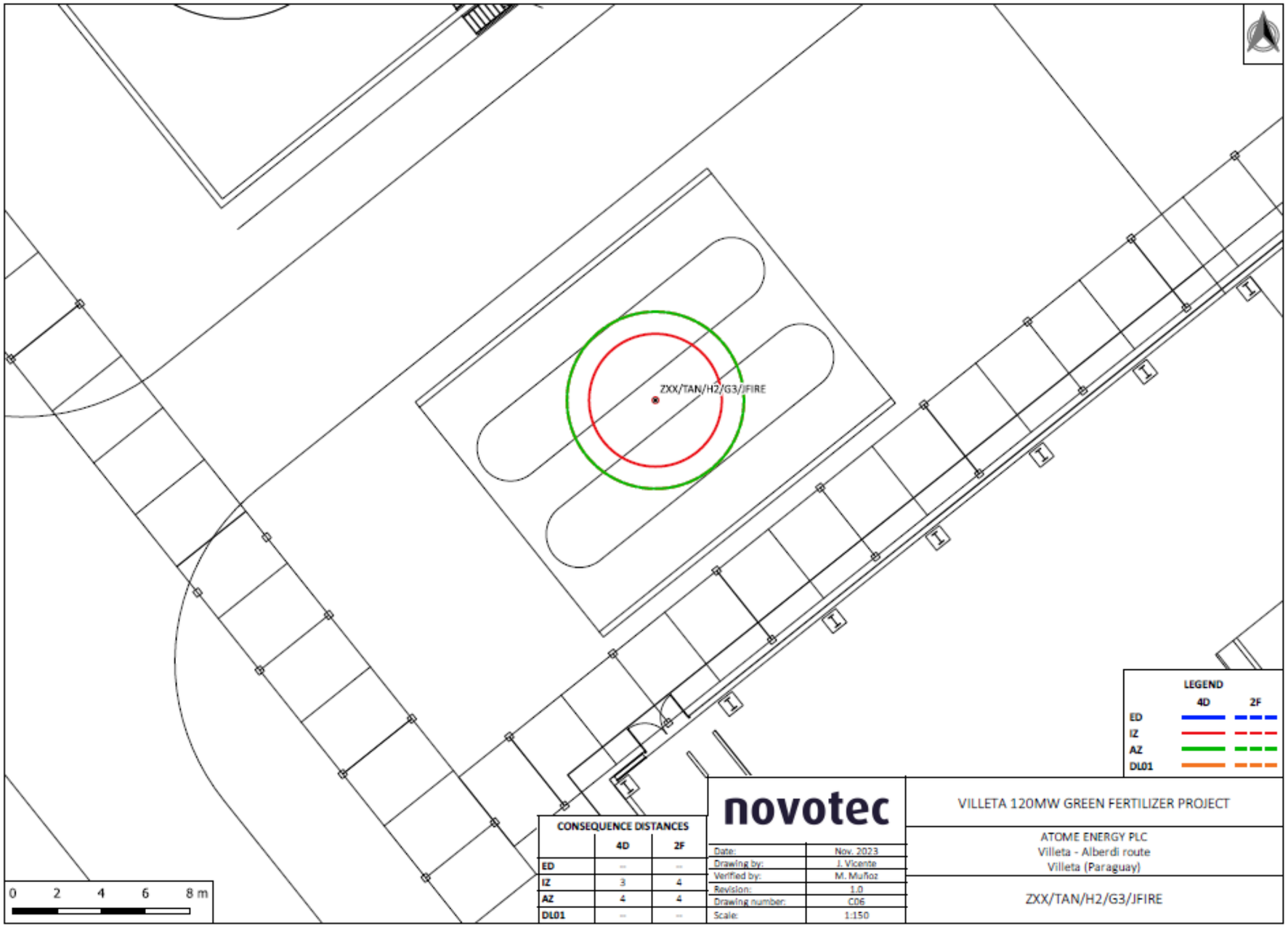

Figure 6.4.1.3.b-7
Physical Explosion Hazard (ECV) Areas in H2 Tanks

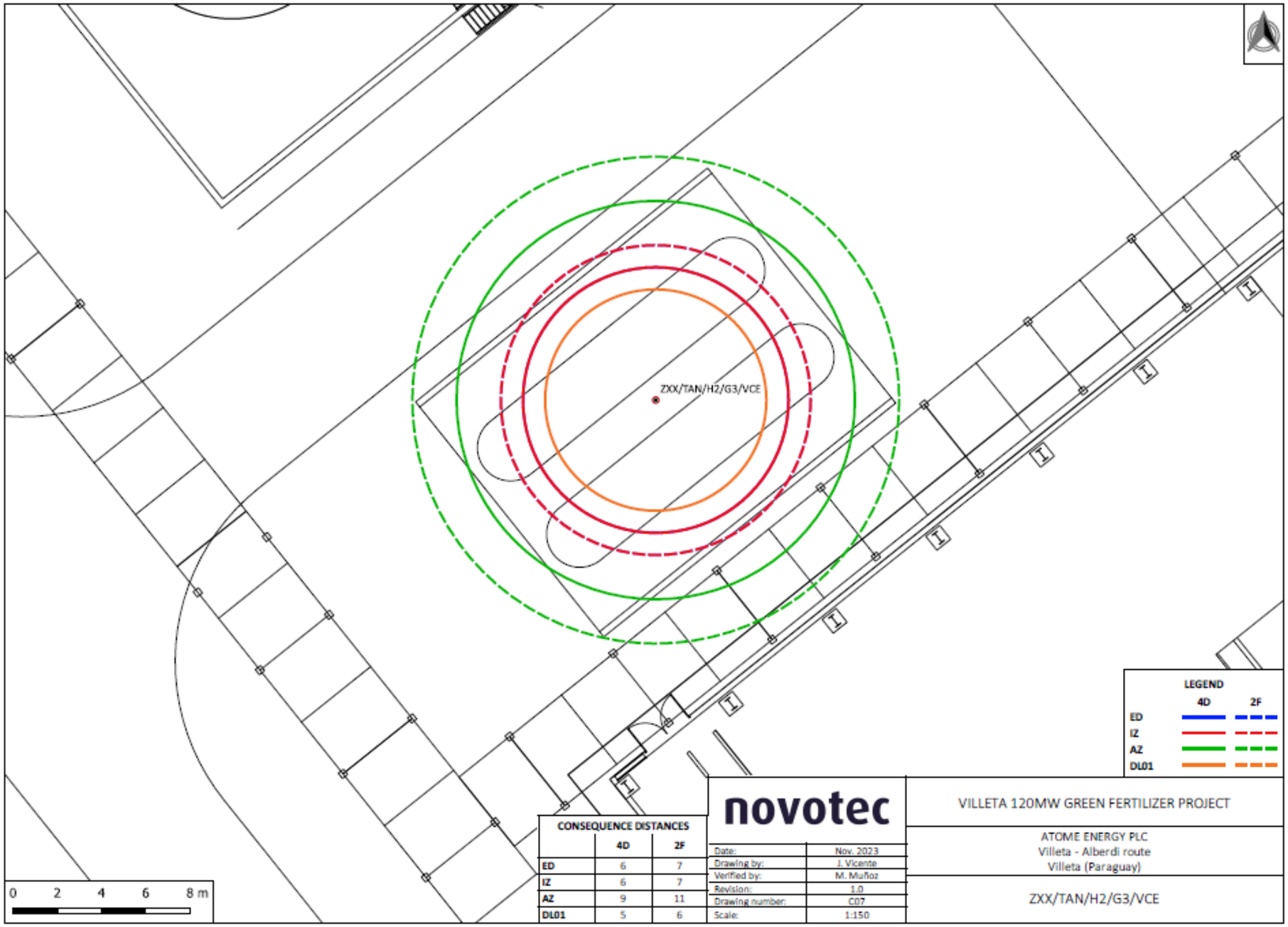

Figure 6.4.1.3.b-8
Flash Fire *Hazard Areas* in the H2 Tank Reserve Park

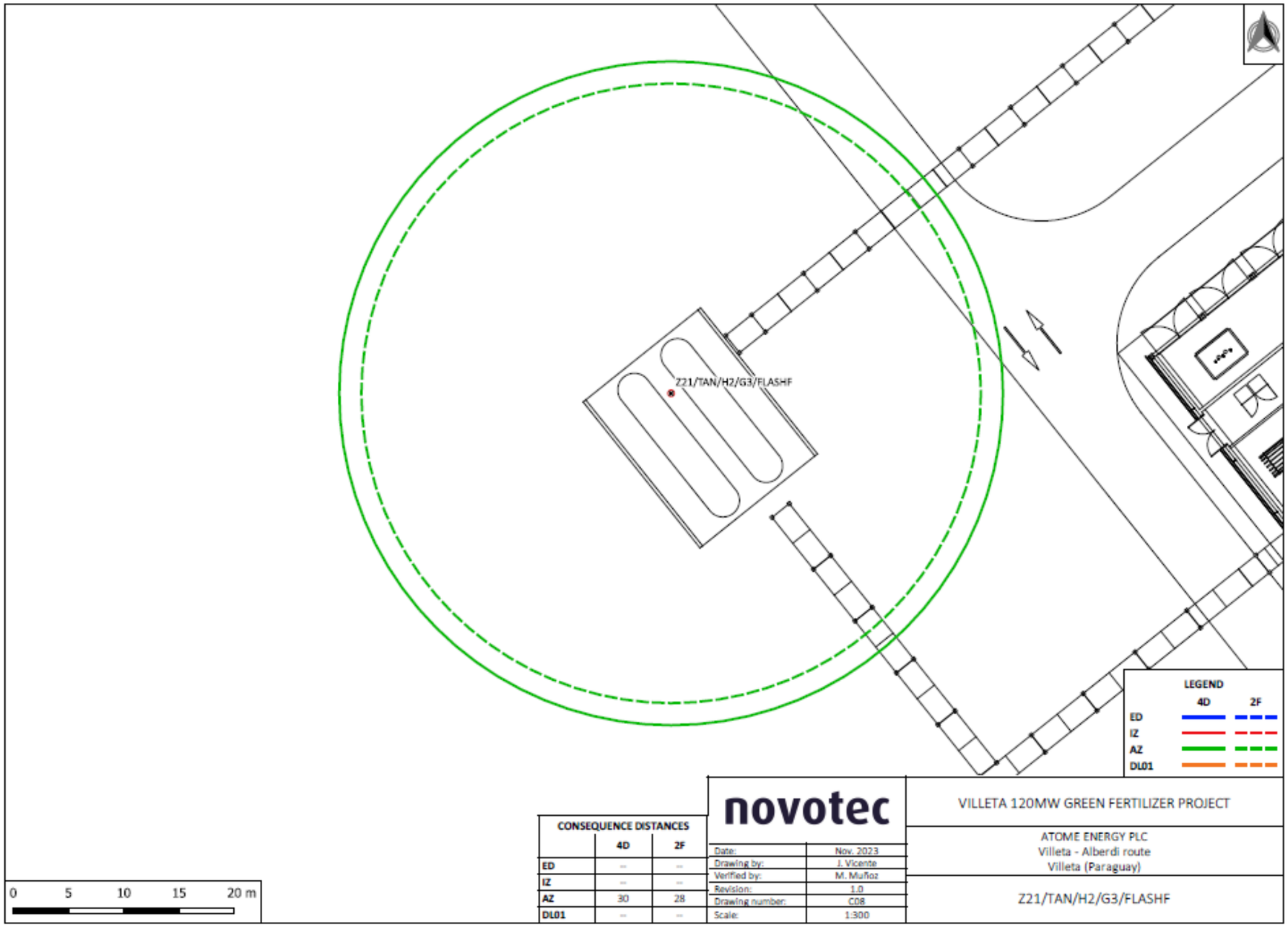

Figure 6.4.1.3.b-9
Physical Explosion Hazard (ECV) Areas in the H2 Tank Reserve Park

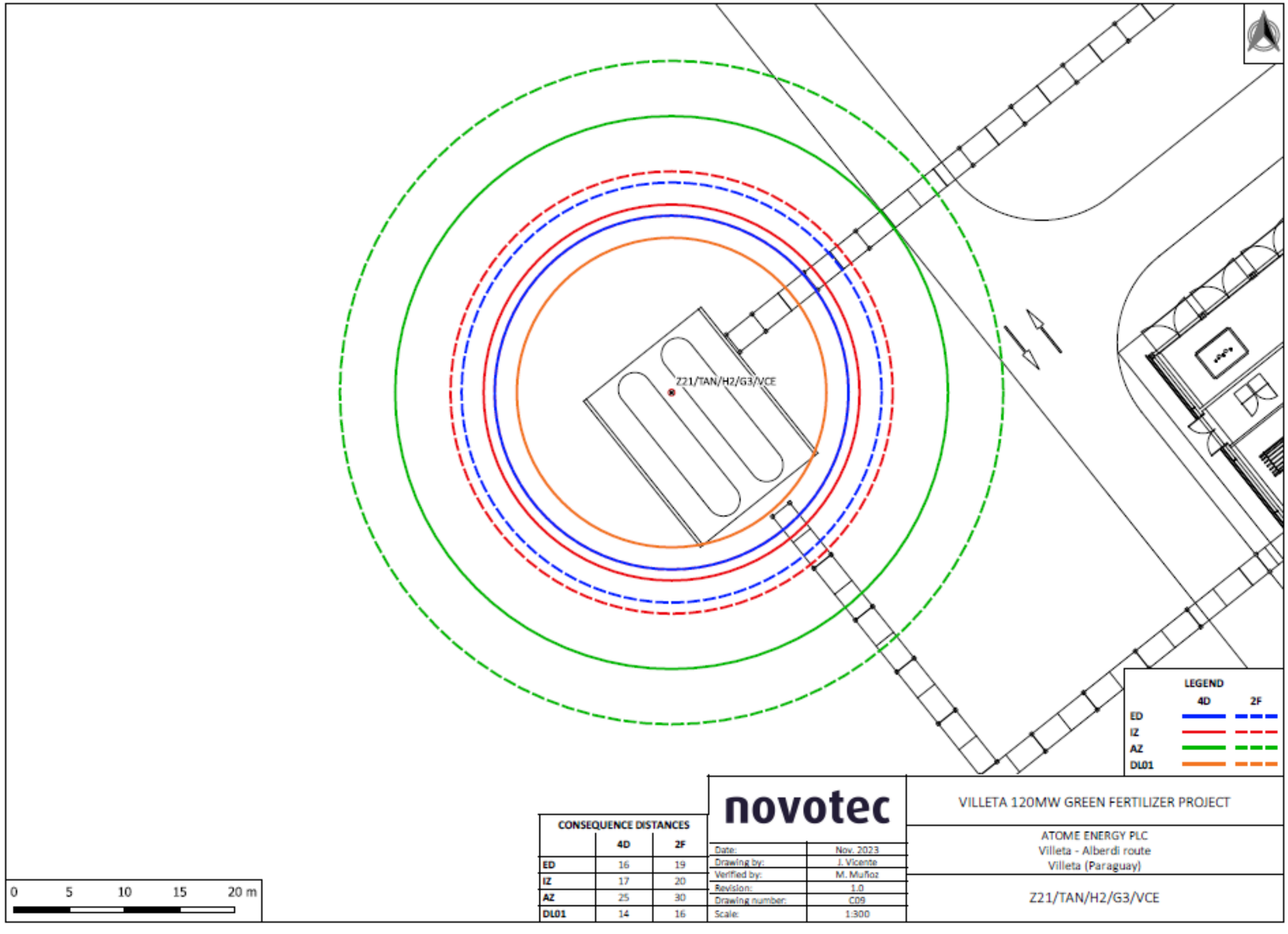

Figure 6.4.1.3.b-10
Jet Fire *Risk Areas* in the H2 Tank Reserve Park

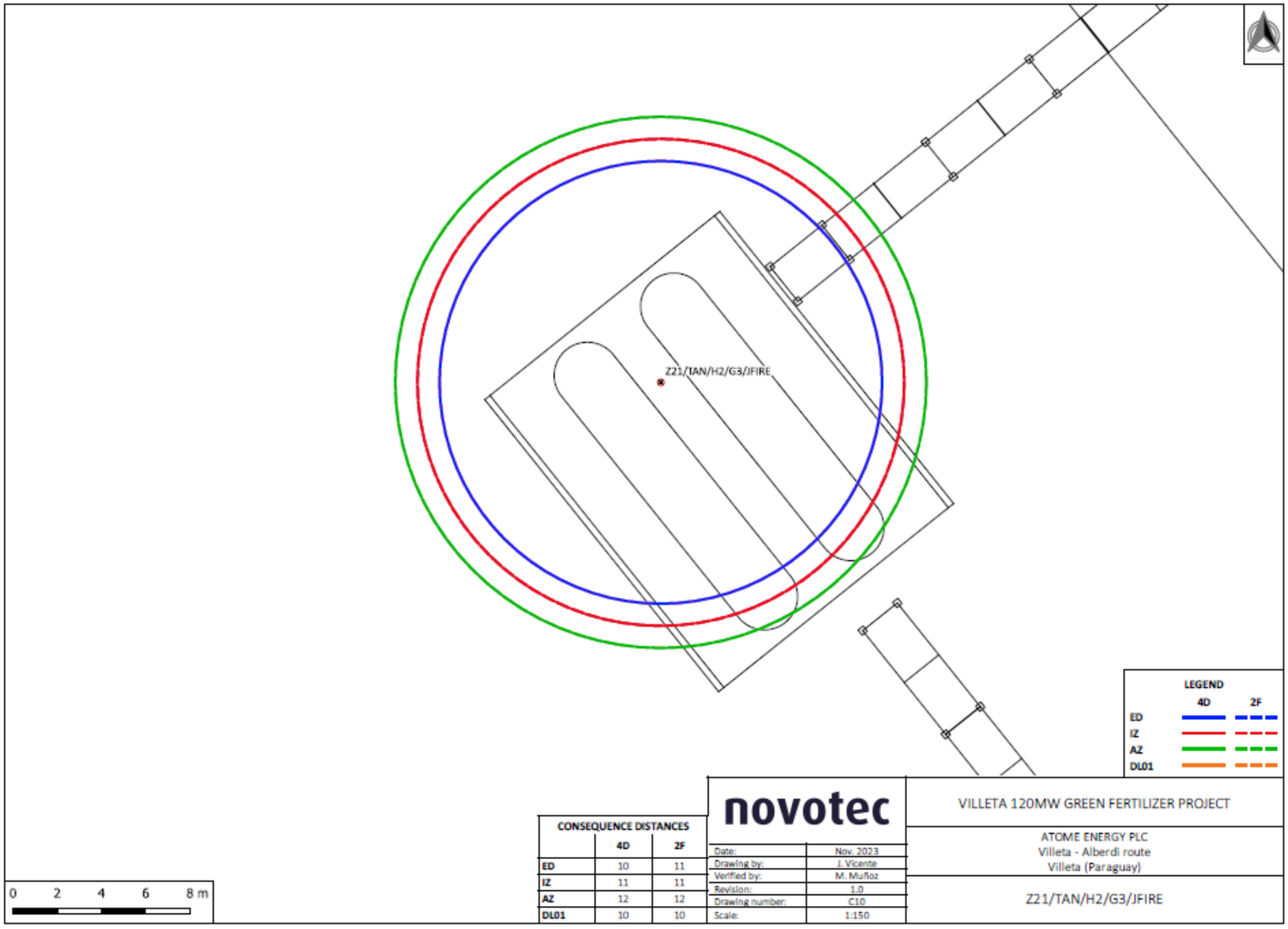

Figure 6.4.1.3.b-11
Flash Fire *Risk Areas in Syngas Compressors*

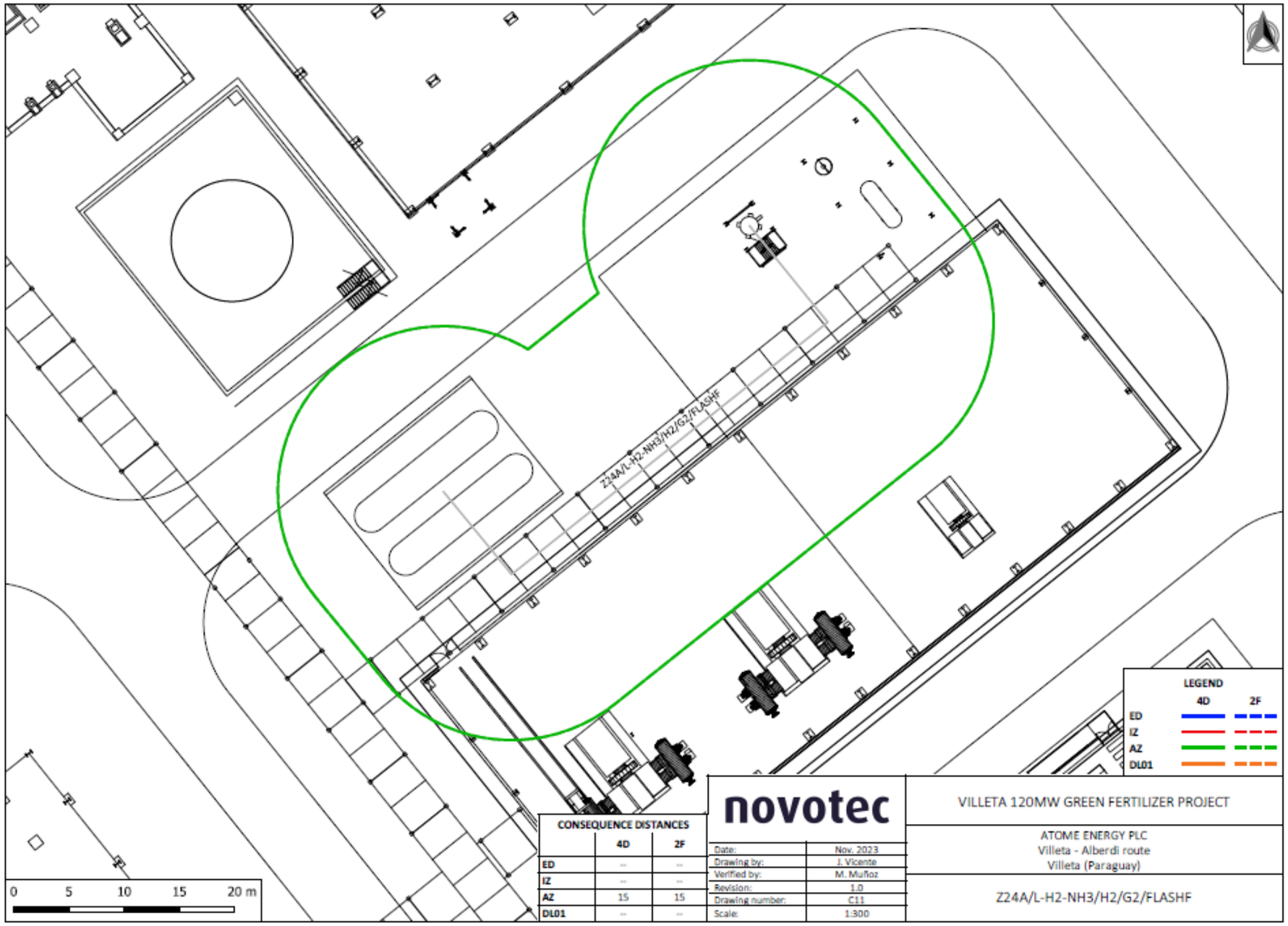

Figure 6.4.1.3.b-12
Physical Explosion (VCE) Hazard Areas in Syngas Compressors

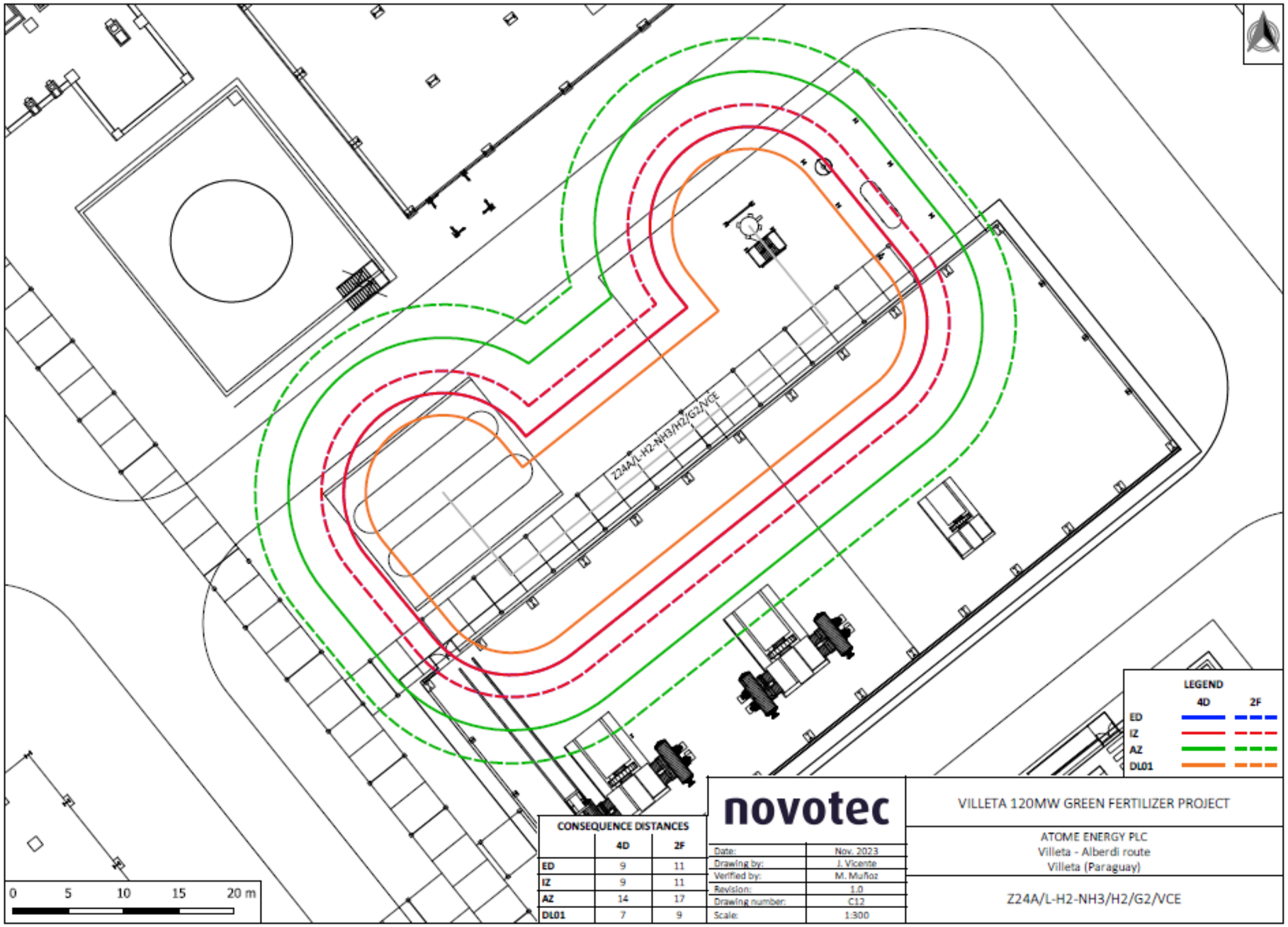

Figure 6.4.1.3.b-13
Jet Fire *Risk Areas in Syngas Compressors*

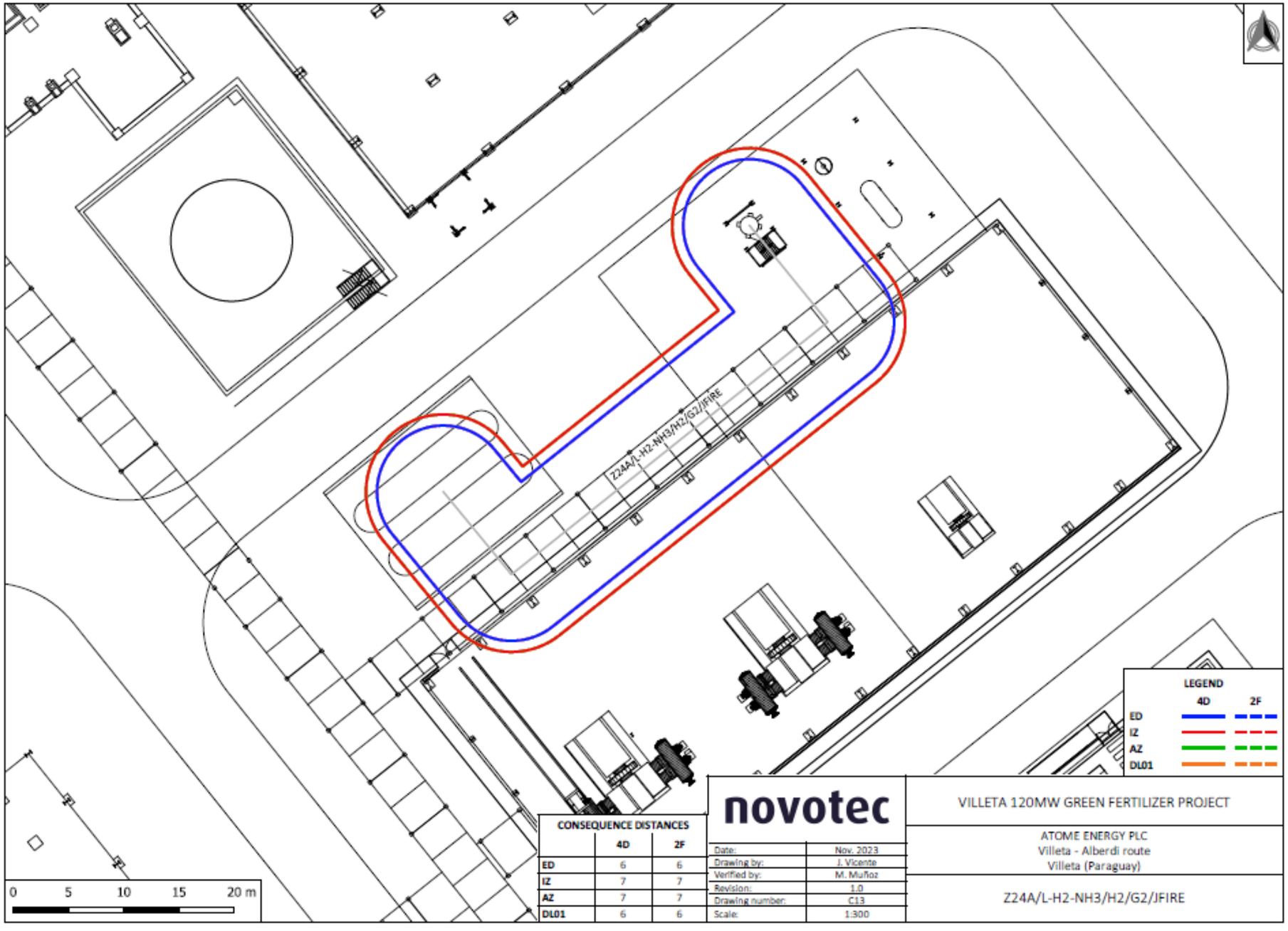

Figure 6.4.1.3.b-14
Flash fire hazard areas in the ammonia compressor of the NH3 Synthesis Unit

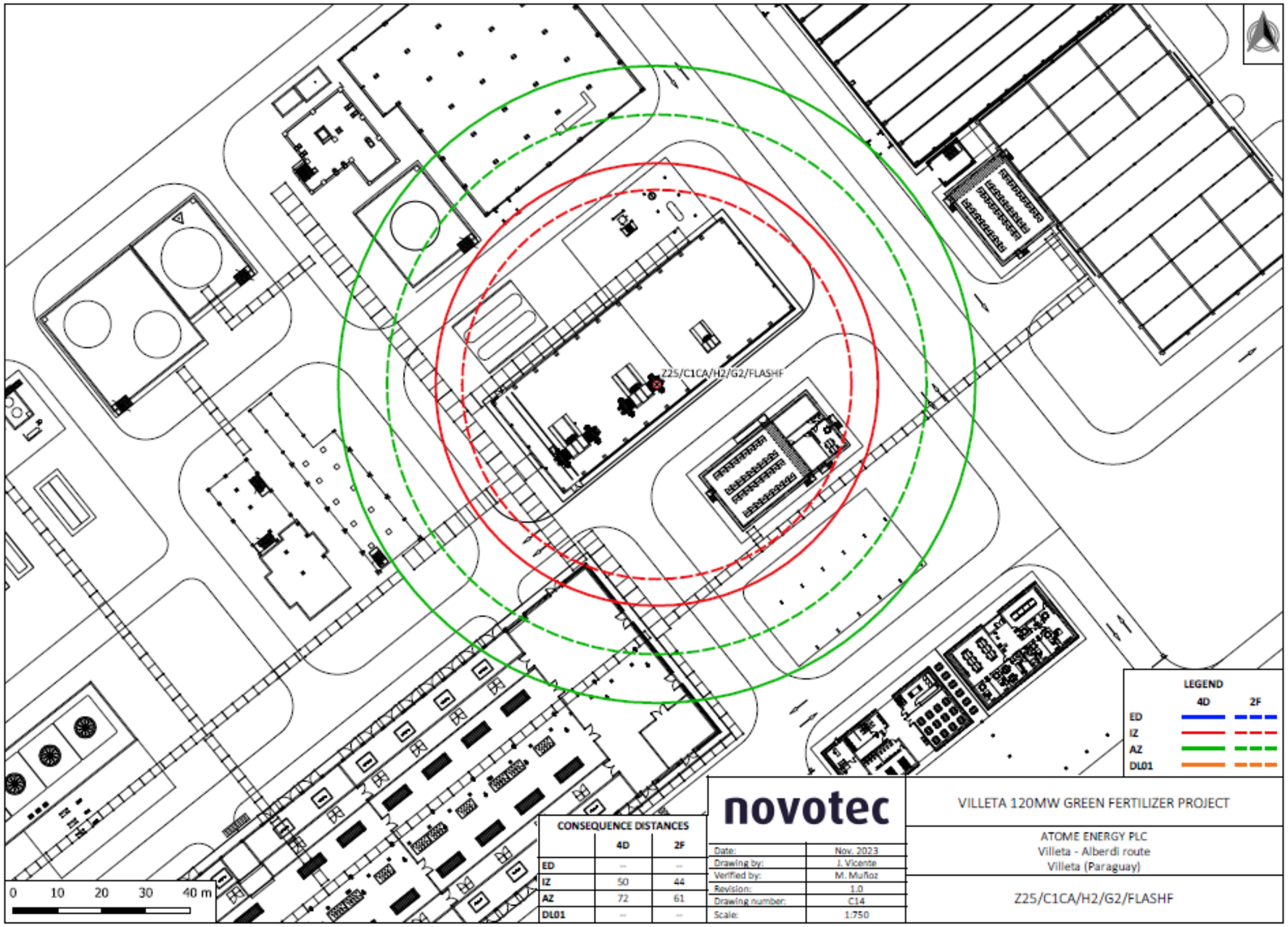

Figure 6.4.1.3.b-15
Jet Fire Risk Areas in the Ammonia Compressor of the NH3 Synthesis Unit

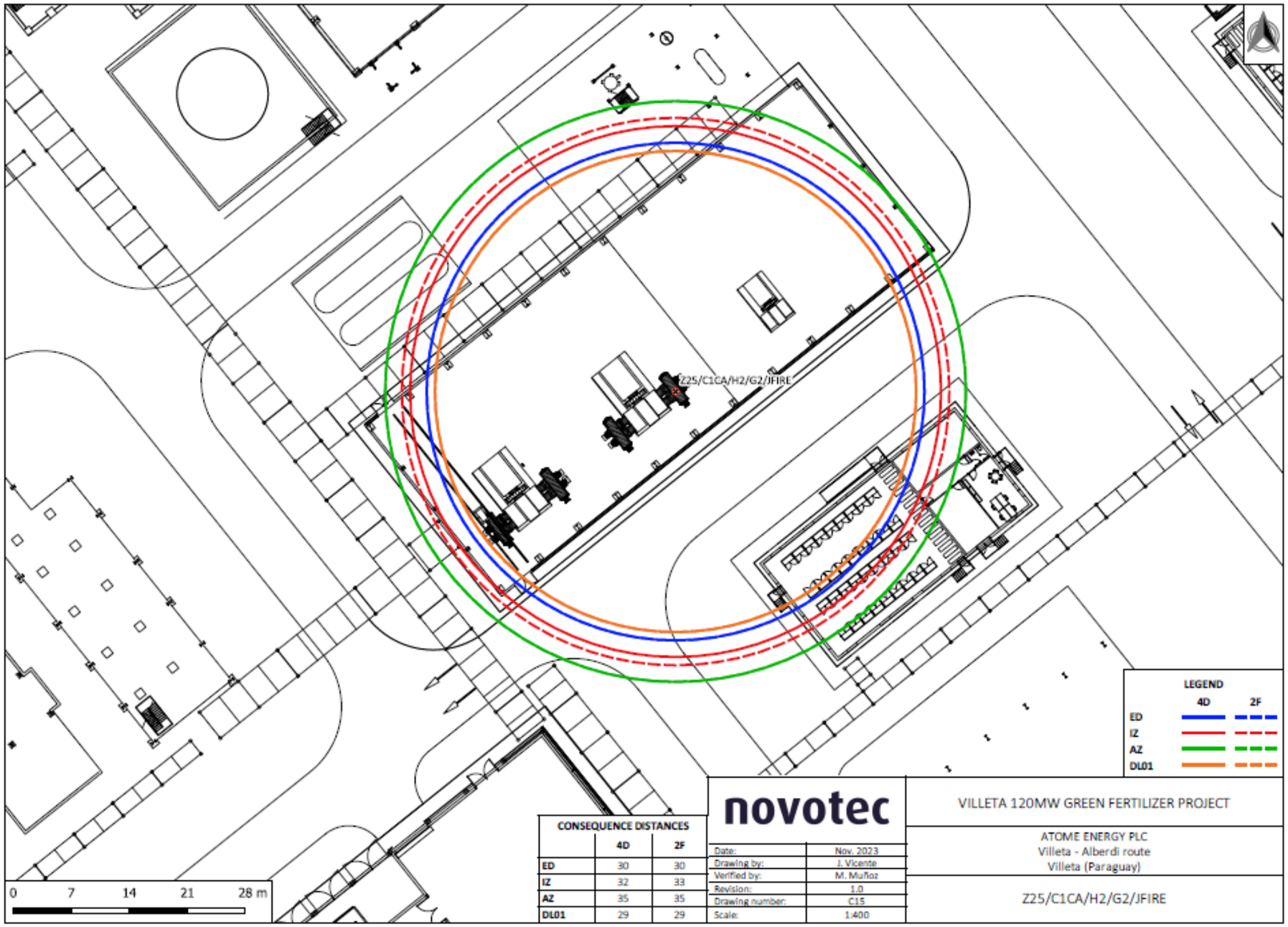

Figure 6.4.1.3.b-16
Physical Explosion (VCE) Hazard Areas in the Ammonia Compressor of the NH3 Synthesis Unit

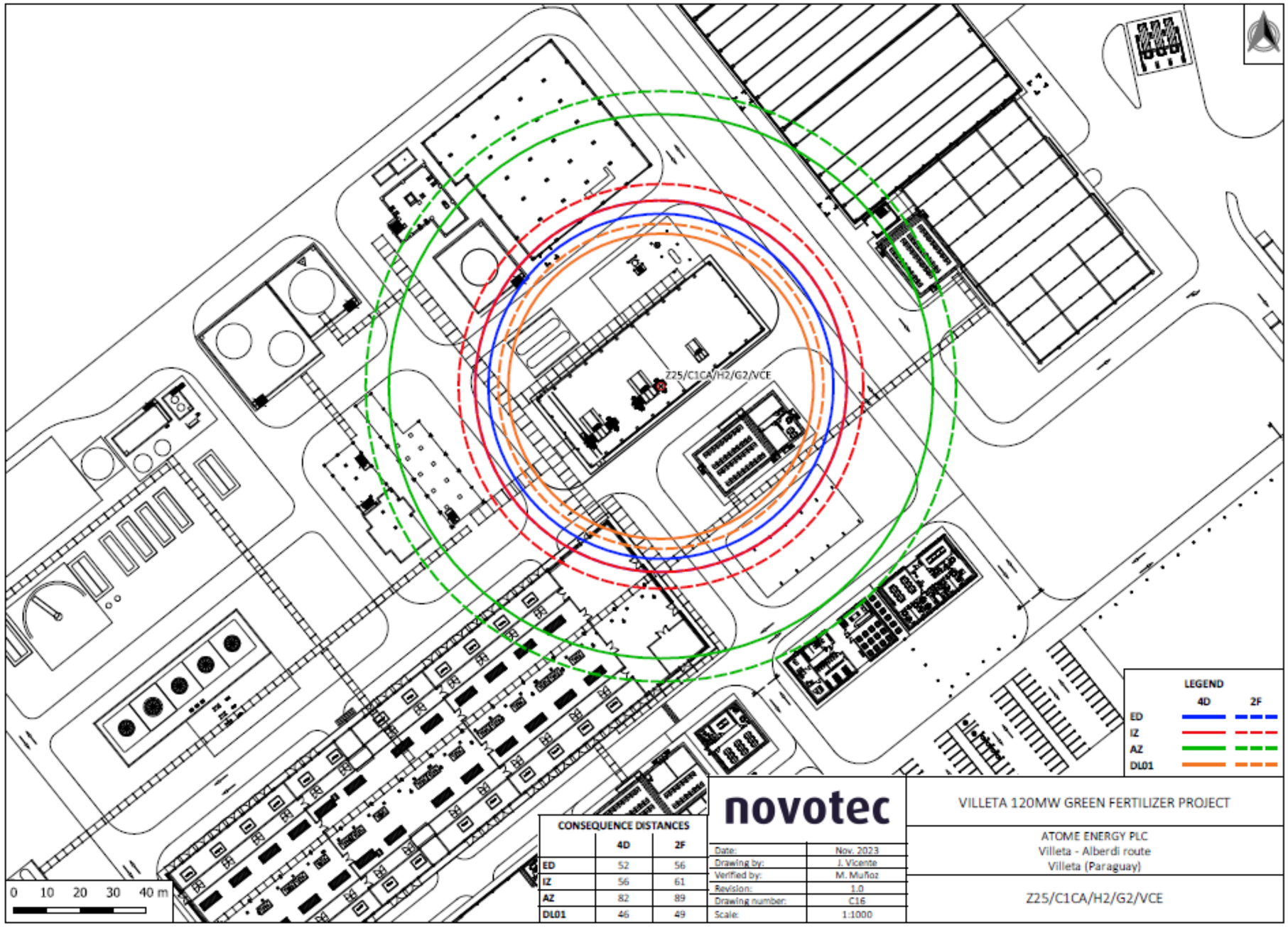

Figure 6.4.1.3.b-17
Flash fire *hazard areas* in the NH3 Synthesis Unit reactor

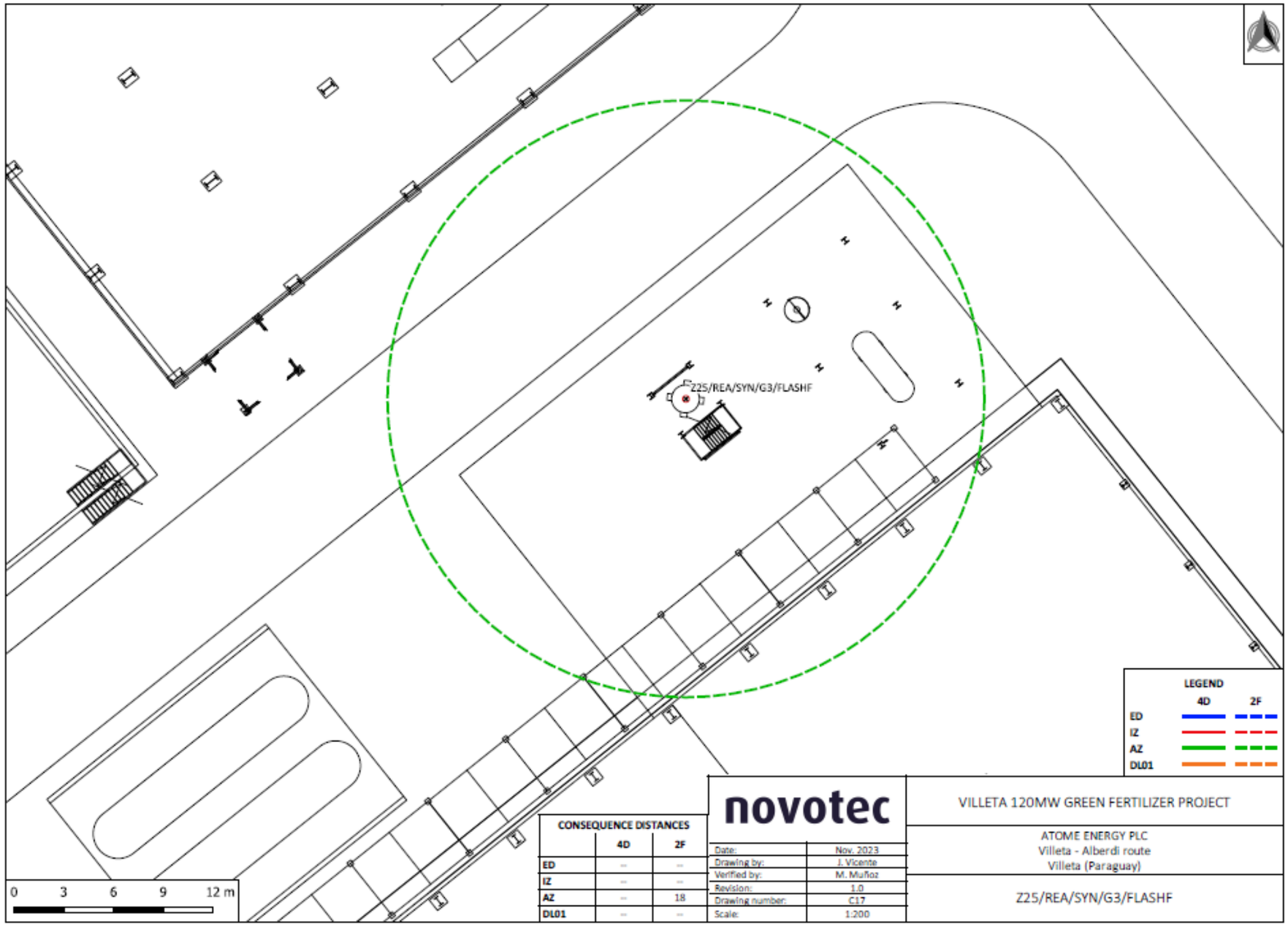

Figure 6.4.1.3.b-18
Jet Fire *Risk Areas* at the NH3 Synthesis Unit Reactor

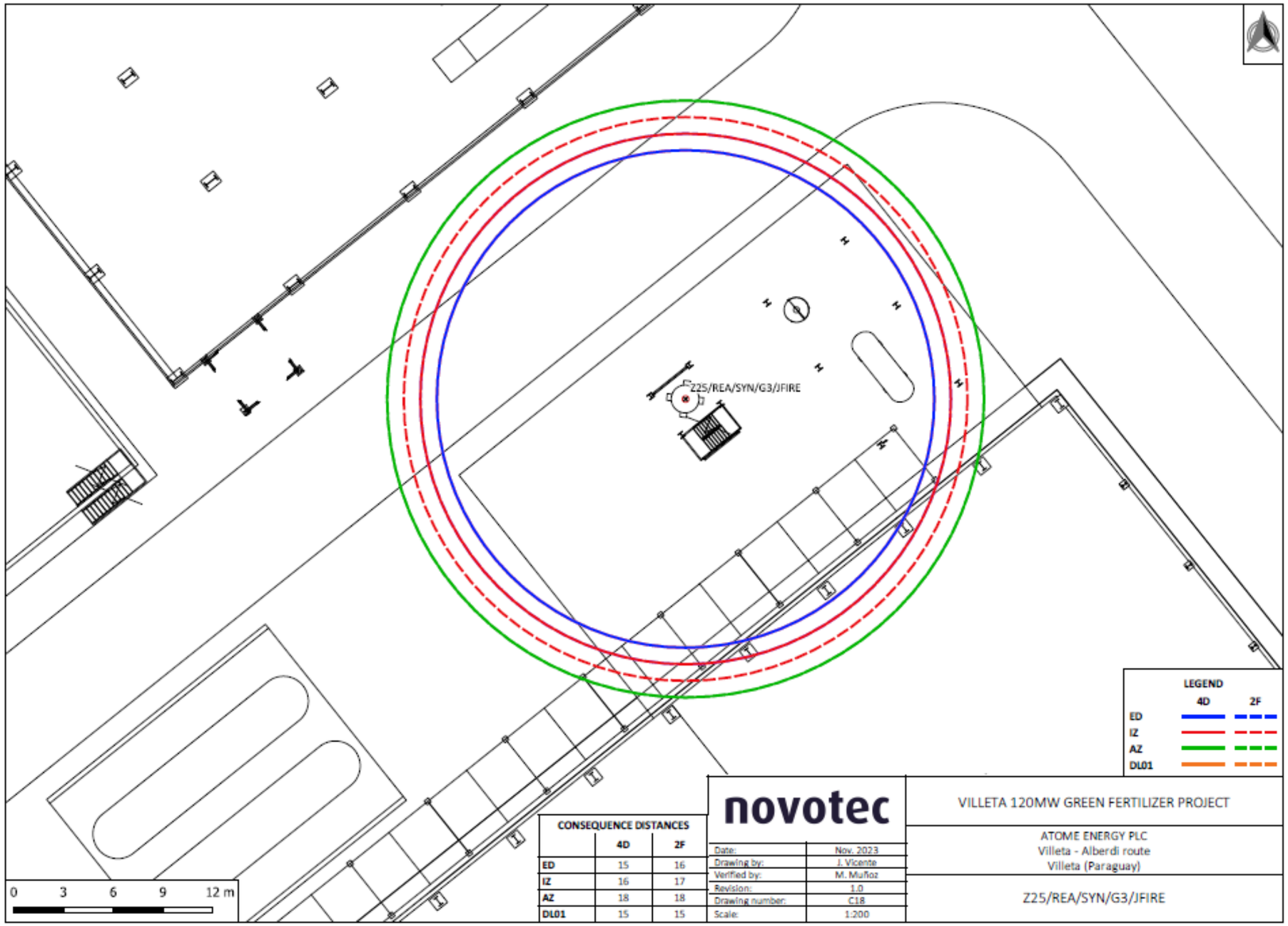

Figure 6.4.1.3.b-19
Physical Explosion Hazard (VCE) Areas in the NH3 Synthesis Unit Reactor

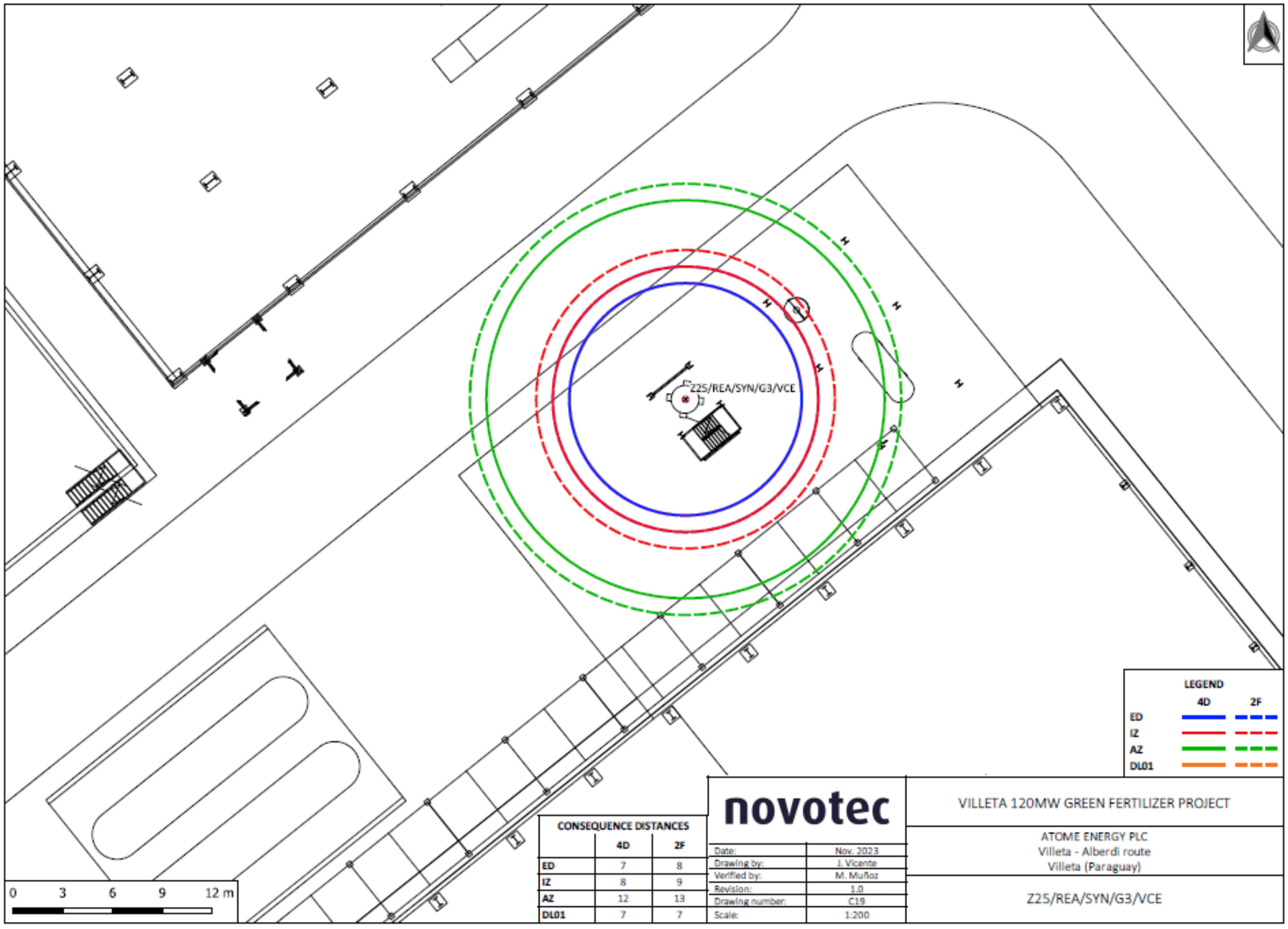

Figure 6.4.1.3.b-20
Flash fire *hazard areas* in the syngas line of the NH3 Synthesis Unit

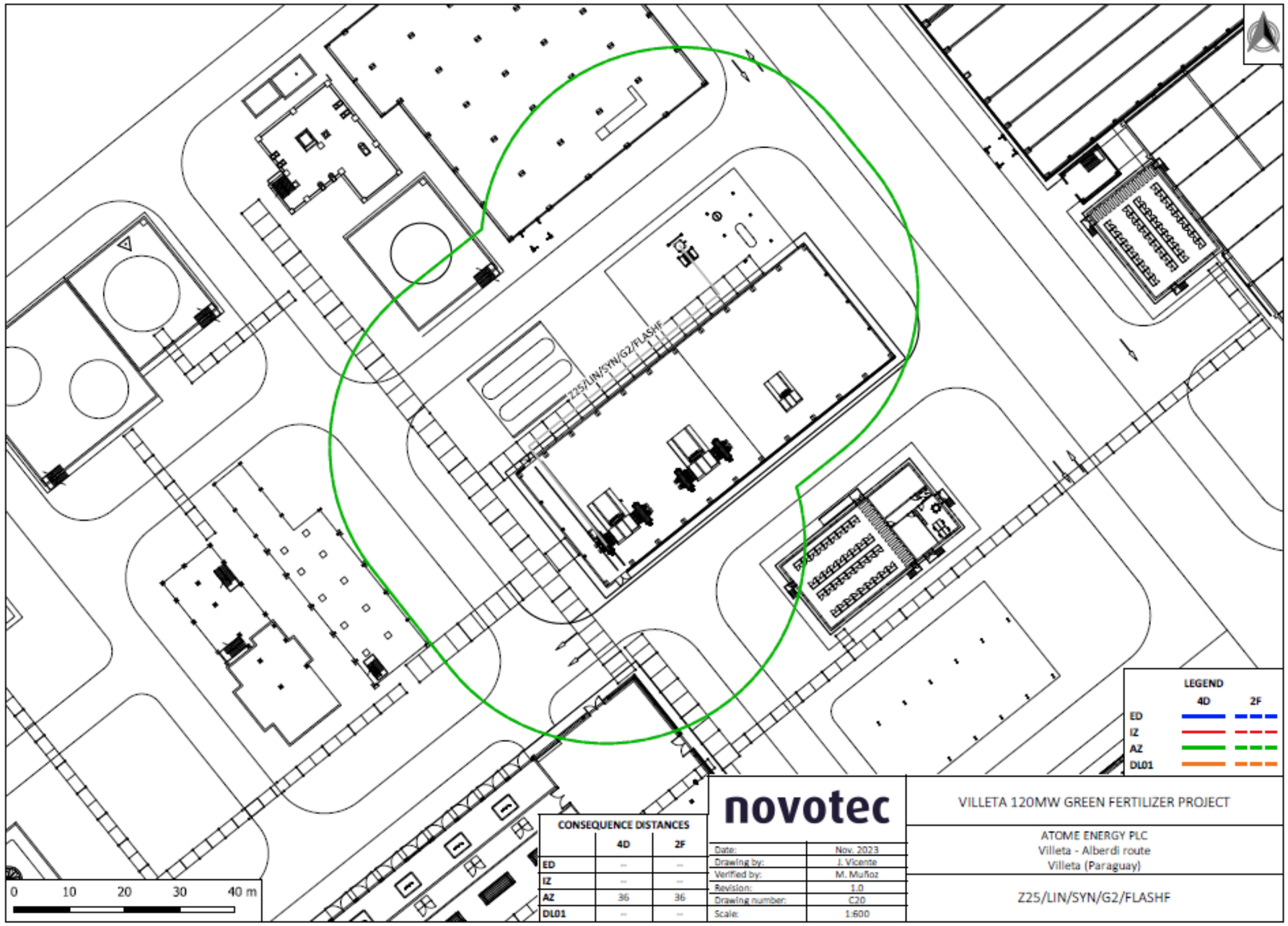

Figure 6.4.1.3.b-21
Physical Explosion Hazard (VCE) Areas in the Syngas Line of the NH 3 Synthesis Unit

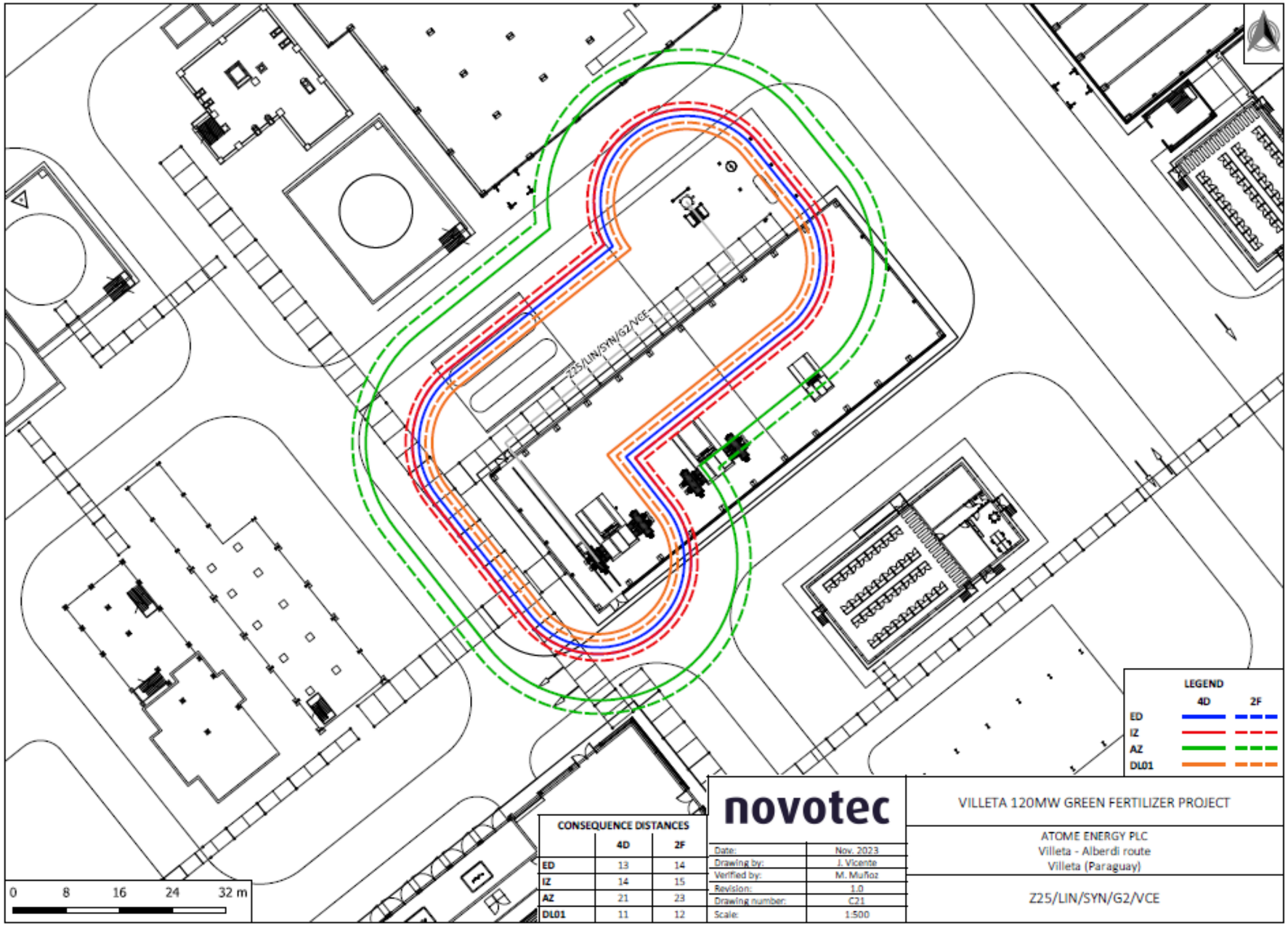

Figure 6.4.1.3.b-22
Jet Fire *Risk Areas* in the NH3 Synthesis Unit Syngas Line

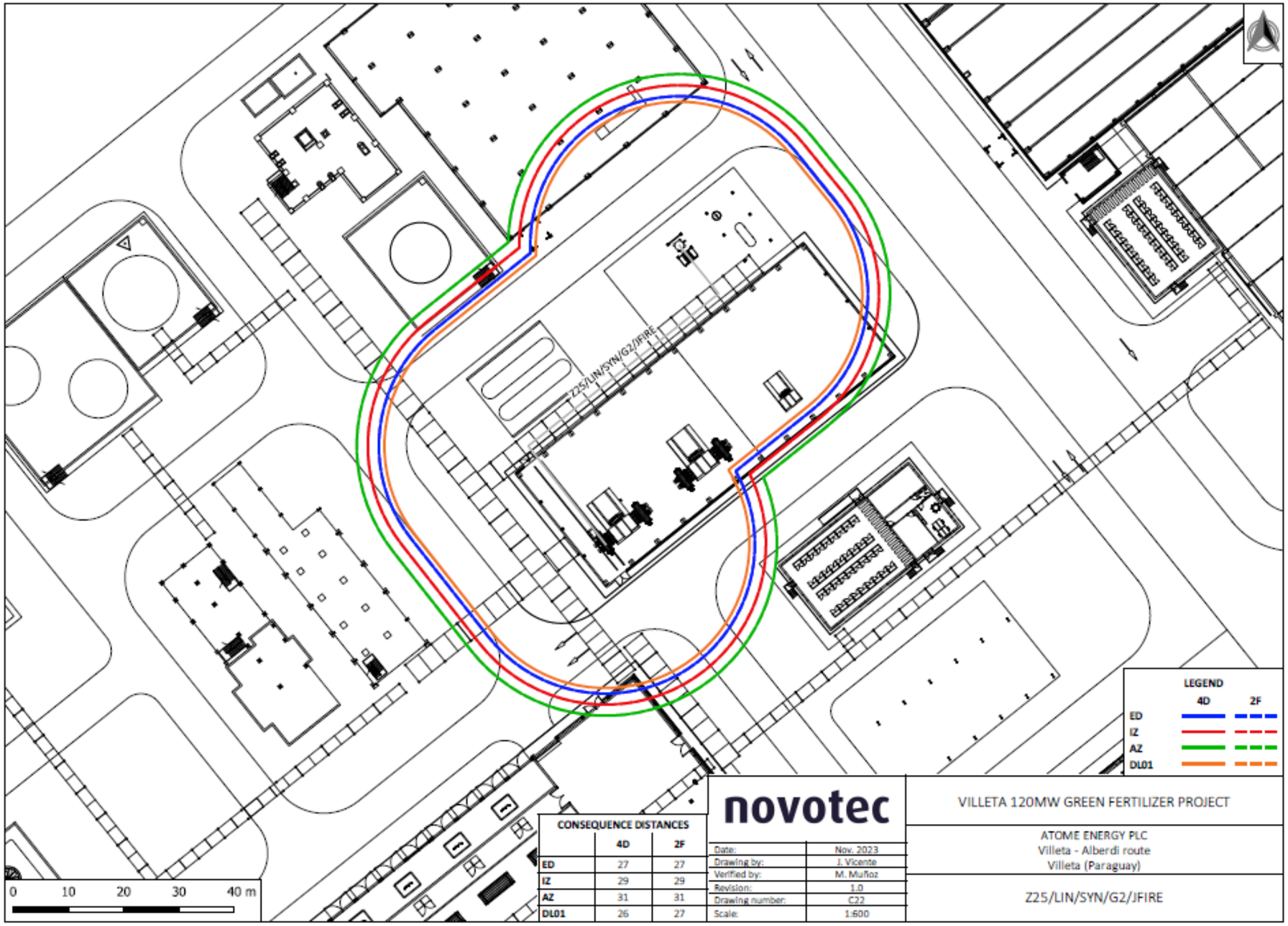

Figure 6.4.1.3.b-23
Physical Explosion Hazard (VCE) Areas in the NH3 Synthesis Unit's High Pressure NH3 Separator

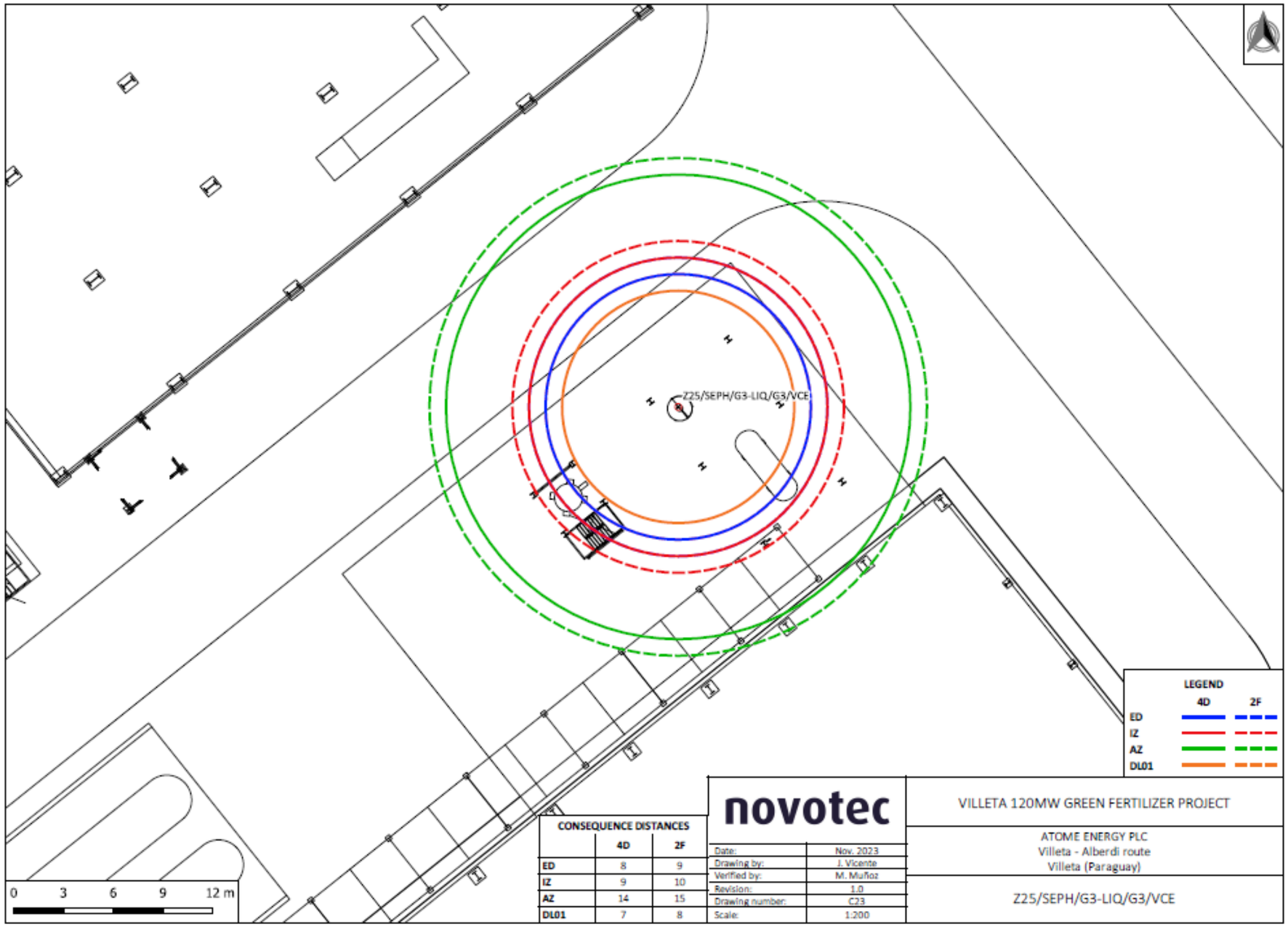

Figure 6.4.1.3.b-24
Jet Fire *Risk Areas* in the High Pressure NH3 Separator of the NH3 Synthesis Unit

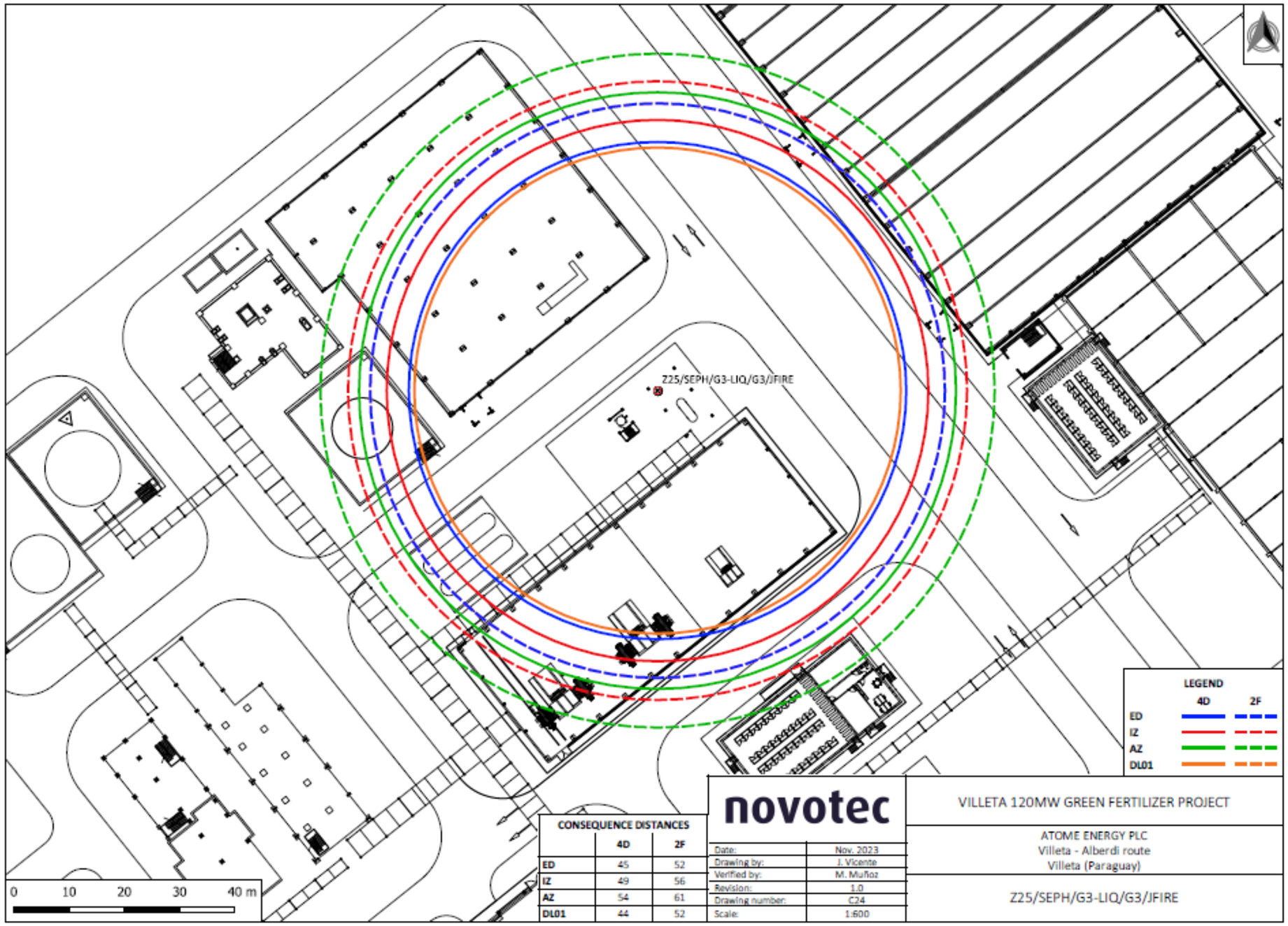

Figure 6.4.1.3.b-25
Flash fire *hazard areas* in the NH3 separator under atmospheric conditions of the NH3 Synthesis Unit

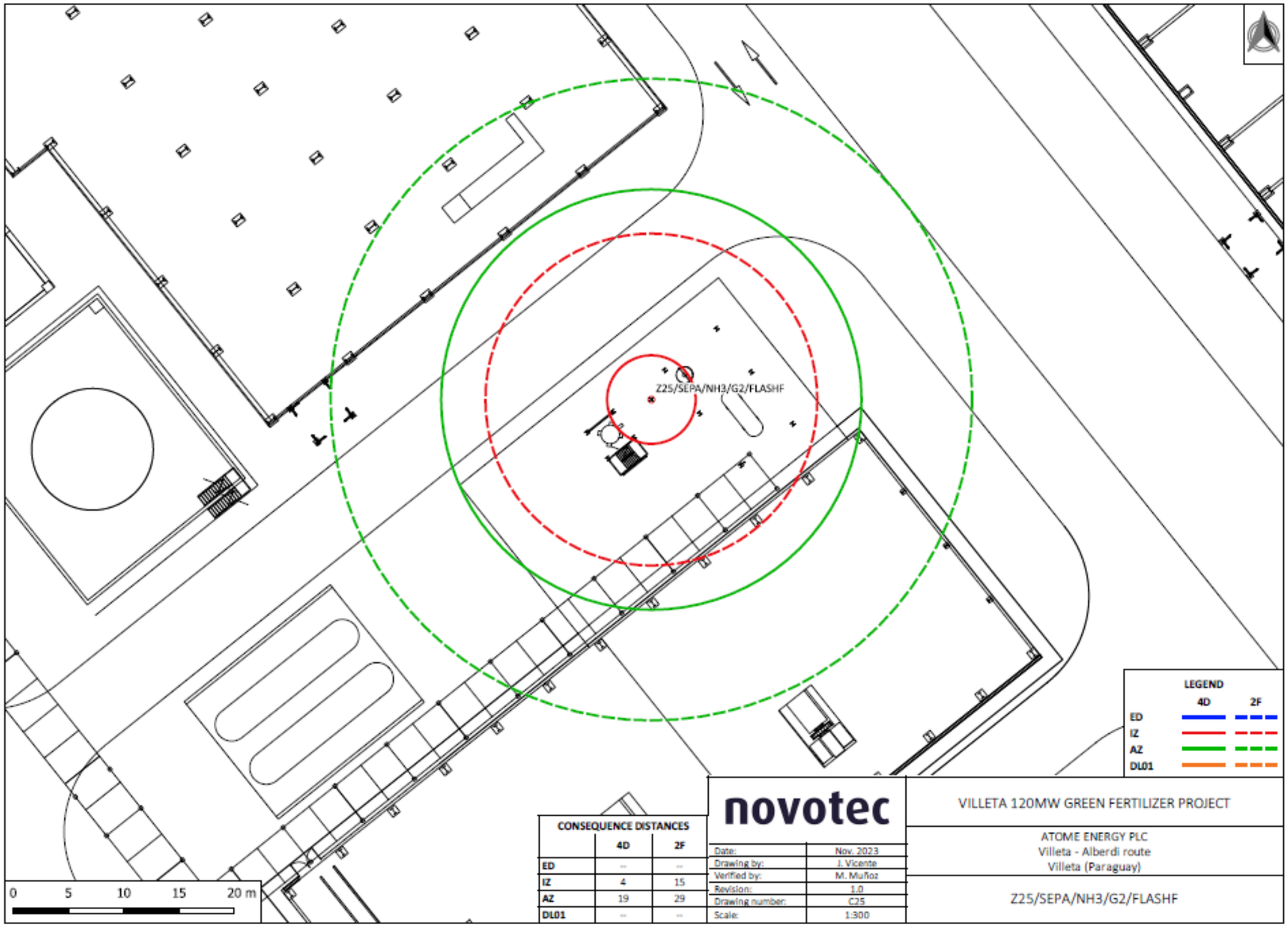

Figure 6.4.1.3.b-26
Jet fire *hazard areas* in the NH3 separator under atmospheric conditions of the NH3 Synthesis Unit

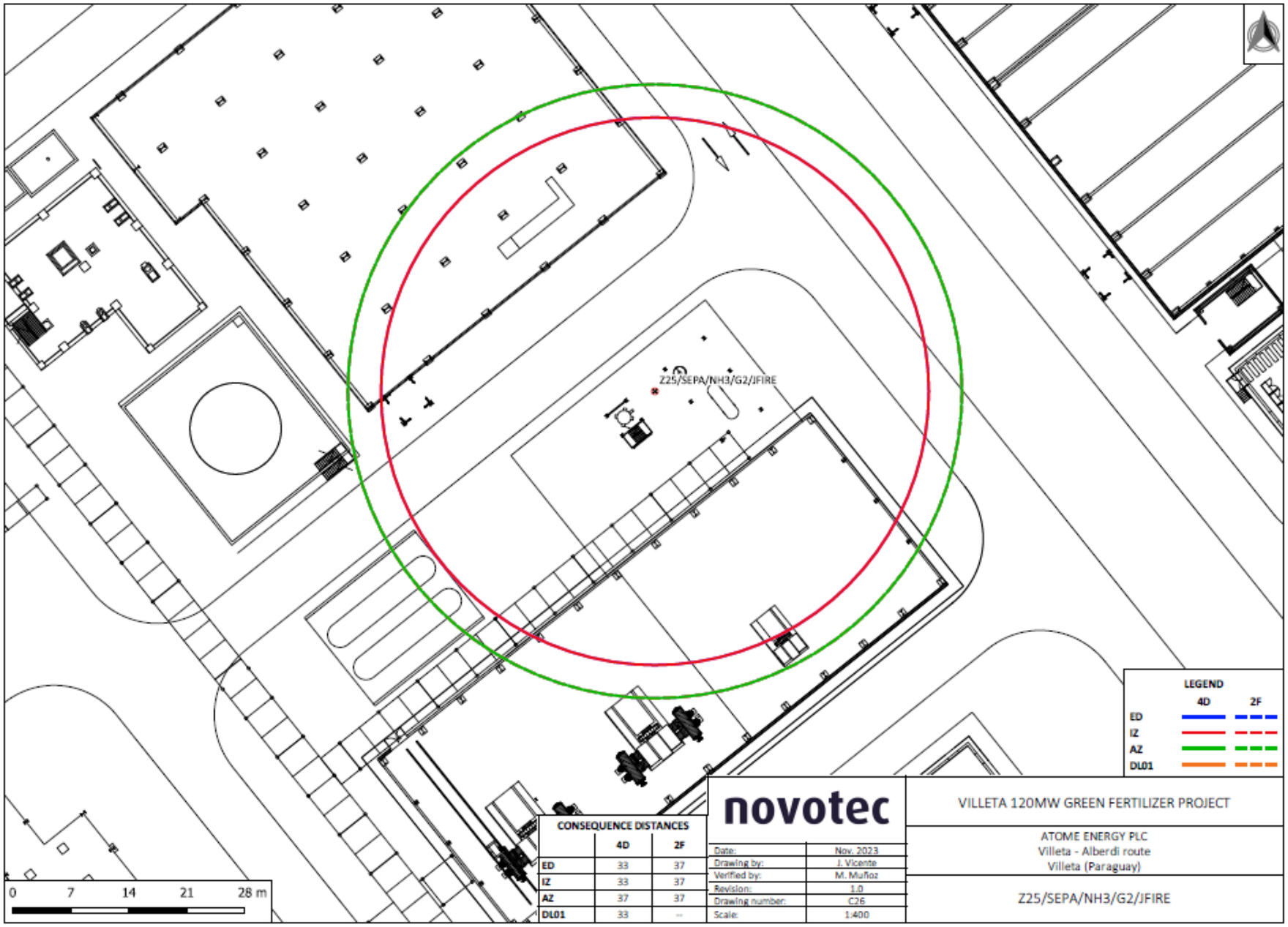

Figure 6.4.1.3.b-27
Pool fire *hazard areas* in the NH3 separator under atmospheric conditions of the NH3 Synthesis Unit

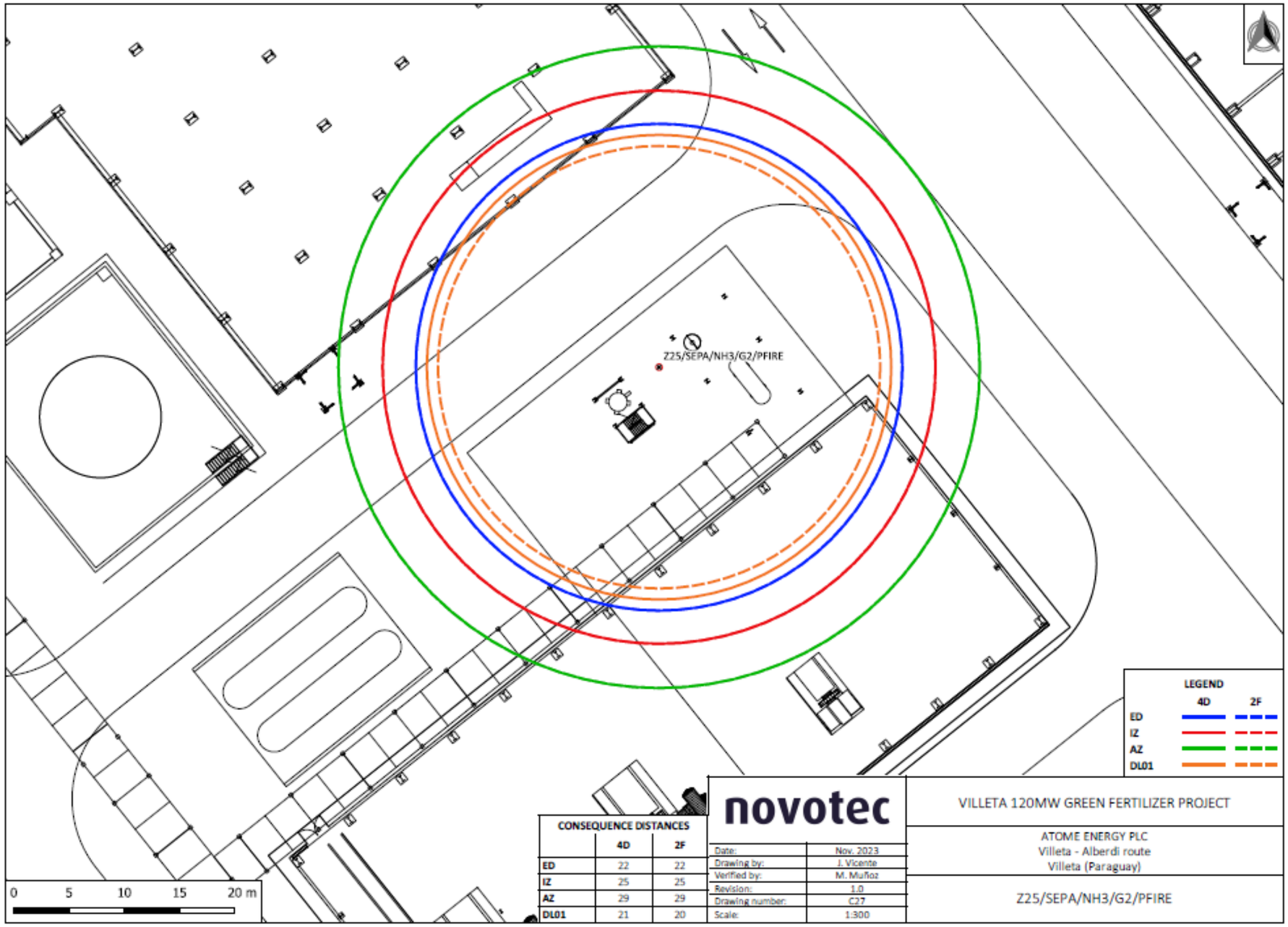

Figure 6.4.1.3.b-28
Flash Fire *Hazard Areas* in the NH3 Buffer Tank

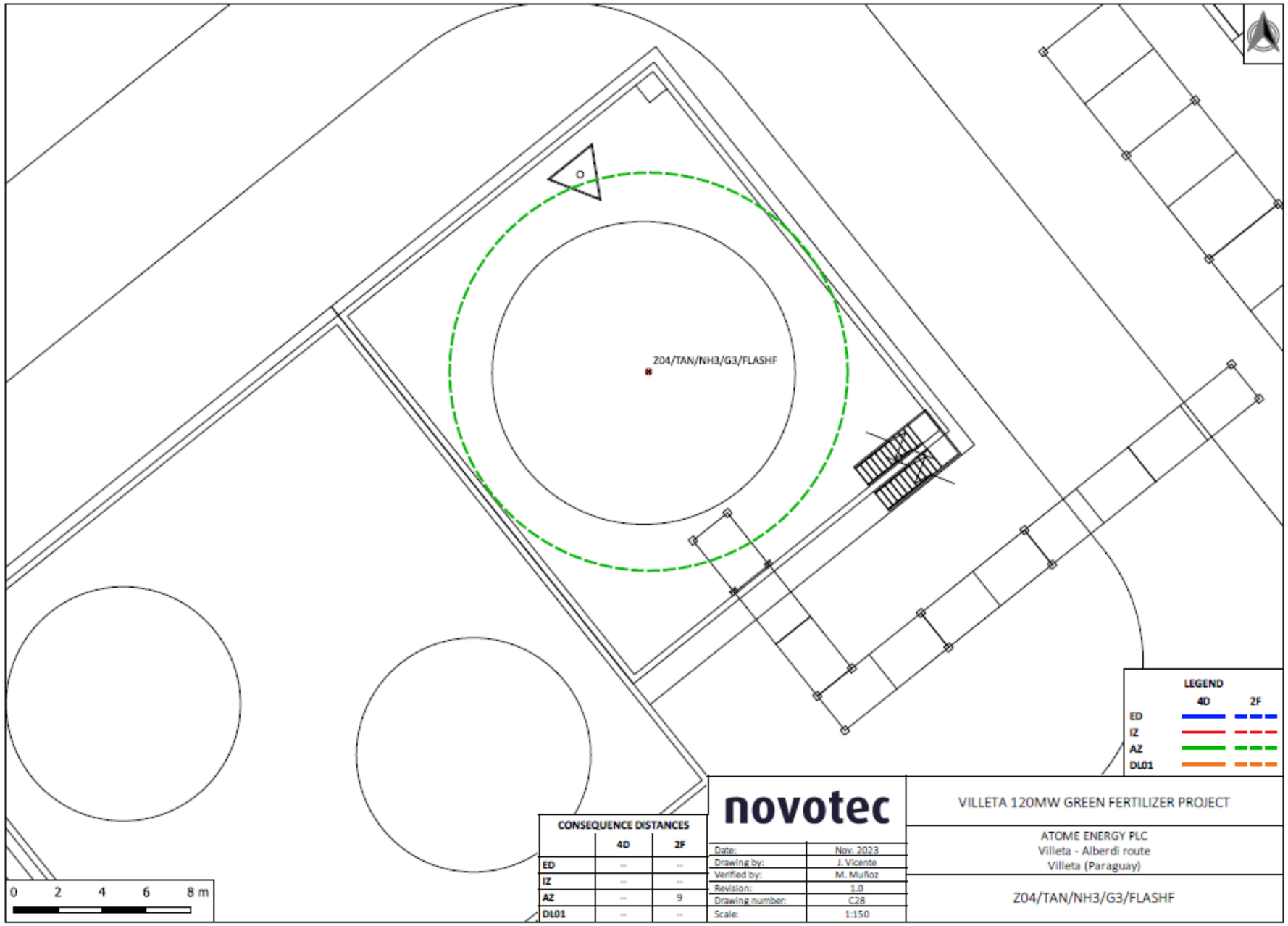

Figure 6.4.1.3.b-29
Jet Fire *Hazard Areas* in the NH3 Buffer Tank

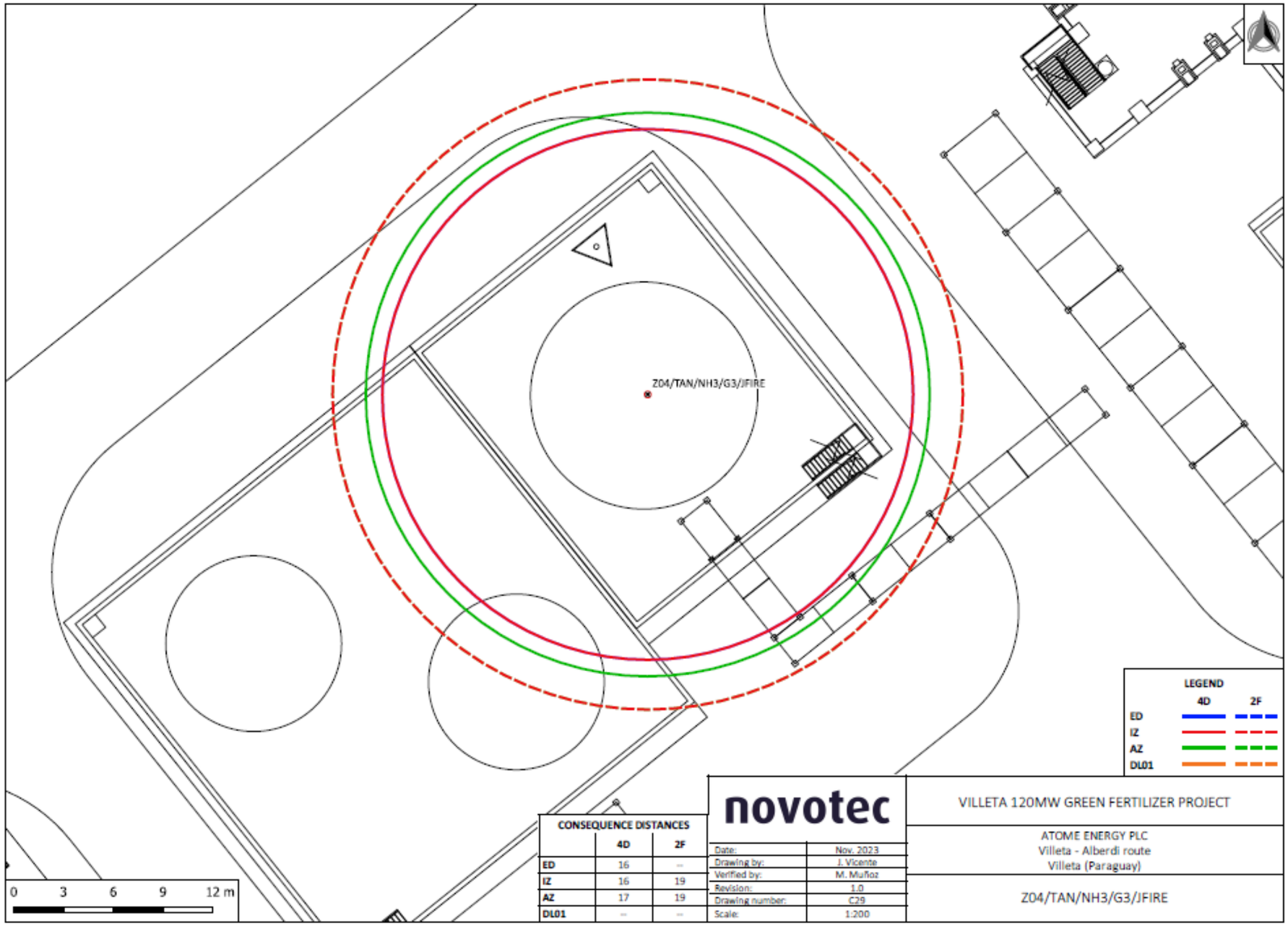

Figure 6.4.1.3.b-30
Pool Fire Hazard Areas in the NH3 Buffer Tank

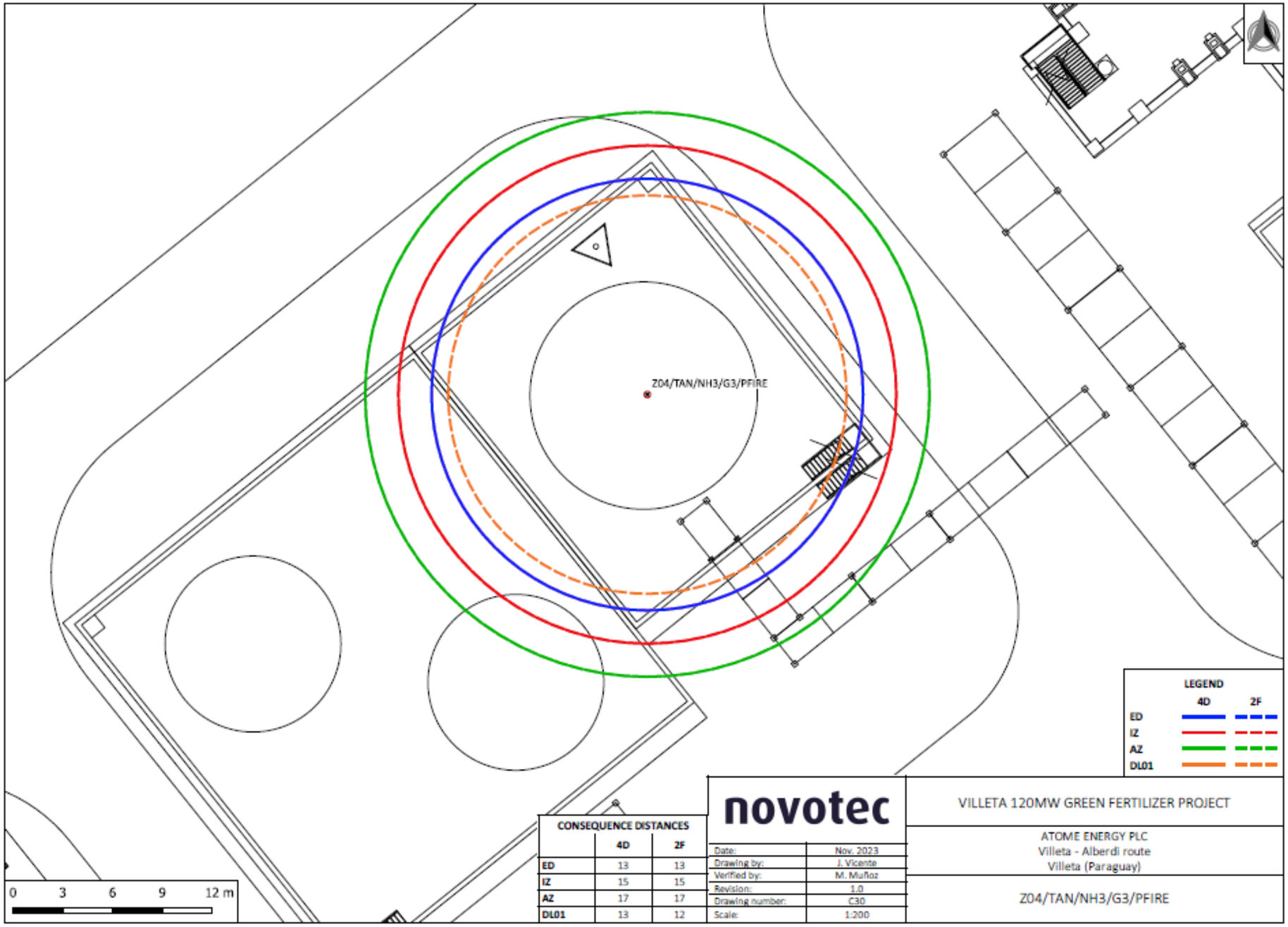

Figure 6.4.1.3.b-31
Flash Fire *Hazard Areas* on NH 3 Buffer Pump

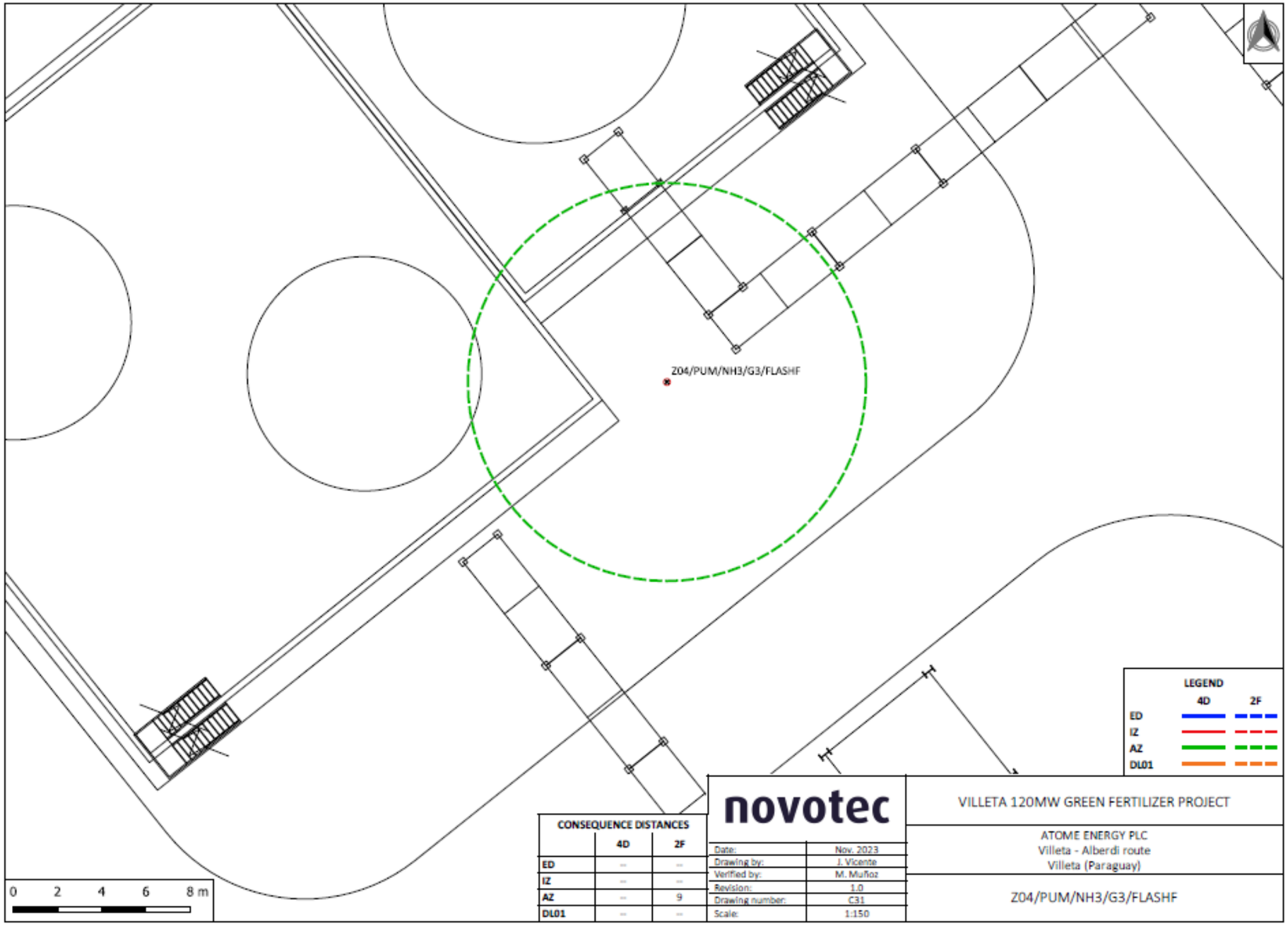

Figure 6.4.1.3.b-32
Jet Fire *Hazard Areas* in the NH 3 Buffer Pump

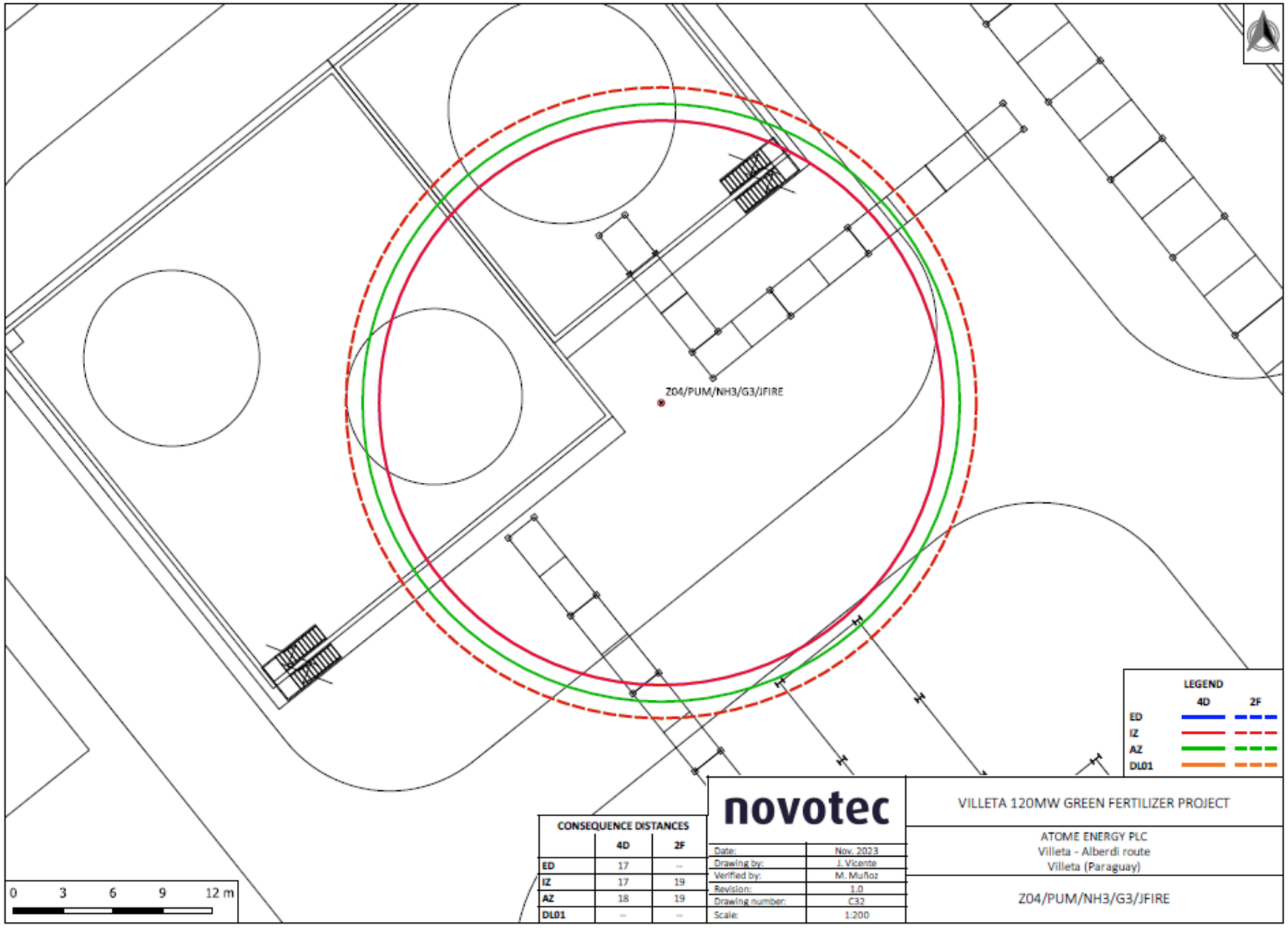

Figure 6.4.1.3.b-33
Pool Fire *Hazard Areas* at the NH3 Buffer Pump

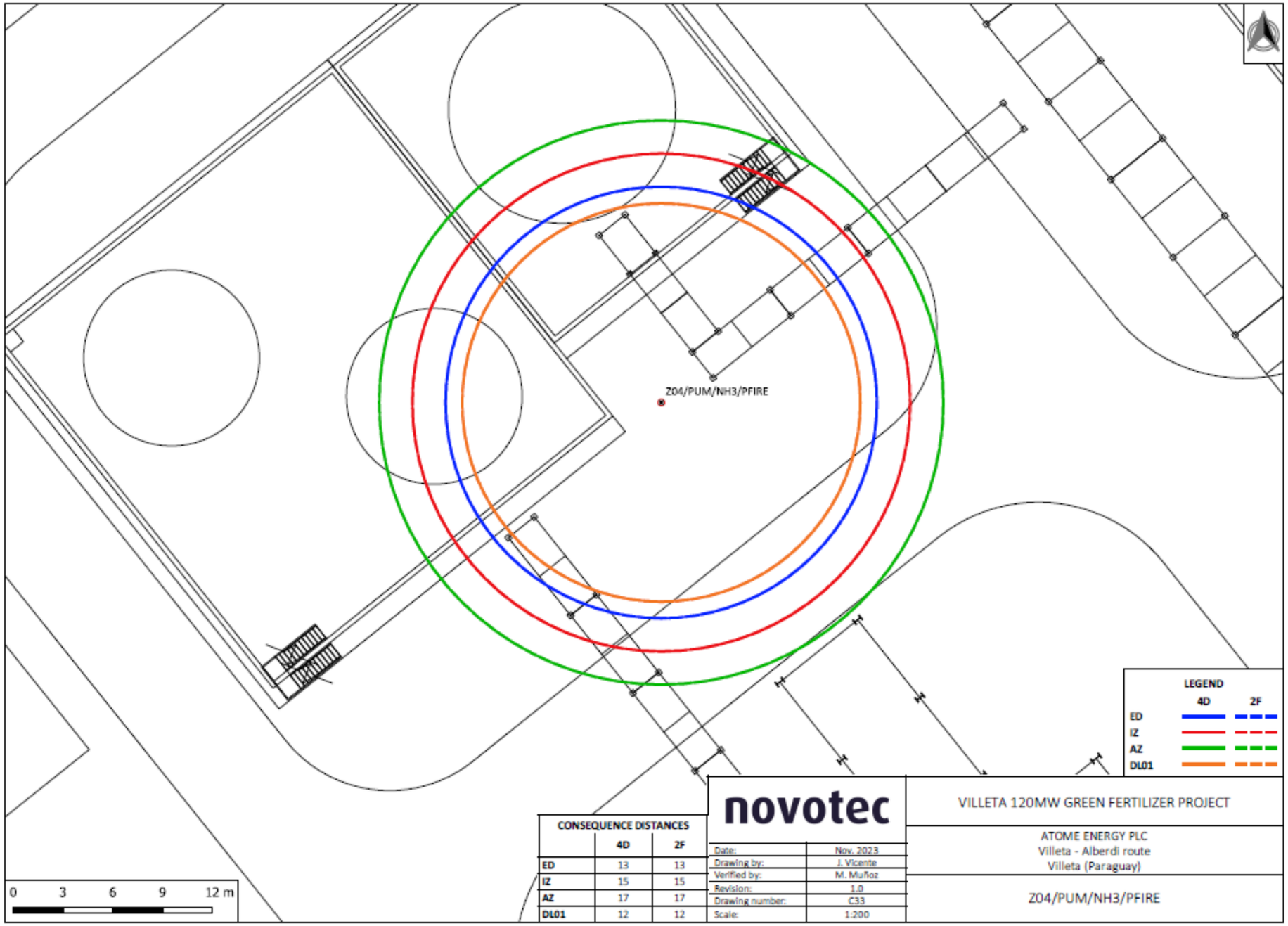

Figure 6.4.1.3.b-34
Pool Fire *Risk Areas* on the Nitric Acid (AN) Plant Line

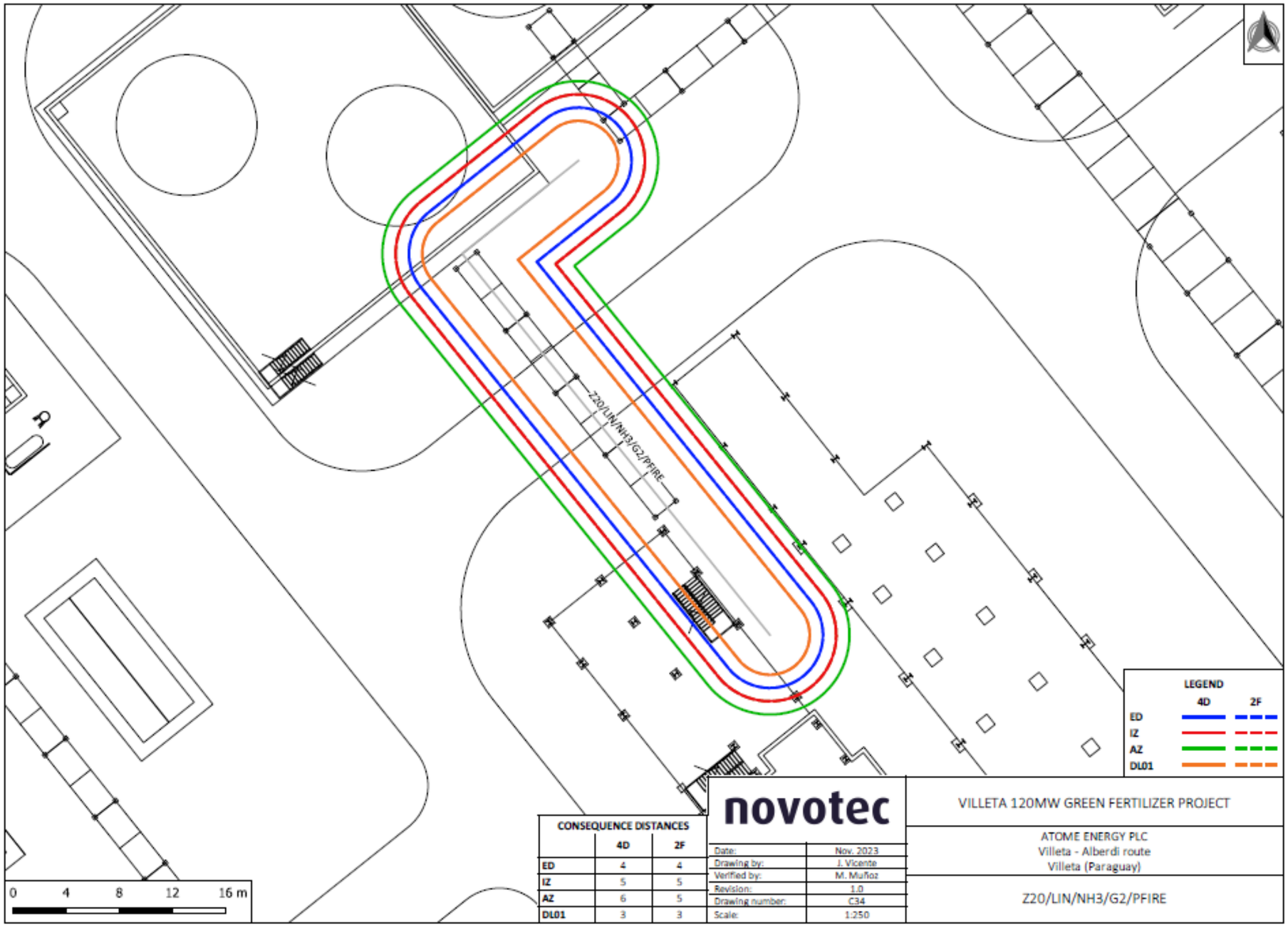

Figure 6.4.1.3.b-35
Pool Fire *Hazard Areas* on the Ammonium Nitrate Solution (SNA) Plant Line

