ARCADIS Design & Consultancy for natural and built assets

ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT

Piauí Nickel Project

Volume I

Chapter 1 – Identification of the Company and Environmental Consultancy responsible for ESIA/RIMA

Chapter 2 – Project Description

Chapter 3 – Applicable Legal Regulations

NOVEMBER 2017

ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT

Volume I

Piauí Nickel Project

PIAUÍ NÍQUEL METAIS S.A

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Location	Capitão Gervársio Oliveira, PI
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Date of document:	29/11/2017

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This document consists of 04 (four) volumes and is being delivered in 03 (three) printed copies and 03 digital copies.

This is an English Translation of the Original Portuguese ESIA which was submitted to SEMAR.

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Introduction

This document refers to the Environmental and Social Impact Assessment (ESIA) and the respective Environmental Impact Report (RIMA) for the implementation of the Piauí Nickel Project, prepared by the independent consulting company ARCADIS in order to proceed with the environmental licensing process with the Secretariat of Piauí State of Environment and Water Resources (SEMAR-PI), aiming to obtain the project's environmental feasibility permit called *Licença Prévia – LP* (first License followed by the Installation and Operation Permits).

This process started with the protocol of the Term of Reference (TR) for the Preparation of Environmental and Social Impact Assessment - ESIA / RIMA of the Piauí Nickel Project, on October 14, 2016 (Protocol AA.130.1.007975 / 16). On December 12, 2016, SEMAR-PI issued the Technical Opinion of process No. 7,975 / 16 approving and complementing the submitted TR. These two documents served as guidelines for the achievement of the present work.

The venture, which consists of a mineral-processing complex for the production of a Nickel Hydroxide Precipitate (NHP), is the responsibility of the company Piauí Níquel Metais S.A. - PNM.

In addition to the municipality of Capitão Gervásio Oliveira, where the nickel ore deposit is located, and where the nucleus of the Piauí Nickel Project is projected, other municipalities will be included in the project. In São João do Piauí, the municipality where two of the main inputs will be supplied from, water, which is expected to be captured from the Jenipapo dam and transported by a projected water pipeline 33.52 km long, and electricity, from the construction of a 69kV and 42.63 km long transmission line to the CHESF substation. Part of a new exclusive access road between the project and the PI-465 state road will pass through the municipality of Campo Alegre do Fidalgo, and in the municipality of Dom Inocêncio, limestone extraction and processing will be implemented at a location called Umbuzeiro, 33 km away from the Piauí Nickel Project nucleus. A road will also be built between the mining & processing complexes of Brejo Seco and Umbuzeiro.

Originally conceived by the Vale do Rio Doce Company, the Piauí Nickel Project was sold through international tender opened in 2012. After the acquisition of the project in 2013, PNM carried out studies to increase the accuracy of the mineral prediction, in addition to adapting the existing pilot plant built by Vale, in order to apply its own know-how in nickel heap leaching.

These studies culminated in adjustments in the process technology significantly reducing the area to be occupied by the future venture and the implementation of new technologies making the entire process more environmentally friendly, without however changing the concept of the mining project.

The characteristics of land use and occupation of the project's areas of influence remained practically unchanged over the period since 2008, when at this time, Arcadis Tetraplan carried out the environmental study (ESIA / RIMA) for Vale. Thus, the primary and secondary surveys, carried out to support the preparation of the 2008 ESIA, proved adequate to be used in the composition of the environmental and social diagnosis of the present ESIA / RIMA and lacked only some additions and updates of some data to technically support the evaluation of environmental impacts and propose mitigating measures for the current project.

The objective of this ESIA is, therefore, to present the project conceived by PNM, as well as the socio-environmental diagnosis of its areas of influence, aiming to identify and evaluate the environmental impacts linked to the planning, implementation (construction), operation and closure phases of the project and to propose actions to prevent, mitigate, compensate and monitor them. In this perspective, the ESIA is structured in 4 Volumes.

- Volume I
  - Chapter 1 - Identification of the Company and the Consulting Company: data on the Company and the company responsible for the ESIA / RIMA are presented.
  - Chapter 2 - Project Description: includes the project's history, objective and description, including its planning, implementation, operation and decommissioning phases, the description of the project's structures and facilities, based on information provided by PNM. In this chapter, Technological and Locational Alternatives are also addressed, presenting the alternatives of layout, location and dimension of the different structures of the project, as well as an evaluation of the advantages and disadvantages of each alternative.
  - Chapter 3 - Applicable Regulation: presents the current environmental legislation, summarized in the form of a framework, at the federal, state level and other resolutions and technical standards relevant to the project.

- Volume II
  - Chapter 4 - Definition and Delimitation of the Areas of Influence: the geographical limits of the Areas of Indirect Influence - AII, Areas of Direct Influence - ADI and Directly Affected Areas - DAA adopted in the study are presented, as well as the methodology used for their definition.
  - Chapter 5 – Environmental and Social Diagnosis: presents the Socio-Environmental Diagnosis of the areas of influence of the project for the physical, biotic and socioeconomic environments. This diagnosis will support the assessment of environmental impacts and the preparation of environmental prognosis, in addition to the respective proposal for Social-Environmental Programs.

- Volume III
  - Chapter 6 - Integrated Analysis: comprises an integrated assessment of the study areas considering all aspects studied of the physical, biotic and socioeconomic environments and the assessment of their fragility in the face of the presence of the future project.
  - Chapter 7 - Identification and Assessment of Environmental and Social Impacts - Presents the methodology used for this and the identification and assessment of environmental and social impacts.
  - Chapter 8 - Mitigating, Compensatory Measures and Environmental Programs: includes the set of consolidated measures in the form of detailed programs based on: justifications, objectives, scope and target audience, planned activities, duration / schedule and expected results.

- Chapter 9 – Prognosis with Social-Environmental Impact Assessment: presents an assessment showing the possible future scenarios for the region where the project is inserted considering its implementation or not, and considering the impacts and measures foreseen in each of these scenarios.
- Chapter 10 - Conclusions: the main results of the study are summarized.
- Chapter 11 - Bibliographic References: bibliography and consulted sites are presented.
- Chapter 12 - Technical Team Board responsible for preparing the ESIA / RIMA, with the appropriate Technical Responsibility Notes (TRNs) of the professionals in the respective Class Councils.

- Volume IV – Annexes

The Environmental and Social Impact Assessment Report - RIMA, which consists of a summary document of the main results and conclusions of this ESIA, prepared with colloquial language and accessible to the general public, is presented in a separate and independent document to this ESIA.

1. Identification of the Company & the Consultant

1.1. Identification of the Company

Company	Piauí Níquel Metais
Registered Name	Piauí Níquel Metais S/A
CNPJ	18.459.538/0002-05 – Filial
State registration	19.550.500-0
Address	AC Brejo Seco S/N, Zona Rural, Capitão Gervásio Oliveira/PI, CEP: 64763-000
Legal Representative	Luciano Tadeu Silva Ramos
Technical Contact	Marcelo Rideg Moreira
Phone	(031) 98413-8009
E-mail	mrideg@piauiniquel.com.br

1.2. Identification of the Consultant Responsible for the Study

Company	Arcadis S/A
Registered Name	Arcadis S/A
CNPJ	07.939.296/0001-50
State registration	145.071.983.114
Address	Rua Líbero Badaró, 377 – 15º andar CEP 01009-906 – São Paulo/ SP
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Phone / fax	(11) 3117-3171
E-mail	karin.formigoni@arcadis.com
Contact Person & Study Coordinator	Geza de Faria Arbocz
Phone / fax	Telephone: (11) 3117-3171 – Ext. 6080 Cell.: (11) 99422-2282
E-mail	geza.faria@arcadis.com.br

2. Project Description

This chapter presents the characterization of the Piauí Nickel Project. These characteristics will support the survey of the environmental aspects that will be considered in the impact assessment and will determine the mitigating and compensatory measures.

It should be noted that all the information presented here was provided and validated by the company, Piauí Níquel Metais S.A. - PNM.

2.1. Licensing Objective

The Piauí Nickel Project aims to extract and process nickel laterite ore for the production of Nickel Hydroxide Precipitate (NHP) and a separate Cobalt product. To this end, it is planned to implement the following structures:

- Mine & Process Plant – Brejo Seco:
  - Nickel ore mining;
  - Crushing;
  - Two ore stockpiles;
  - Leach pad for heaps;
  - Four Solution ponds;
  - Emergency Pond (to collect from 4 solution ponds);
  - Conveyor Belts and Pipes;
  - Process Plant, composed of the Sulfuric Acid Plant and Hydrometallurgical Plant;
  - Two waste rock stockpiles;
  - Residue storage area;
  - Containment pond (from the residue storage);
  - Pipeline Pumping;
  - Water Treatment Plant - WTP;
  - Explosives Storage;
  - Four Containment Dikes;
- Limestone Quarry – Umbuzeiro:
  - Process Plant – Limestone;
  - Limestone Quarry;
  - Two waste rock stockpiles – Limestone;
- Transmission line comprising 103 towers with 42.63 km in length;
- Water supply and pipeline with 33.52 km length;
- Access Roads (70.83 km).

The main activity of the Piauí Nickel Project, according to the classification provided for in CONSEMA Resolution No. 10 of 11/25/2009, is open pit mining with wet treatment - metallic minerals, whose classification by the Resolution is A-02-02-1, framing itself as a large project with great polluting potential.

The following secondary activities / structures are also foreseen in the project, with the respective classification in CONSEMA Resolution No. 10 of 11/25/2009.

- Open pit mining in an untreated karst area (A-02-05-4);
- Infrastructure works for mining activities (A-05-02-9);
- Residue/Waste ore stockpiles (A-05-04-5);
- Roads for transporting ore / waste (A-05-05-3);
- Manufacture of explosives, detonators for blasting rocks (C-04-07-3);
- Manufacture of sulfuric acid from elemental sulfur (C-04-16-2);
- 69kV Transmission Line (possibly on E-02-03-8);
- Containment dikes and watercourse protection (E-05-02-9);
- Pump Station and Water Pipeline from the Jenipapo dam (not classified)

It is essential to highlight that this project will not install or operate a “wet tailings containment dam” (A-05-03-7), once the process will have solid final residues, not liquid ones. The residues will also be transported without using water to this Storage area, and stacked and compacted in geotechnically stable heaps and on a protected lined area, the project does not therefore require the use of dams for final disposal of tailings, and thus will not present the risk of the rupture of dams, nor soil / groundwater contamination. These are important differentials of this project in order to ensure socio-environmental sustainability and operational safety for its region of insertion.

2.1.1. General Description of the Project and the Production Process

The process plant and the nickel mine will be implemented in Brejo Seco, in the municipality of Capitão Gervásio Oliveira.

For the extraction of nickel ore, an open pit mine with benches will be developed, by means of mechanical dismantling, which will be carried out partly by explosives, and partly by mechanical excavation. The material extracted at the mine will be transported by dump trucks to the stockpiles, crushing or waste stockpiles. After crushing and agglomeration, the ore will be stacked in 4 m high heaps for leaching with a dilute solution of sulfuric acid in order to extract metals.

In the hydrometallurgical plant, Nickel and Cobalt will be separated from other metals of no economic interest, by precipitation processes using limestone and sodium carbonate (Na2Co3), followed by a filtration process to remove water, in such a way that both products, as the process waste, will be in solid condition (filter cake). The products will be bagged in "Big-bags" for commercialization, and the dry waste will be stacked in the Residue Storage in geotechnically stable stockpiles on compacted soil and waterproofed with geomembrane.

In order to make the Piauí Nickel Project feasible, it will be necessary to implement the entire electricity supply infrastructure, access roads, facilities for handling inputs and products, disposal of waste and effluents, and for the capture of water, in addition to the storage and shipping of final products.

The limestone, one of the main inputs of the Piauí Nickel Project, will be extracted from a future quarry, to be constructed approximately 33 km from the project, in the town of Umbuzeiro, in the municipality of Dom Inocêncio, southeast of the State of Piauí.

The entire mining and processing operation associated with the production of limestone is part of the Piauí Nickel Project and is also the subject of this Environmental and Social Impact Assessment - ESIA, and thus the object of the licensing, presented in compliance with the requirements for obtaining the Preliminary License (*Licença Prévia*) - LP.

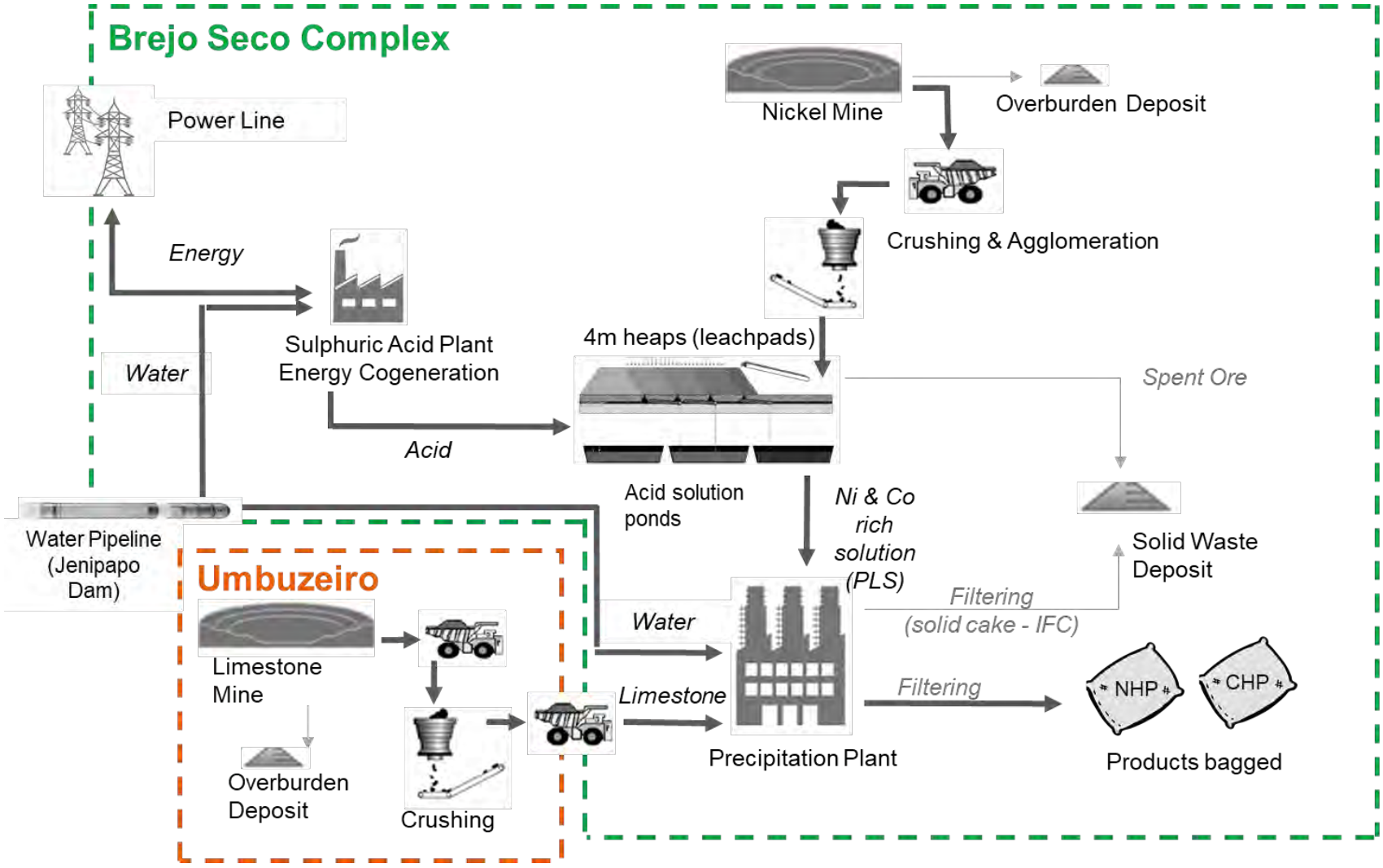
Sulfuric acid, another of the main inputs of the project, will be produced at the Sulfuric Acid Plant, to be built next to the Brejo Seco Hydrometallurgical Plant, from elemental sulfur imported and transported to the site by road.

The raw water needed for the project will be taken from an existing local dam called Barragem Jenipapo (located about 25 km from the future industrial plant in the municipality of São João do Piauí) and transported through a new pipeline that will be built for this purpose. It is worth mentioning that PNM already has a permit to collect all the volume of raw water necessary for the project, issued by the National Water Agency - ANA in 2014 and valid for 10 years. The drinking water consumed in the project will be captured through underground wells.

The demand for electricity will initially be met by the CHESF substation, located in São João do Piauí, through a 69 kV Transmission Line with a length of 46 km, to be built for the project. Once the Sulfuric Acid Plant is fully operational, it will have the capacity to co-generate the necessary power for the operation of the project, thus making it self-sufficient, and even supplying the electricity grid with excess energy from the cogeneration process.

The main activities and structures involved in the operation of the nickel mine, the units of the process plant and the limestone quarry are summarized in Figure 2.1-1.

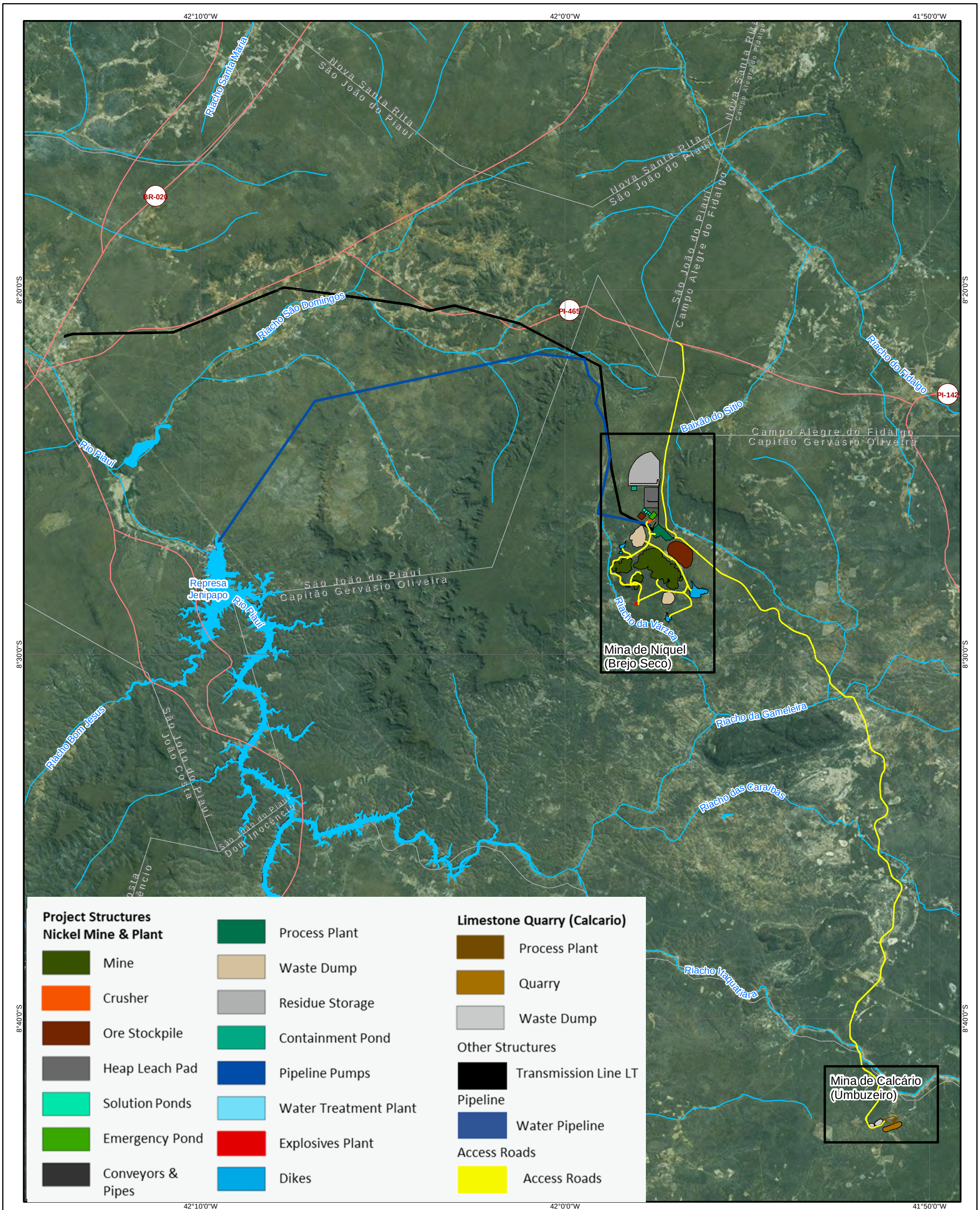
Figure 2.1-1 – Summary of the main activities and structures of the Piauí Nickel Project.



Source: Arcadis, 2017.

Map 2.1-1 presents the future layout of the project with all the structures provided for and that, therefore, constitute the Area to be Directly Affected (DAA) by this project for its full operation and development of mining, processing and hydrometallurgical activities associated with the nickel (Map 2.1-2) and limestone quarrying and processing (Map 2.1-3).

Map 2.1-1 – Layout of the Total Project – PNM, 2017



LEGENDA

- Vias Existentes
- Hidrografia
- Limite Municipal
- Massa D'água

REFERÊNCIAS

Fontes:
IBGE, Base Contínua 1:250.000, 2015.
Projeto Piaui Níquel, 2016.

ESCALA GRÁFICA
0 2,5 5 km

Sistema de Coordenadas: GCS SIRGAS 2000

LOCALIZAÇÃO

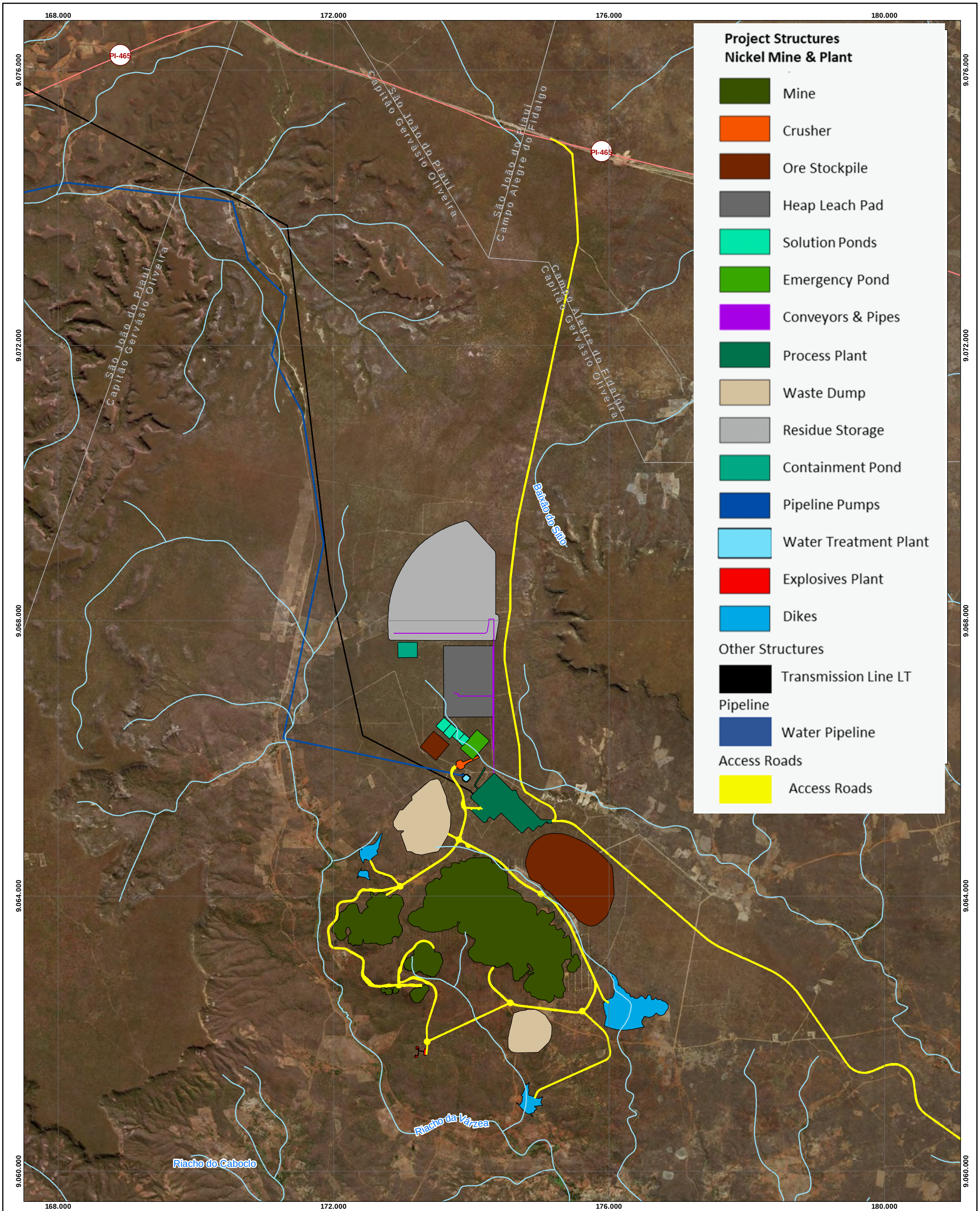
PIAUÍ NÍQUEL | ARCADIS

EIA/RIMA – PROJETO PIAUÍ NÍQUEL

MAPA 2.1-1 – LAYOUT GERAL DO EMPREENDIMENTO

EXECUTADO POR:	ESCALA	FORMATO:	FOLHA:	DATA:
ARCADIS	1:175.000	A3	ÚNICA	MAI /2017

Map 2.1-2 – Layout – Brejo Seco



LEGENDA

- Vias Existentes
- Hidrografia
- Limites Municipais

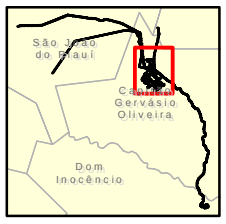
REFERÊNCIAS

Fontes:
IBGE, Base Contínua 1:250.000, 2015.
Projeto Piauí Níquel, 2016

ESCALA GRÁFICA
0 0,5 1 km

Sistema de Coordenadas: SIRGAS 2000 UTM Zone 24S
Projeção: Transverse Mercator

LOCALIZAÇÃO



Piauí Níquel | ARCADIS

EIA/RIMA – PROJETO PIAUÍ NÍQUEL

MAPA 2.1-2 – LAYOUT DO EMPREENDIMENTO
MINA DE NÍQUEL BREJO SECO

EXECUTADO POR:	ESCALA	FORMATO:	FOLHA:	DATA:
ARCADIS	1:50.000	A3	ÚNICA	MAI /2017

Map 2.1-3 – Layout – Umbuzeiro

LEGENDA

Hidrografia

ESTRUTURAS DE PROJETO

Limestone Quarry

Process Plant

Waste Dump

Quarry

Access Roads

REFERÊNCIAS

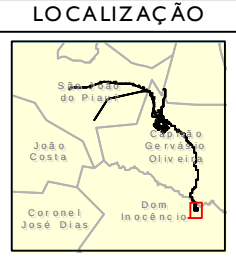
IBGE, 2014
Projeto Piauí Níquel, 2016

ESCALA GRÁFICA

0 125 250 Metros

Sistema de Coordenadas: SIRGAS 2000 UTM Zone 24S
Projeção: Transverse Mercator

LOCALIZAÇÃO



Piauí Níquel

ARCADIS

EIA/RIMA – PROJETO PIAUÍ NÍQUEL

Mapa 2.1-3 - MINA DE CALCÁRIO UMBUZEIRO

EXECUTADO POR:	ESCALA	FORMATO:	FOLHA:	DATA:
ARCADIS	1:15.000	A3	ÚNICA	JAN/2017

In Data Table 2.1-1 the area (in hectares) to be occupied by each of the project's structures is presented.

Data Table 2.1-1 – Area Occupied by Structures.

Structure	Area (hectares)
Mine & Processing Plant– Brejo Seco	
Nickel ore mine	330.46
Crushing circuit	2.26
Stockpile for crushing	115.39
Stockpile for Agglomeration	9.00
Heap Leach Pad	75.04
Solution Ponds (4)	7.82
Emergency Pond	8.89
Conveyors & Pipes	1,20
Process Plant (Acid Plant & Hydrometallurgical Plant)	45.16
Waste rock Stockpiles (2)	95.21
Residue Storage Area	222.39
Containment pond (run-off residue storage)	6.21
Pipeline Pumping	0.14
Water Treatment Plant	0.16
Explosive Storage	0.75
Containment dikes (4)	52.09
Limestone Quarry – Umbuzeiro	
Processing Plant – Limestone	7.32
Limestone Quarry	24.38
Waste Stockpiles	13.77
Transmission Line	
Transmission line (42.63 km)	11.26
Towers (103)	2.31
Water Pipeline	
Water pipeline (33.52 km)	26.73
Access Roads	
Access roads (70.83 km)	106.19
TOTAL	**1,164.13**

Source: Arcadis, 2017.

2.2. Regional Location

The mineral deposit of the Piauí Nickel Project is located in Brejo Seco, in the municipality of Capitão Gervásio Oliveira, southeast of the state of Piauí, about 50 km from the municipality of São João do Piauí and about 530 km from Teresina, the state's capital (Map 2.2-1).

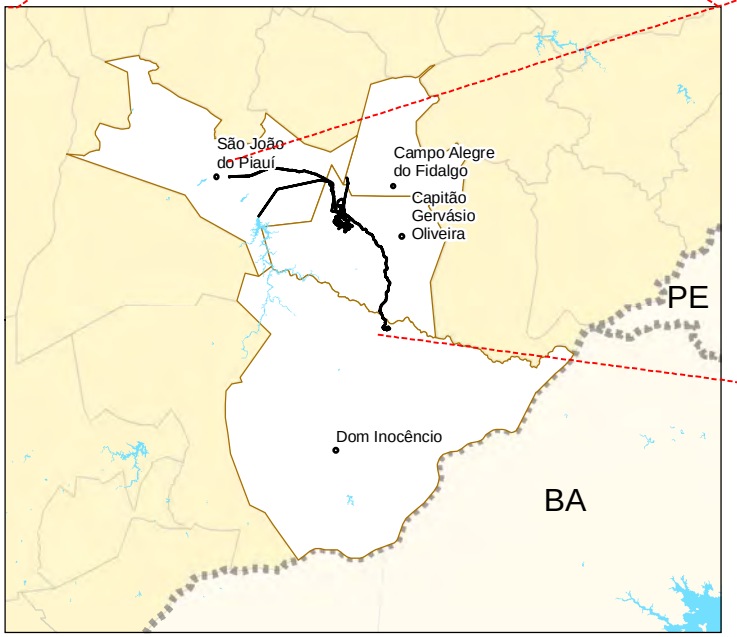
The municipality of Capitão Gervásio Oliveira has an area of 1,516.66 km², geographic coordinates of 08º29'25 "latitude (S) and 41º49'11" longitude (W), with the center of the municipality 400 meters above sea level. It is bordered to the north with the municipality of Campo Alegre do Fidalgo, to the south with Dom Inocêncio, to the east with Lagoa do Barro do Piauí and to the west with São João do Piauí.

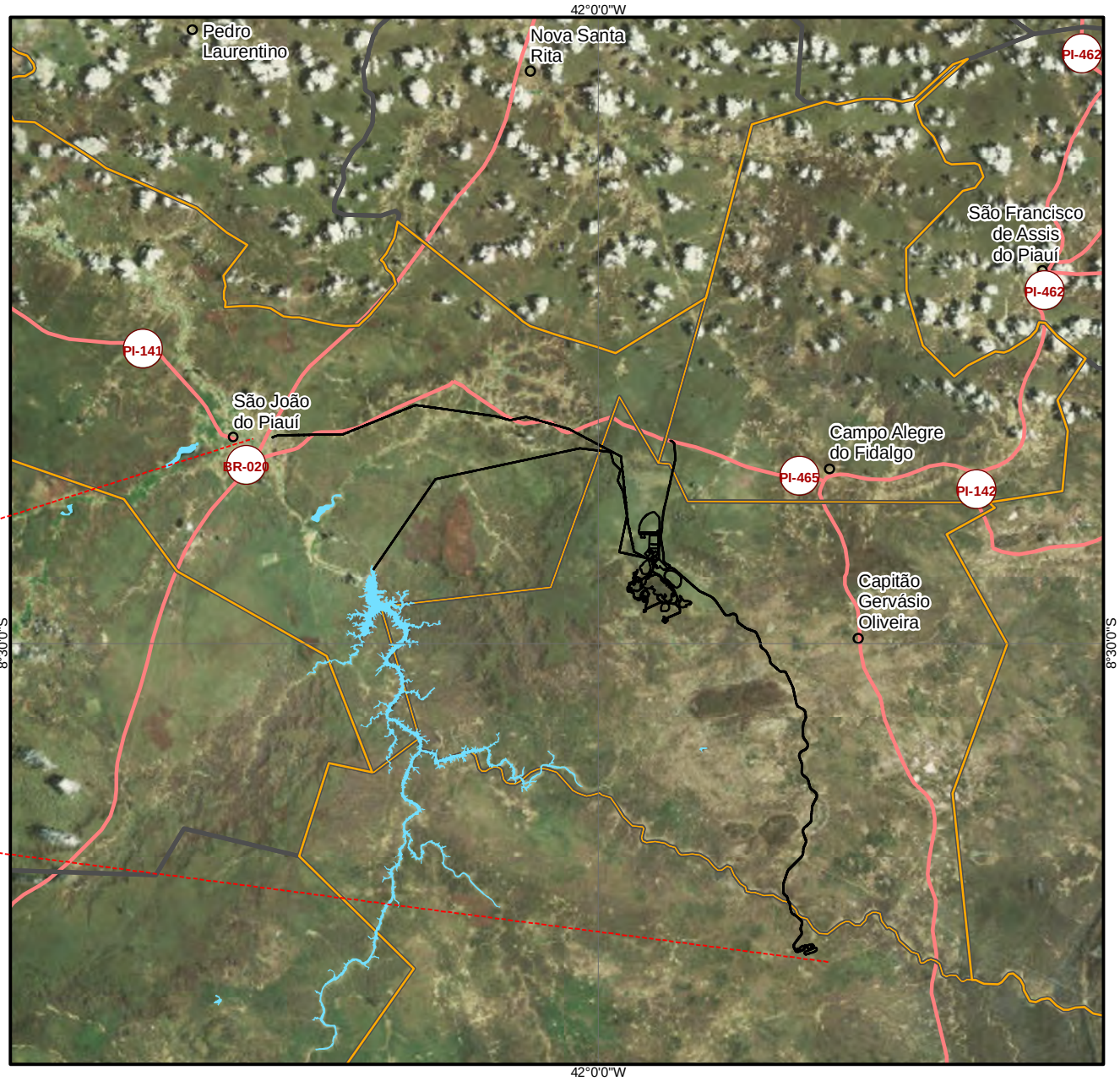
The municipality of Capitão Gervásio Oliveira originated from the division of the municipalities of Dom Inocêncio and São João do Piauí, by means of State Law No. 4.680, of 26/01/1994.

The municipality of Campo Alegre do Fidalgo, also originated from the division of São João do Piauí and Lagoa do Barro do Piauí, through State Law No. 4.810, of 12/14/1995.

São João do Piauí is located to the west, is the main city of this micro-region and, further south, about 80 km away, is the city of São Raimundo Nonato, where the Serra da Capivara National Park is located.

To the east of the Park is the municipality of Dom Inocêncio, formed by the division of São Raimundo Nonato on June 7, 1988.





LEGENDA

- Sedes Municipais
- Sistema Viário
- Limite Municipal
- Massa D'água
- Municípios da Área Diretamente Afetada - ADA
- Área Diretamente Afetada - ADA

REFERÊNCIAS

IBGE, Brasil ao milionésimo, 2014;
Projeto Piauí Níquel, 2016.

Sistema de Coordenadas: GCS SIRGAS 2000

MAPA DE LOCALIZAÇÃO

Piauí Níquel

ARCADIS

EIA/RIMA – PROJETO PIAUÍ NÍQUEL

MAPA 2.2-1 – LOCALIZAÇÃO

EXECUTADO POR:	ESCALAS:	FORMATO:	NÚMERO:	DATA:
ARCADIS	1:500.000	A4	Única	set /2017

2.2.1. Access to the Area

There are two possibilities of access to the project area. One from Teresina, which has two route options, and another through Petrolina / PE, which also has two route options. These possibilities are presented below.

2.2.1.1. From Teresina

A) Option 1:

Leaving Teresina by the federal road BR-316, in the southeast direction, towards Picos, continue for 277 km until the junction with the BR-230. From the the BR-230, head west to the city of Oeiras, 44 km from the junction. In Oeiras, from the Piaui State road PI-143, one heads south of the state to the city of São João do Piauí, a distance of 179 km. From São João do Piauí, in an easterly direction, take the state road PI-465 to the city of Capitão Gervásio Oliveira, 62 km from São João do Piauí.

Total distance = 562 km.

B) Option 2:

Leaving Teresina by the BR-316, in the south direction, continue towards the city of Água Branca, a distance of 97 km. From Água Branca, follow south on the BR-343 to the city of Floriano, on a 155 km route. In Floriano, from the PI-140 road, one heads south to the city of Canto do Buriti, a distance of 168 km. From Canto do Buriti, in an easterly direction, follow to São João do Piauí, another 90 km. From São João do Piauí take the state road PI-465 to the city of Capitão Gervásio Oliveira, 62 km from São João do Piauí.

Total distance = 572 km.

2.2.1.2. From Petrolina/PE

A) Option 1:

Leaving Petrolina on the BR-407, head to Picos, follow for 106 km to the city of Afrânio, Pernambuco. In Afrânio, take the road on the left to Queimada Nova, in Piauí, about 57 km away, and from there for another 42 km to Lagoa do Barro. From Lagoa do Barro to Capitão Gervásio there is another 33.4 km. Piaui Níquel's accommodation is in Campo Alegre do Fidalgo, about 5 km from Capitão Gervásio. This route is about 243 km from Petrolina. Until São João do Piauí there is another 55 km through the state road PI-465.

B) Option 2

Leaving Petrolina to the west, take the BR-235 to Casa Nova, in Bahia, about 75 km away, and from there to Remanso, for another 177 km. From Remanso, taking the BR-324, travel another 100 km to São Raimundo Nonato, in Piauí, and from there another 100 km to São João do Piauí. From São João do Piauí to Brejo Seco, where the deposit is located, it is about 50 km. From there to the headquarters of the municipality of Capitão Gervásio there is another 15 km or 17 km to Campo Alegre do Fidalgo.

2.3. History of the Venture

2.3.1. Mining Situation

The mining law in Brazil is regulated by the Mining Code (Decree Law No. 227 of February 28, 1967), its respective Regulation (Law No. 62,934 of July 2, 1968) and other subsequent related legal provisions. The mining entrepreneur is obliged to comply with the legal procedures of the Federal Autarchy linked to the Ministry of Mines and Energy, the National Department of Mineral Production (DNPM), through processes and titles granted by the said Department.

In compliance with this legislation, nickel mining activities will be developed in the polygonal area defined in the DNPM processes owned by Piauí Níquel Metais SA, in Brejo Seco in Capitão Gervásio Oliveira, and limestone mining activities will be developed in the area polygonal defined in the DNPM process currently available and required by Piaui Níquel, in Umbuzeiro, in Dom Inocêncio.

2.3.1.1. Target of Brejo Seco

The area of the Brejo Seco Basic-Ultrabasic Massif is included in the DNPM 804.290 / 70 process. The brief description of which is presented here, from its initial conception to the present date. This process was granted to Mr. José da Luz Coelho, to research asbestos and nickel ore, through Research Permit No. 68, of 02/05/1971, published in the Official Gazette - DOU, on 02/17/ 1971.

The first geological research work was carried out by Companhia Brasileira de Amianto and reported to DNPM in December 1972. In November 1973, an agreement of intentions was made between José da Luz Coelho and Companhia Vale do Rio Doce - CVRD.

From June 1973 to July 1974, CVRD, through the company Rio Doce Geologia e Mineração S/A, carried out research work, which resulted in the completion of a reserve of the order of 20 million tonnes of nickel ore, with an average content of 1.57% of Ni, whose report was approved, as published in the DOU, on 07/04/1975.

On 06/30/1976, the mining request was submitted to DNPM on behalf of the company José da Luz Coelho - JLC Ltda., with the respective Economic Use Plan - PAE. In December 1982, requirements were presented to better instruct the mining request and the Economic Use Plan.

On 09/16/2003, complying with the legal requirements, the document with the Installation License referring to process 804.290 / 1970 was filed at DNPM, which made it possible, on August 25, 2004, to grant the grant, by the Minas Gerais Secretariat of Mining and Metallurgy of the Ministry of Mines and Energy, of Mining Concession No. 258, published in the DOU, on 08/26/2004.

In mid-2003, after 27 years of the mining application, CVRD entered into a new agreement with JLC, aimed at carrying out new research to resize the nickel reserves in the Brejo Seco deposit and study its economic use, considering the current scenario, characterized by the increase in nickel prices in the international market, combined with the emergence of a new technology for the concentration of this metal. The information obtained through the new surveys, carried out on a 100 x 100 meter grid, made it possible to calculate the resources, estimated at 85 million tonnes of ore, with an average content of 0.98% Ni. In April 2007, the installation of a pilot ore

beneficiation plant was completed, where heap leaching tests were carried out from May 2007 to March 2009. After completion of the tests in the Pilot Plant, the plant was put into care and maintenance. CVRD then requested the extension of the terms of LI - D000469/12 a few times, when in 2013, it decided on the sale of the asset.

Since November 6, 2014, the ownership of the DNPM 804.290 / 70 process has been in the name of Piauí Níquel Metais SA. After an arduous process of searching for investors to refurbish and make the necessary changes and maintenance in the pilot plant, aiming at resuming the tests, finally in December 2015 Piaui Níquel obtained the necessary investment. Thus, maintenance and repair services were carried out until mid-July 2016, and currently the Demonstration Plant is in full operation under the terms of the Operation License - LO Number D000741 / 15 / Process 007768/15, valid until 16/11/2017.

The Demonstration Plant will continue to operate throughout the environmental licensing process of the present project that is the subject of this ESIA / RIMA, aiming to continue the necessary tests to improve processes, and also as a fundamental strategy to prove the viability of this project and to raise the necessary financial resources for its implementation after it is properly licensed.

2.3.1.2. Target of Umbuzeiro

The area called Umbuzeiro, located in the municipality of Dom Inocêncio, is the subject of research application 803.144 / 2002, with an area of 901.59 hectares.

In December 2002, the research permit was granted on behalf of Cia Vale do Rio Doce - Vale, as published in the DOU of 12/09/2002. In 2006, the exploration license was extended until September 2009. After that period, Vale did not request further extensions or request mining concession.

Currently, process 803.144 / 2002 is available for request of the mining concession for exploitation, according to the Notice of Availability No. 6/2016 published in the DOU of 10/26/2016. PNM has already prepared a new Economic Use Plan - PAE for the extraction of limestone to supply this project, and filed it in December 2016 with DNPM to request the mining concession of process 803.144/2002.

2.3.2. Work History

In order to study the technical feasibility of implementing the project in the desired location, several activities related to mineral research were promoted by Vale in the mid-2000s. Laboratory studies were also carried out to develop a process for obtaining solutions rich in nickel, through leaching in columns and heaps, using sulfuric acid solution.

To confirm the results obtained in the laboratory and prove the behavior of the ore, at this time Vale decided to carry out metallurgical tests on a pilot scale, aiming to adjust the process variables and geotechnical stability of the heaps. The results of the tests allowed confirmation of the applicability of the process route and provided engineering data to be used in the consecutive stages of industrial development and construction of the project. The construction of the pilot plant started in 2006 and was completed in May 2007 by Vale.

The ore necessary for the formation of the leach heap was obtained from a pilot mine in the northeast part of the so-called Morro do Brejo Seco. The environmental studies required to obtain the Installation License for the pilot plant and experimental mine (RCA-PCA) were completed by Golder Associates in December 2005.

In July 2007, Vale / MOP-Mineração Onça Puma filed with SEMAR- Secretariat for the Environment and Water Resources of the State of Piauí the request to extend the Installation License for the pilot plant, including the MHP (Mixed Hydroxide Precipitate) circuit. The request was accompanied by a report, describing the status of the project at the time, including the environmental programs provided for in the PCA and future actions.

After the purchase of the project by Piauí Níquel, the pilot plant underwent a maintenance period for the equipment previously installed by Vale, and new tests began to be carried out in 2016, as shown in the previous section.

2.3.2.1. Nickel Mineral Research

This section presents a brief history of the works carried out in the various research phases that were developed in the region.

A) Work phase 1971 to 1974

The preliminary research works, developed by the management of the Distrito Centro Oeste da Docegeo (Vale's subsidiary company), were carried out between February and May 1972, and included a topographic survey on a scale of 1: 10,000, geological mapping and geochemical sampling of soils for Ni, Cr, and Cu, with collection of 894 samples in areas where gabbro occurs.

In this stage, the following infrastructure works were carried out:

- Recovery and opening of 30 km of roads;
- Assembly of autonomous camp with hydraulic and electrical networks, radio communication and construction of airstrip for small aircraft;
- Opening of 120 km of drill holes in a regular grid and semi-regional research profiles, with spacing of 200 m and 100 m, with topographic survey of the entire area of the complex. Making a planialtimetric map at a scale of 1: 10,000, with intervals of contour lines of 5 m.

The research work, based on drill holes and shallow boreholes, showed a deposit of lateritic nickel, whose reserves were estimated at 21.4 million tonnes of ore with an average content equal to 1.57% Ni.

Due to the inexistence, at the time, of economically viable technological processes for the extraction of nickel from oxidized ore, the research activities in the prospectus were suspended.

B) Work Phase from 2003 to 2008

The agreement for the purchase of mining rights in April 2003, between CVRD and JLC, the Prospecting Brazil - GABIK / CVRD team, immediately started a new phase of geology work to assess the potential of the deposit for nickel laterite at Brejo Seco, emphasizing above all the plateau.

Based on the results obtained in the preliminary work carried out in 2003, still in the conceptual design phase, a reverse circulation (RC) drilling plan was drawn up to delimit the deposit. Once the area of occurrence of supergenic enrichment of Ni was defined, a campaign of drilling in 100 mx 100 m grid was carried out to assess the potential resources of the deposit. At the same time, a large diameter drilling campaign ("metallurgical holes") was developed to obtain samples for technological tests.

With the data obtained, the preliminary geological modeling of the deposit was performed, the corresponding resources were calculated and the mining plan prepared.

After the deposit's mining plan had been defined, the RC drilling campaign was extended, closing the grid at 50 m x 50 m inside the pit, considering eight years of mining activities. Also to open areas to obtain large volume samples for pilot scale tests.

These stages of geological research were in line with the terms defined by the agreement for the purchase of mining rights, signed between JLC and CVRD, respecting the financial disbursement terms until their complete acquisition.

The development of geological research also considered the alternatives of nickel production routes, first the high pressure leaching route in autoclaves (HPAL), which proved to be economically unfeasible, evolving into a combined alternative between HPAL routes and routes with heap leaching (HL) and atmospheric leaching (AL), whose economic viability was positive.

C) Work Phase from 2013 to 2016

In April 2013, CSA Global was contracted by PNM to review all information related to geological quality, QA-QC analyzes of the Piauí Nickel Project and to update the mineral resource estimates, based on studies of the Brejo Seco Complex mining project carried out by contracted companies (Snowden, Pincock, Allen and Holt and Prominas) under the supervision of Vale.

From the Vale drilling database, the geological model with types of ore relevant to heap leaching has been redefined, simplifying the classification made earlier.

CSA Global considered a cut-off grade of 0.6% for the estimate, based on the application of Whittle 4D, the mining resources and on the preliminary cost modelled. Thus, a new geological blockmodel and a new resource estimate were obtained, with 72.2 Mt at 1.00% nickel (0.6% nickel cut-off), while the one estimated by Vale was 76 Mt to 0.88% of Ni (0.5% cut-off). The values of mining resources obtained are presented in Table 2.3-1.

Table 2.3-1 – Mining Resources of the Piauí Nickel Project.

Cut-off Grade (% Ni)	0.6	
Category	Ore	Waste
Tonnage	52,527	96,969
Ni (%)	1.076	
Al2O3 (%)	5.31	
MgO	11.13	
Fe2O3 (%)	17.71	
Cr2O3 (%)	1.04	
MnO (%)	0.29	
SiO2 (%)	47	
Co (%)	0.048	

Source: PNM, 2017.

In addition to studies to increase the accuracy of the mineral resource estimation, as mentioned above, after obtaining the current LO D000741/15, in December 2015 actions are initiated to refurbish the facilities of the Demonstration and Test Plant constructed by Vale at the site, to allow demonstration of PNM's own know-how in leaching nickel laterites.

The Demo plant consists of crushing processes; sieving; thickening; filtration; blending; agglomeration; acid leaching in heaps and columns; purification of the leachate solution (PLS); neutralization; extraction of nickel with resin in columns; resin elution, washing and regeneration; treatment and disposal of effluents. The Demo plant also has a compressed air system and water storage operation; sulfuric acid unit for receiving, storage and preparation of acid solutions; limestone unit for receiving, storage, preparation of limestone solution and feeding the neutralization tanks; laboratory; environmental control systems, consisting of water sprinkler systems, residue storage and emergency pond.

The refurbishment and operation of this Demonstration Plant by PNM aimed at:

- Identify and extract a representative sample from the ore deposit;
- Leach the ore under planned operating conditions:
  - Demonstrate the technical viability of the metallurgical process proposed by PNM; and
  - Obtain initial technical data to develop the BFS (Economic and Financial Feasibility Study) and engineering projects for the next steps;

- Operate the hydrometallurgical plant (for nickel and cobalt recovery) and so;
  - Demonstrate the technical viability of the metallurgical process proposed by PNM;
  - Obtain technical data to support the future preparation of BFS and engineering projects; and
  - Produce the product MHP (Mixed Hydroxide Precipitate), containing Ni and Co, for initial product disclosure and productive viability for potential buyers and investors;
- Develop and validate the process simulation model (software) for use in BFS.

This PNM testing phase started in December 2015 with additional surveys carried out in the existing experimental pit at Morro do Brejo Seco, in the same location as the former “Lavra Experimental” previously deforested and opened by VALE S/A in 2007, in order to determine the volume of samples for the test.

In March 2016, a sample of 11,000 tonnes of ROM (Run of Mine, or crude ore) was extracted from the test pit, and the ROM was transported to the Demonstration Plant and separated in a storage yard. Then, about 7,100 tonnes of ore were crushed, agglomerated (with a mixture of water + sulfuric acid to “agglomerate” fine particles), and formed 3 leaching heaps 4 meters high each (on an impermeable pad) , to later receive slow irrigation through dripping with diluted aqueous solution of sulfuric acid.

Of this amount, 1,935 tonnes were arranged in the first heap (called Heap 0). Irrigation with the dilute acid solution (about 60g / L) started on May 30, 2016. After three days, the first solution containing metals started to flow from the heap. The first results of samples of the solution resulting from leaching in this heap, indicated a concentration of 9.5 g/L of nickel in the solution and 0.22 g/L of cobalt. Amounts of iron, aluminum, magnesium and others were also found.

The initial results showed that, in relation to iron, nickel was being leached 15 times faster, and cobalt leaching 9 times faster. This demonstrated how the leaching process is highly selective, being able to recover the target metals.

In the second heap (Heap 1), a little over 2,900 tonnes of crushed ore was stacked, starting irrigation, in neutralization mode, on June 28, 2016. Neutralization allows the use of residual acid from Heap 0 to recover some additional nickel and cobalt from Heap 1, before this solution is fed to the Nickel and Cobalt recovery plant.

The first heap (Heap 0) has operated in a single-pass regime of the acidified raffinate, which simulates the primary leaching of the future commercial operation that produces the Intermediate Leach Solution (ILS) to feed the neutralization mode. In August 2016, Heap 0 had completed 90 days of leaching, obtaining extraction of 67% nickel, 49% cobalt and 16% iron.

The Demonstration Plant produced the first MHP nickel product (Mixed Hydroxide Precipitate, or Mixed Nickel and Cobalt Product) at the end of August 2016 with a nickel content of 30%.

As well as the MHP to be produced, the solution of none-value metals (Iron, Aluminum etc.) is separated from Nickel and Cobalt through precipitation in tanks by the use of limestone (predominantly). This also undergoes a thickening and filtering process, in such a way that the water is reused in the production process (irrigation of the heaps), and the final waste is a solid

residue, called IFC (Iron Filter Cake, or “iron cake”). This generated solid waste was then deposited in a waterproofed/lined waste storage pond with a HDPE liner (geomembrane).

In October 2016, PNM started tests with the ion exchange unit for the generation of Nickel Hydroxide Product (NHP - Nickel Hydroxide Precipitate) and a separate cobalt product, which will be the target products of this project on a commercial and industrial scale and the object of this ESIA / RIMA.

To date, PNM has managed to demonstrate the metallurgical process for the extraction of nickel contained in the ore and its transformation into a product that can be sold in national and international markets. From now on it is necessary to continue developing tests to achieve the following complementary objectives:

- Generation of additional data from the nickel and cobalt extraction and recovery process on a smaller scale (columns) for the validation of the simulation model (software) that is already available;
- Testing of different operating conditions to optimize the consumption of reagents and generation of residues;
- Experiment with the different filtering options for residues and products to optimize their physical characteristics and to facilitate their handling;
- Continue to evaluate the information generated so far to optimize the operation's water balance;
- Optimization of the ion exchange process (to achieve final and efficient separation of Nickel and Cobalt in different solutions, and to allow the production of separate products with greater added value);
- Demonstration of the technical feasibility of producing the Cobalt product.

To achieve these new objectives, PNM has a work plan to be developed over the next few years at the demonstration plant (in parallel with the licensing of the full scale project), using existing facilities and personnel, and therefore has already requested renewal of the current LO with to SEMAR, on July 19, 2017.

The following photographic record shows the route of the production process and the activities developed in the Demonstration Plant for the production of MHP.

Photo 2.3-1 – Overview of the PNM ore beneficiation test plant, located at the base of the Brejo Seco hill.

Photo 2.3-2 – Primary and secondary crushing of ore, into smaller particles.

Photo 2.3-3 – Ore agglomeration (fine particles) with application of water + sulfuric acid.

Photo 2.3-4 – Agglomerated (wet) ore being transported to assemble the heaps.

Photo 2.3-5 – View of the 4m high leach heaps, mounted on an impermeable pad with HDPE geomembrane.

Photo 2.3-6 – Pond of acid solution diluted with water to leach heaps (in the background) in a closed circuit for several months.

Photo 2.3-7 – View of the plastic pipe network mounted on top of the heaps for slow dripping of them with acid solution diluted with water.

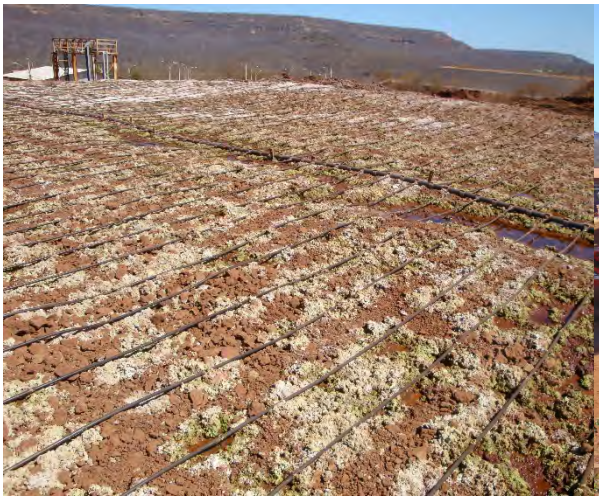


Photo 2.3-8 – Hydrometallurgical Testing Plant that receives the metal-rich solution (PLS) for separation, precipitation, and filtration of the MHP product and the IFC residue (both in solid state).

Photo 2.3-9 – Precipitation tanks separating Nickel and Cobalt from unwanted metals from the ore (Fe, Al), by adding limestone.

Photo 2.3-10 – Filtration of the nickel and cobalt slurry to remove water (reused in the leaching process of the heaps).

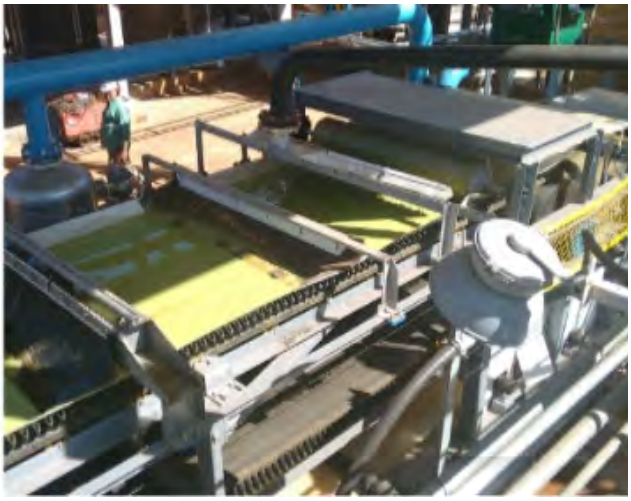


Photo 2.3-11 – Detail of the MHP product at the end of the filtration process, showing its solid texture.

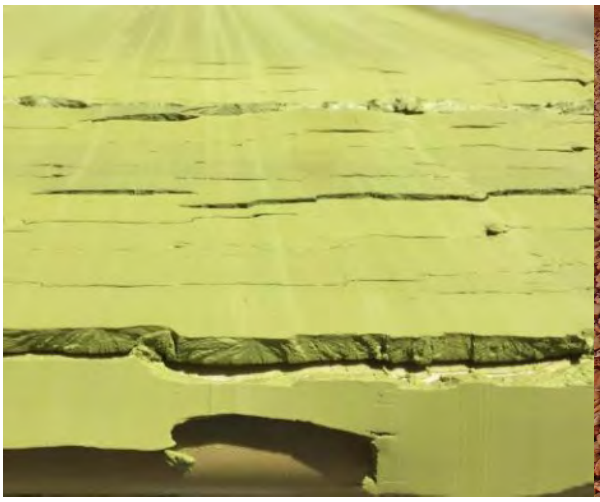


Photo 2.3-12 – Bagged solid MHP for storage and testing.

Photo 2.3-13 – Detail of the IFC residue produced also in solid state at the end of the filtration process.

Photo 2.3-14 – Another view of IFC residue produced in solid state after the filtration process.

2.3.2.2. Limestone Mineral Exploration

Under the coordination of Vale SA, several outcrops of carbonate rocks were registered and described, mainly calcitic and dolomitic limestones, covering extensive areas, especially in the place called Umbuzeiro, near the left bank of the Itaquatiara River, between UTM 9,030,000N / 9,040,000N coordinates and 180,000E / 195,000E.

In a second stage, the research work was detailed, supporting the studies for modeling the deposit and defining the limestone reserves. The mapped limestone rocks form a general direction set N60-70E, with moderate to high average dip to the northwest.

The mineral survey was carried out on a 200m x 400m topographic grid, in addition to several support works and survey of planialtimetry of relevant details of the region.

The geological mapping was carried out in detail along and between open trails in 200 m x 25 m grid, totaling about 74.35 km of mapped lines, covering an area of 12,077 km². Geotechnical studies were carried out in an expeditious manner based on rotating drilling results. The carbonate units, formed from calcitic and magnesian limestones, have an RQD (rock quality designation) index above 95%, with rare open fractures and sporadic intervals of fragmented rocks and with low RQD.

A 200 m x 200 m rotopercussive drilling campaign was also carried out to evaluate a mineable reserve up to the limit depth of 90 m. The investigated area was expanded, in a 400 m x 400 m grid, to delimit the continuity of the limestone body to the southeast and the consequent calculation of resources. Parallel to the rotating drilling, a campaign of 2,503.70 m of complementary rotary drilling was carried out, when new areas of limestone were identified, only in the known portion of the deposit.

In 2008, the Umbuzeiro limestone deposit was geologically modeled with the aid of the DATAMINE software covering the entire limestone exposure area containing the grid of the

exploratory drilling carried out. The topography of the deposit, presented by Esteio Engenharia e Aerolevantamentos S.A., the lithological data of the drill holes and their chemical analyzes, carried out by Vale, were imported into the DATAMINE platform.

2.4. Justifications

The Piauí Nickel Project aims at the extraction and processing of lateritic nickel ore for the production of Nickel Hydroxide Precipitate (NHP) and a separate Cobalt product. For the implementation and operation of the Piauí Nickel Project, it will be necessary to implement a Mining-Industrial Complex covering, in addition to the direct operating activities, several related activities that will form the infrastructure and support to the project.

At the same time, the Umbuzeiro limestone quarry, located 33 km away from the Brejo Seco mine, will be established. This venture will consist of mining and crushing of limestone, one of the main inputs in the process of obtaining nickel and cobalt.

World primary nickel consumption is about 2 million tonnes per year, with global refined cobalt consumption estimated at approximately 80,000 tonnes / year. About 85% nickel is used in combination with other metals to make what are known as alloys. These substances have physical and mechanical properties distinct from the properties of their constituent elements. The main alloy containing nickel is stainless steel, corresponding to about 70% of nickel consumption. Nickel is also used in other steel alloys, some copper-nickel alloys, batteries and increasingly in rechargeable batteries, such as those of the lithium-ion type that are being used for electric vehicles. Cobalt has a diverse range of metallurgical and chemical uses ranging from aircraft engines to rechargeable batteries, permanent magnets and cutting tools, is used in paints and pigments, and is also used as a catalyst in various industrial chemical processes.

Nickel is predominantly supplied from mines of sulfide deposits or oxide deposits (laterite), such as the Piauí Nickel Project. The processing of sulphide-type ore consumes less energy, and for this reason, it has been preferred by mining companies. Mine ores are processed in a variety of plant types to produce nickel metal, although a limited amount of nickel compounds are also sold to the chemical and battery industries. Within the nickel industry, several concentrated ores and intermediate products are traded to supply chemical and metal producers.

The mineral beneficiation process by acid leaching followed by a step to obtain the nickel hydroxide precipitate is the most suitable for the type of lateritic ore in the Brejo Seco mine. It is a modern technology and represents the state of the art of nickel mineral processing in the world.

Unlike other industries, such as copper and gold, the nickel industry has a relatively small number of producers. About 80 to 100 companies, 70% of the production coming from only 16 companies, of which Vale, Norilsk, Glencore and Jinchuan are the four largest, representing 40% of the world nickel supply. The average production targeted at the Piauí Nickel Project, of 24,500 tonnes / year, would represent about 1.2% of the world supply.

Nickel refineries and ferronickel plants are the main markets to be served by NHP (Nickel Hydroxide Precipitate), produced in the Piauí Nickel Project. Nickel refineries that operate with the processing of a mixed nickel and cobalt hydroxide (MHP) product, require little or no change to process NHP.

The world market for MHP consumes around 80,000 to 100,000 tonnes per year. However, it is estimated that the potential is 300,000 to 400,000 tonnes. Considering that the MHP market is currently limited by the supply on offer, the NHP strategically meets the global demand for nickel metal, representing a market estimated at more than 1 million tonnes per year, since it can also feed ferronickel plants.

Furthermore, the Piauí Nickel Project is designed to be installed in a very needy region, in the northeastern semi-arid, where living conditions are precarious due to the lack of service infrastructure and job opportunities. A good portion of the population still lives in the rural area, with emphasis on subsistence family farming. Environmental conditions, such as scarce water availability for most of the year, in addition to irregular and torrential rainfall, disadvantage the development of more extensive activities.

Thus, the Piauí Nickel Project will promote the offer of up to 1,865 direct and indirect jobs during the implementation of the project and 653 in the operation, in addition to the implementation of structural works for the region, such as a transmission line, water supply, and roads; offering support to the Public Authorities for improvements in social equipment, from the generation of taxes, and an increase in the regional economy from the injection of resources from the payment of wages, consumption of goods and services, and partnership programs with labor qualification bodies and small businesses.

2.5. Alternative Locations and Technologies

2.5.1. Alternative Technologies

From the mineralogical assessment, the desired product and local geoeconomic factors (availability of water resources and electricity, etc.) it is possible to determine the technology to be employed.

Lateritic ore deposits are predominantly shallow or near surface, friable and basically found in warmer tropical climates. The nickel deposit of the Brejo Seco Mafic-Ultramafic Complex in Capitão Gervásio Oliveira (PI), is of the lateritic type, and has the typical characteristics of the main occurrences of this type. So, the ore occurs on the surface and in most of the area it is easily mined.

Unlike sulphide ore, laterite is easily mined in the open, with mechanical excavation, selectively and with medium-sized equipment. Usually, the use of explosives is unnecessary or very restricted. The ore is mined with the help of excavators and transported in trucks.

There are several technologies known worldwide for obtaining nickel from lateritic ore, some of these methods are presented in Table 2.5-1.

Table 2.5-1 – Comparison of Methods for the Production of Nickel.

Method	Advantages	Disadvantages	Necessary Resources
Ferro Nickel (smelting)	Standard Technology	High cost of capital High power consumption Demanding criteria in ore selection High reject rate	> 50 Mt of ore with 1.8% Ni mostly saprolitic
High Pressure Acid Leaching (HPAL)	High Recovery (of ore treated)	Extremely high cost of capital History of costs overruns and long ramp-ups	>200 Mt ore mostly with 1% + Ni, limonite
'Nickel Pig Iron' NPI EAF Nickel	Lower cost (CAPEX) Recovers iron	High Energy consumption	Ore with 1.5% content
Atmospheric Tank Leaching (AL)	Lower Capital cost (CAPEX) than HPAL Reasonable operating costs (OPEX)	Large tailings dam and related risks of dam failure and environmental problems	30 Mt of ore with a content of approximately 1%
Heap Leaching	Lowest capital (CAPEX) and operating cost (OPEX) High recovery * Does not demand tailings dam * Lower water consumption and energy self-sufficiency *	Production period	30 Mt of ore with a content of approximately 1%

** PNM Technology.*
Source: PNM, 2017.

Ferronickel smelting process is highly energy intensive. In addition, the necessary investment is in the range of 1.5 to 3.5 billion dollars and a mineral volume of more than 50 Mt to 1.7% nickel would be needed (for example, as in the case of the Onça Puma Mine which contains 99 Mt at 1.73% Ni, or Soroako Mine that has 103 Mt at 1.79% and Morro Sem Boné Mine 47 Mt at 1.76%).

Likewise, HPAL plants, with investments of up to US$ 4 billion, require large volumes of ore above 1% nickel.

Recent ferronickel and HPAL projects have spent excessive time and costs, and in some cases have operational problems.

Nickel Pig Iron production by the NPI EAF process, using an electric arc furnace, has become popular in China. Located close to their customers, these plants produce low-grade ferronickel using imported ore. This method requires the use of high-grade iron laterite, at least 1.5% nickel. PNM ore is unsuitable for this process.

Atmospheric or tank leaching has been discussed in some projects with lower grade lateritic nickel. However, the process has not been tested on a commercial scale and requires a large tailings dam. In addition, investments and operating costs for atmospheric leaching are higher than for heap leaching.

Thus, the technology selected as most suitable for PNM is heap leaching using sulfuric acid, as detailed in section 2.9.2 of this study.

This technology chosen by PNM uses a lower acid concentration than predicted in the Vale project (ESIA / RIMA 2008 produced by Arcadis Tetraplan). The decrease in concentration does not significantly reduce the leaching kinetics, but improves the selectivity of nickel and cobalt over iron, increasing the leaching efficiency. In addition to the concentration, the amount of acid estimated to feed the process also decreased, while the Vale project envisaged the use of 420 kg of acid per ton of ore, the Piauí Nickel project estimates consumption 250 kg per ton of ore.

The PNM project foresees the recirculation of the solutions in the leaching and neutralization stage. Once the intermediate leach solution (ILS) reaches the ideal nickel content (at least 5 g / liter), this solution will irrigate the heap of fresh ore before being sent to the precipitation plant. As the ore is fresh, the acid content of the ILS tends to leach nickel (and cobalt) more easily, which increases the concentration of the metals in the resulting solution (PLS). Another important effect is that part of the iron is precipitated in the leaching stage of the neutralization cell.

The advantages presented by the recirculation of the ILS are an increase in the nickel content in the plant feed solution, a significant reduction in the acid and iron content in this solution, in addition to a reduction in the volume of the solution, requiring smaller equipment in the precipitation process and smaller amounts of limestone, as can be seen in the Table 2.5-2.

For the precipitation of the product, the use of soda ash (sodium carbonate) is foreseen as a potential replacement for the magnesium oxide (MgO) provided by Vale. Magnesium oxide from Queensland Magnesium is known to react well, but other magnesium oxides may not perform as well. In addition, the experience obtained by PNM in the tests carried out to date, indicates that a nickel product with a better content is produced through precipitation using sodium carbonate. Tests in this sense will continue to be carried out in the Demonstration Plant in order to confirm the best reagent to carry out the final precipitation of the products.

The choice for the production and transportation of waste on a dry and non-liquid basis (by carrying out the filtration process in the final stage of production), implies a considerable reduction in water consumption for the production process, in addition to avoiding the use of dams for disposal of the tailings that present a risk of breakage. This choice also allows the

final disposal of the waste in stable stockpiles (in a specific waste deposit that will be compacted and lined).

In Table 2.5-2 the main differences between the Vale project and the PNM project are presented. There is a significant reduction in the volume of inputs such as limestone, sulfuric acid, sulfur, lime and water, as already mentioned. In addition, the technology used by PNM will result in an electric power generation not only capable of meeting its demand, but also generating a surplus that will be made available to the grid.

Table 2.5-2 – Comparison of the projects of Vale & PNM.

Technical Aspect	Vale	PNM
Mineral Resource Estimate	76 Mt at 0.88% Ni	72.2 Mt at 1.00% Ni & 0.048% Co, (0,6% Ni cut-off)
Mineral Resource to be mined		52.5 Mt at 1.08% Ni & 0.048% Co
Life of Operation	25 years	17.6 years
Ore processing capacity (tpa)	2,500,000	3,000,000
Production (tpa) (contained nickel)	22,000 tpa in MHP	24,500 tpa in NHP + 1,100 tpa Co product (CHP)
Type of Product	MHP	NHP & CHP
Production (tpa) - Products		100,000 NHP (40+% Ni); 5,000 CHP (40% Co)
Sulfuric acid consumption (tpa)		750,000
Sulfuric acid consumption (Kg / t ore)	420	250
Sulfur consumption (t / year)	380,000	250,000
Consumption / production of concentrated sulfuric acid (t / day) - peak	3,100	2,500
Concentration of sulfuric acid (g / L) for cell irrigation	200	60
Energy consumption (MWh)	50	21
Power generation (MWh)	0	29,7
Limestone consumption (tpa)	650,000	476,000
Consumption of Calcium Oxide (lime) - tpa	158.000	50.000
Consumption of Soda Ash (sodium carbonate) tpa	0	112,340
Consumption of magnesia (MgO)	34,000	0
Industrial water use (m^3 / h; 24 hours a day; 365 days a year)	670	460

Source: PNM, 2017 and Arcadis Tetraplan, 2008 (ESIA/RIMA Vale).

2.5.2. Alternative Locations

Mineral projects in general are associated with mineral occurrences with anomalous concentrations of one or more species, in a given region. These ventures have two peculiar characteristics that differentiate them from ventures of another nature. The first is the locational rigidity defined by natural geological factors, and not by suppliers, the market and investors. The second is its dynamic nature, where concepts such as ore, waste and mine are associated with technical and economic factors that vary over time.

2.5.2.1. Reserves

Known nickel ore reserves are spread over more than 20 countries, resulting in an average global grade above 1%. The reserves with the highest nickel content are estimated at over 75.9 million tonnes (DNPM, 2013).

Nickel ores are classified into sulfides, nickel laterites and hydrothermal veins. Laterite deposits were formed during periods of erosion and weathering. The laterite resulting from the serpentinite contains iron and nickel (with 1% nickel) as occurs in Cuba and the Philippines. Another type of laterite, which results from peridotite, dunite or pyroxenite, is known as nickel silicate. The nickel content exceeds 1.5% and its main deposits occur in New Caledonia, Indonesia, Venezuela, Brazil and the USA (DNPM, 2008).

Historically in Brazil, the main nickel deposits are of the lateritic type. The mining activities, which are in the research or development phase, are the deposits of Iporá (GO), Santa Fé (GO), Barro Alto (GO), Morro do Engenho (GO), Jacaré (PA), Vermelho (PA) and Onça Puma (PA), in addition to Brejo Seco nickel, at Capitão Gervásio Oliveira (PI).

The national production of nickel ore, in 2013, totaled 13,006,961 tonnes, distributed among the states of Goiás (73.4%), Bahia (21.8%), Pará (4.1%) and Minas Gerais (0.7%).

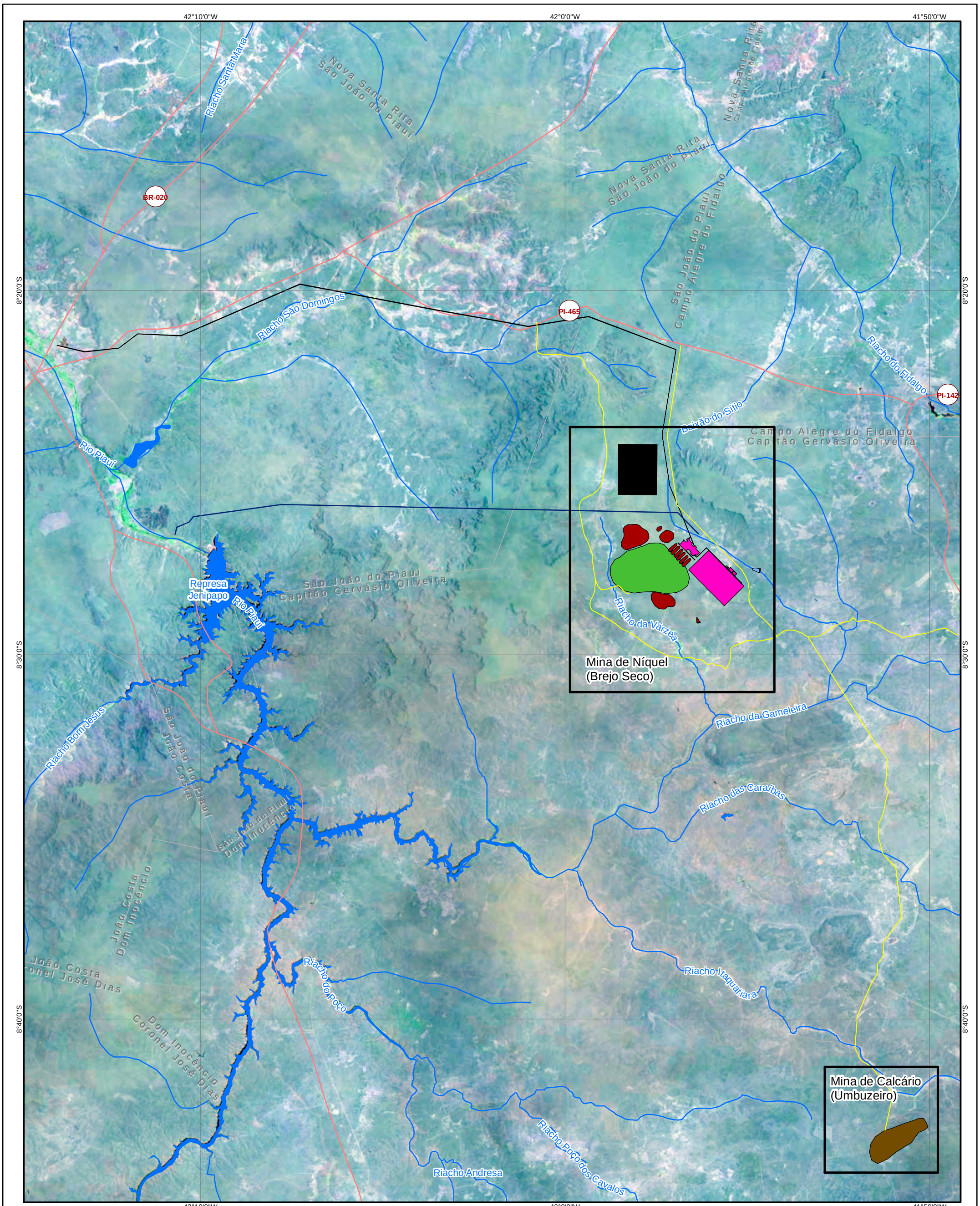
2.5.2.2. Layout Optimization

Despite the locational rigidity defined by natural geological factors, common to this type of project, the new layout proposed by the Piauí Níquel Metais project (Map 2.5-2) optimized the layout and areas occupied by the structures previously proposed in the Vale project (Arcadis Tetraplan, 2008) (Map 2.5-1).

As can be seen in the Map 2.5-3, which presents the comparison between the projects, the areas planned to be the residue storage and nickel mining experienced the greatest reductions of occupied areas. The nickel mining decreased from 764.62 ha, foreseen in the previous project, to 330.46 ha in the PNM project (Map 2.5-3), that is a reduction of about 57% of occupied area.

The area where the limestone will be mined and crushed, Umbuzeiro, also experienced a considerable reduction, going from 324 ha projected by Vale to just 45.47 ha in this Piauí Nickel project (reduction of about 86% in the intervention area).

Map 2.5-1 – Project Layout – Vale, 2009



LEGENDA

- Vias existentes
- Limite Municipal
- Hidrografia
- Massa D'água

ESTRUTURAS DE PROJETO

Nickel Mine
- Transmission Line
- Water Pipeline
- Residues
- Heaps
- Dike

Limestone Quarry
- Quarry

Other Structures
- Transmission Line LT

Pipeline
- Water Pipeline

Access Roads
- Access Roads

REFERÊNCIAS

Fontes:
IBGE, Base Contínua 1:250.000, 2015.
Planta Base Vale, 2008

ESCALA GRÁFICA
0 2,5 5 km

Sistema de Coordenadas: GCS SIRGAS 2000

LOCALIZAÇÃO

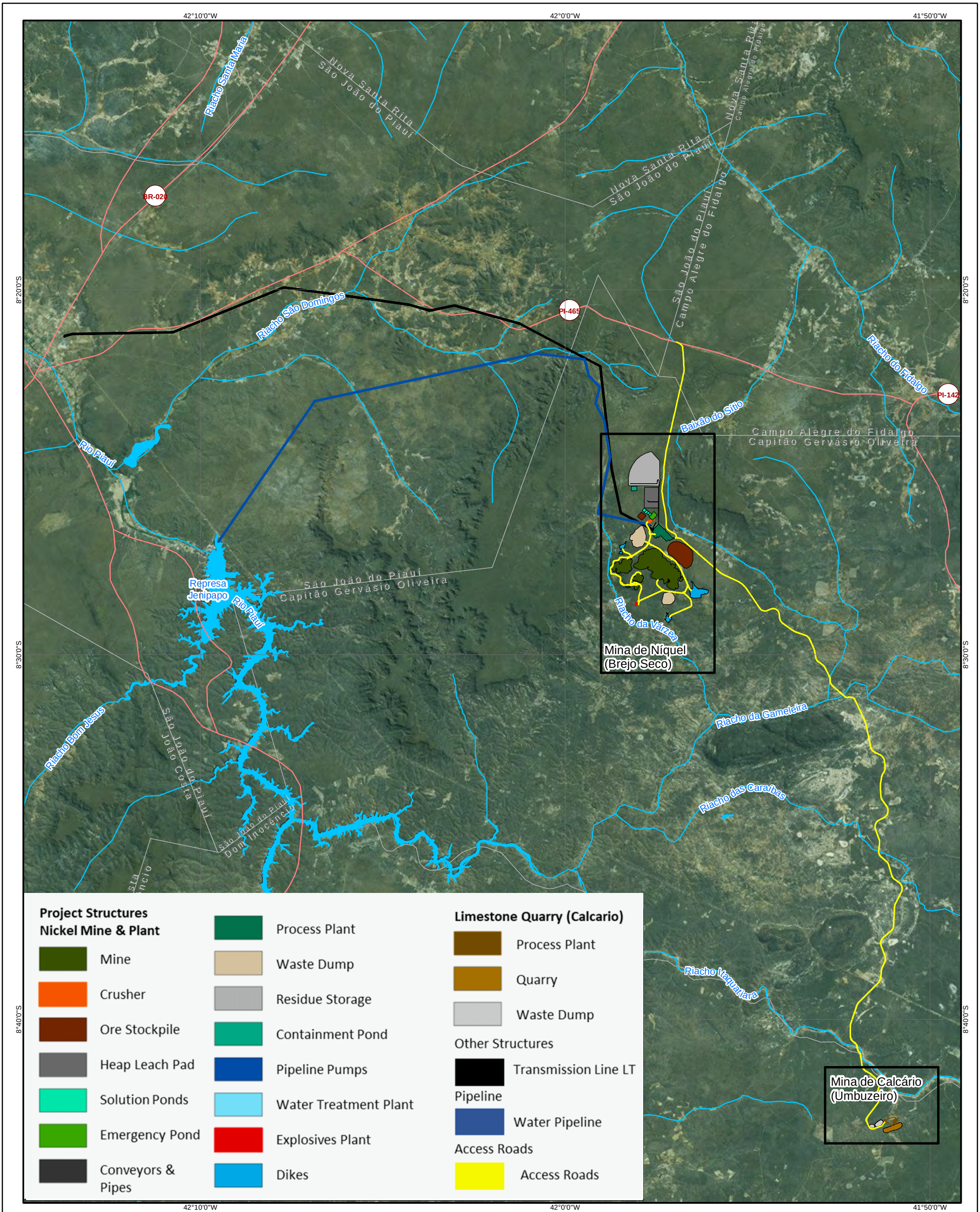
PIAUÍ NÍQUEL | ARCADIS

EIA/RIMA – PROJETO PIAUÍ NÍQUEL

2.5-1 – LAYOUT GERAL PROJETO VALE

EXECUTADO POR:	ESCALA	FORMATO:	FOLHA:	DATA:
ARCADIS	1:175.000	A3	ÚNICA	MAI /2017

Map 2.5-2 – Project Layout – PNM, 2017.



LEGENDA

- Vias Existentes
- Limite Municipal
- Hidrografia
- Massa D'água

REFERÊNCIAS

Fontes:
IBGE, Base Contínua 1:250.000, 2015.
Projeto Piaui Níquel, 2016.

ESCALA GRÁFICA
0 2,5 5 km

Sistema de Coordenadas: GCS SIRGAS 2000

LOCALIZAÇÃO

PIAUÍ NÍQUEL
ARCADIS

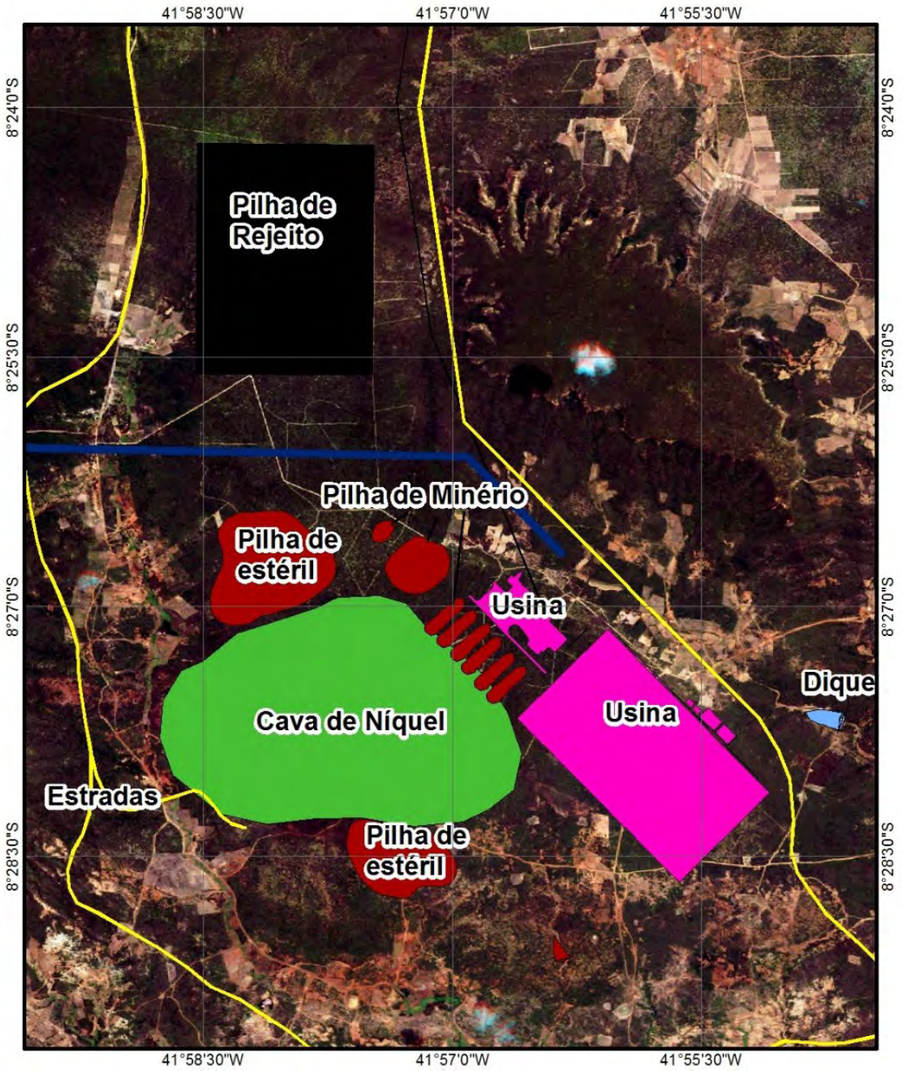
EIA/RIMA – PROJETO PIAUÍ NÍQUEL

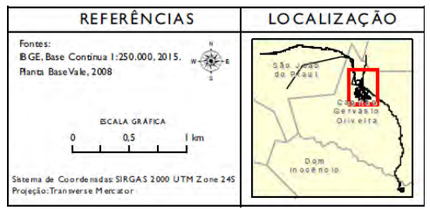
MAPA 2.5-2– LAYOUT GERAL DO EMPREENDIMENTO

EXECUTADO POR:	ESCALA	FORMATO:	FOLHA:	DATA:
ARCADIS	1:175.000	A3	ÚNICA	MAI /2017

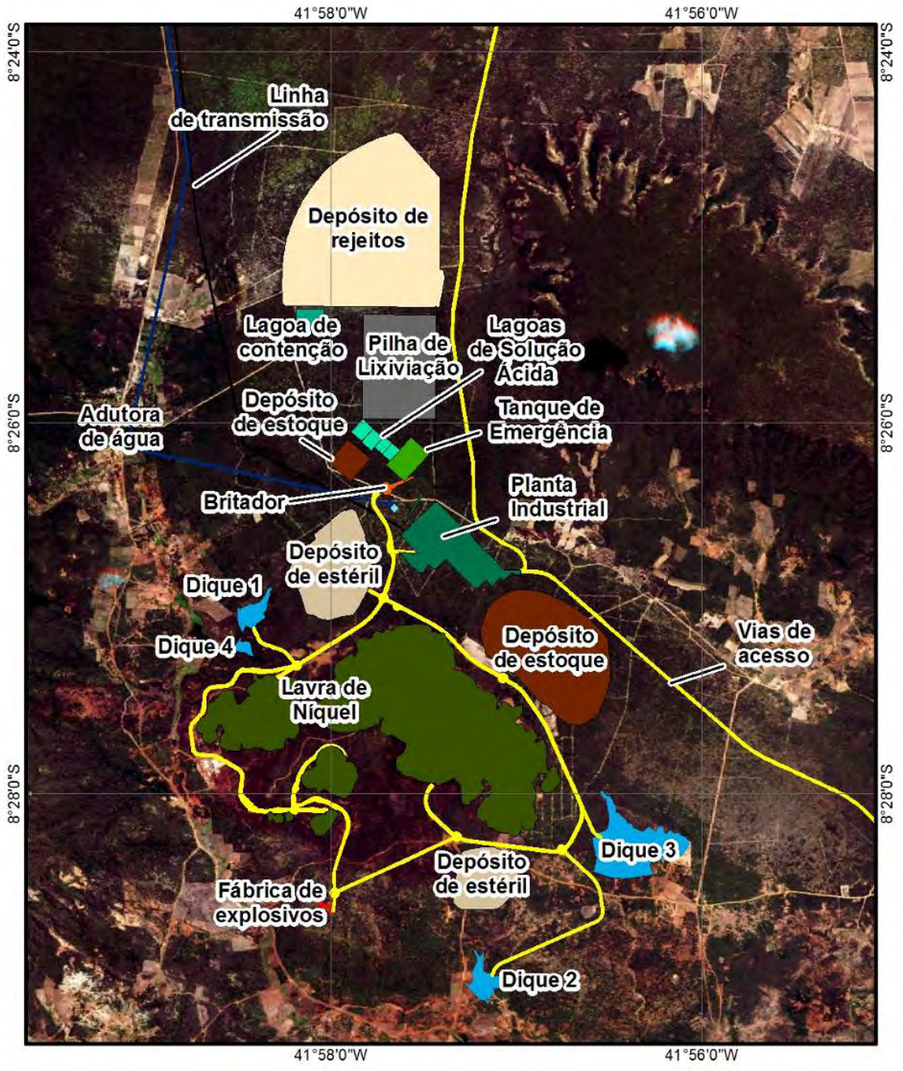
Map 2.5-3 – Detailed comparison of the Projects PNM v Vale.

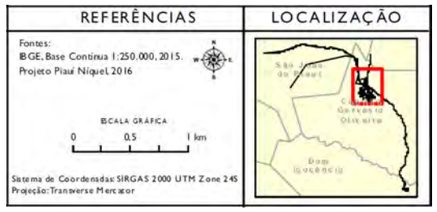
Project Vale – Brejo Seco





Project PNM – Brejo Seco





Where:

Via de Acesso/Estradas = roads

Lavra/Mina = Pit/mine

Níquel =Nickel

Depósito =Stockpile or Dump

Pilha = Heap/Stockpile

Estéril =Waste

Estoque = Stock

Rejeitos = Residues

Planta Industrial = process plant

Usina = Process Plant

Britador = Crusher

Lagoa = Pond

Lixivação = Leaching

Adutora de Água = Water pipeline

Linha de Transmissão = Transmission line

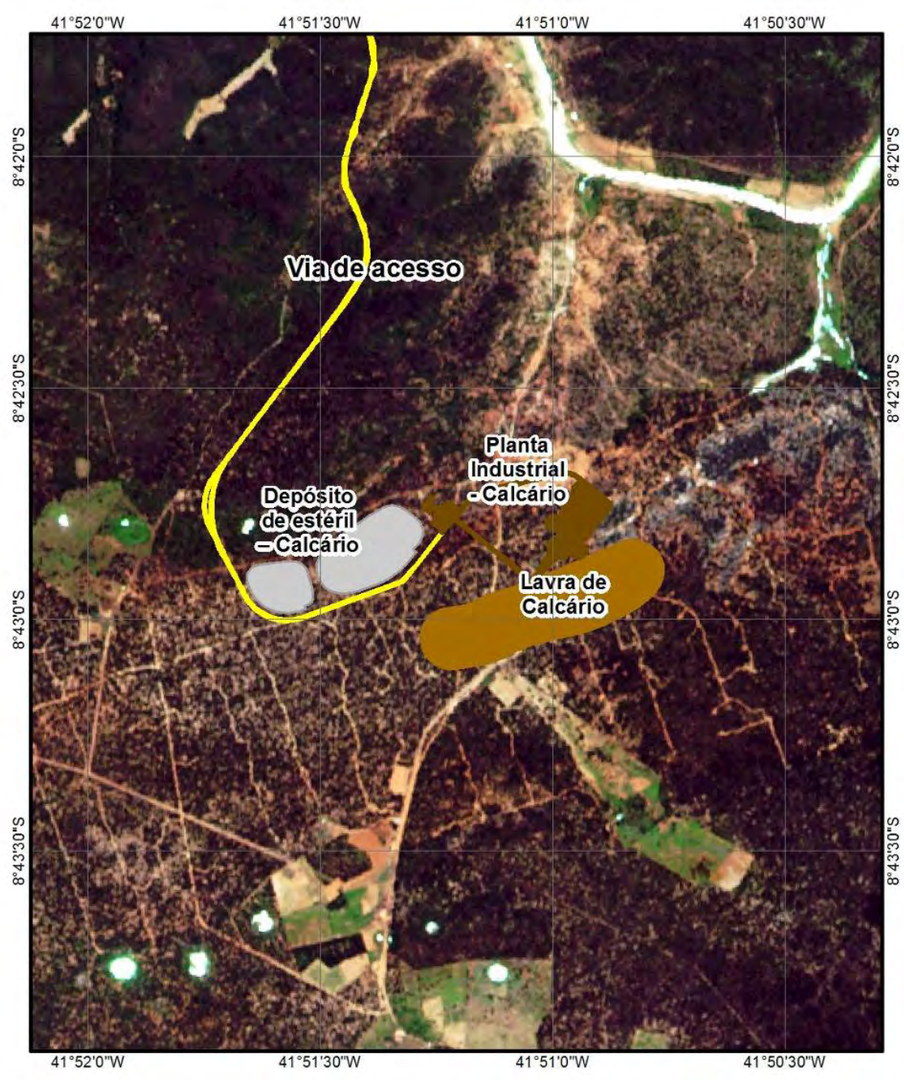
Tanque de Emergência = Emergency Pond

Dique = Dike

Project Vale – Umbuzeiro

Source: ESIA/RIMA Vale Arcadis Tetraplan, 2008.

Project PNM – Umbuzeiro



Source: Arcadis, 2017.

Where:

Via de Acesso/Estradas = roads

Lavra/Mina = Quarry

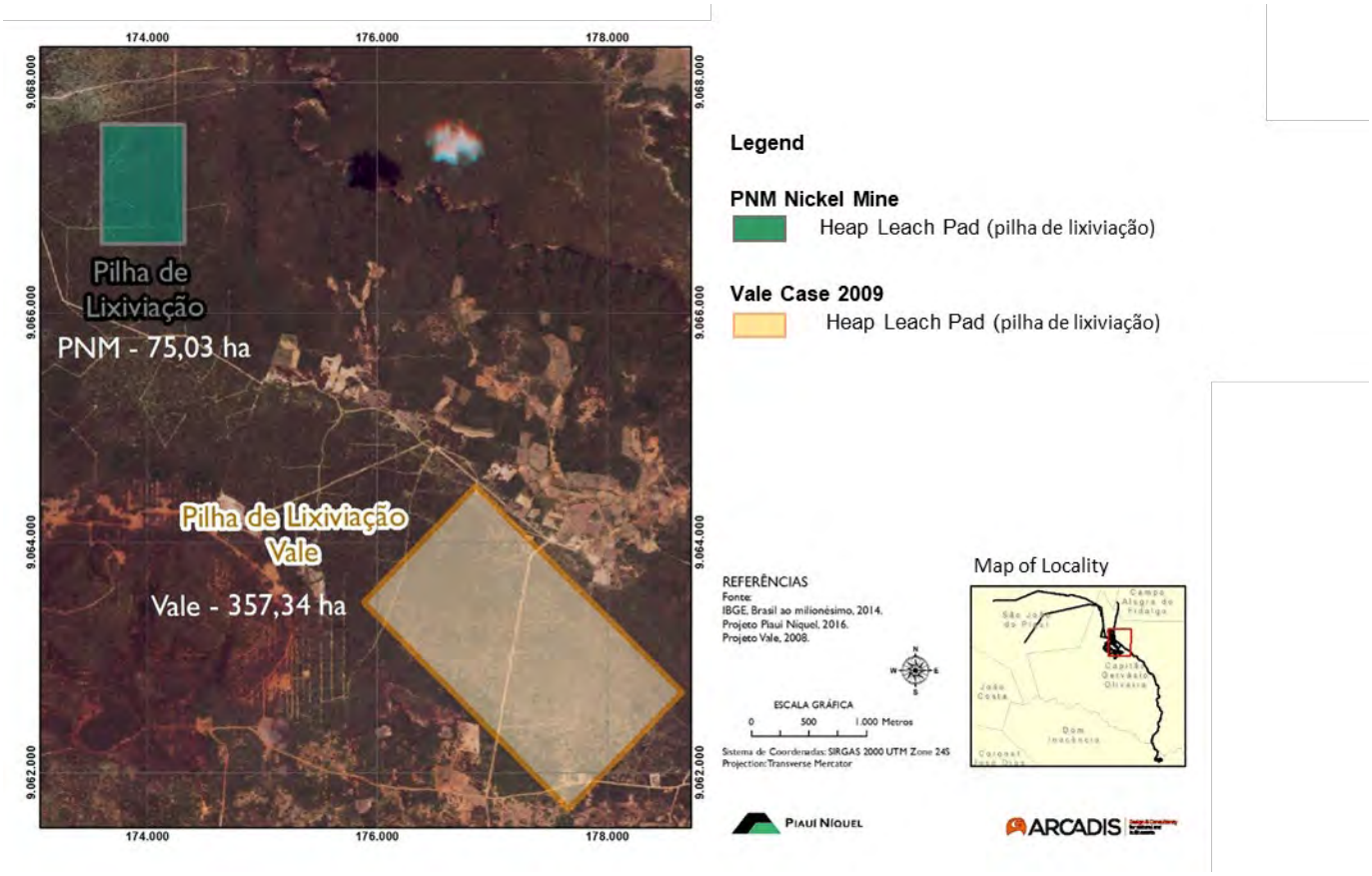
Calcário =Limestone

Depósito de estéril =Waste Dump

Planta Industrial = process plany

The leaching heaps, which previously would occupy approximately 357 ha for Vale's project, in the Piauí Nickel Project will occupy only about 75 ha (reduction of about 78% of occupied area), as indicated in Map 2.5-4

Map 2.5-4 – Comparison of the leach heaps proposed in the project Vale & PNM.

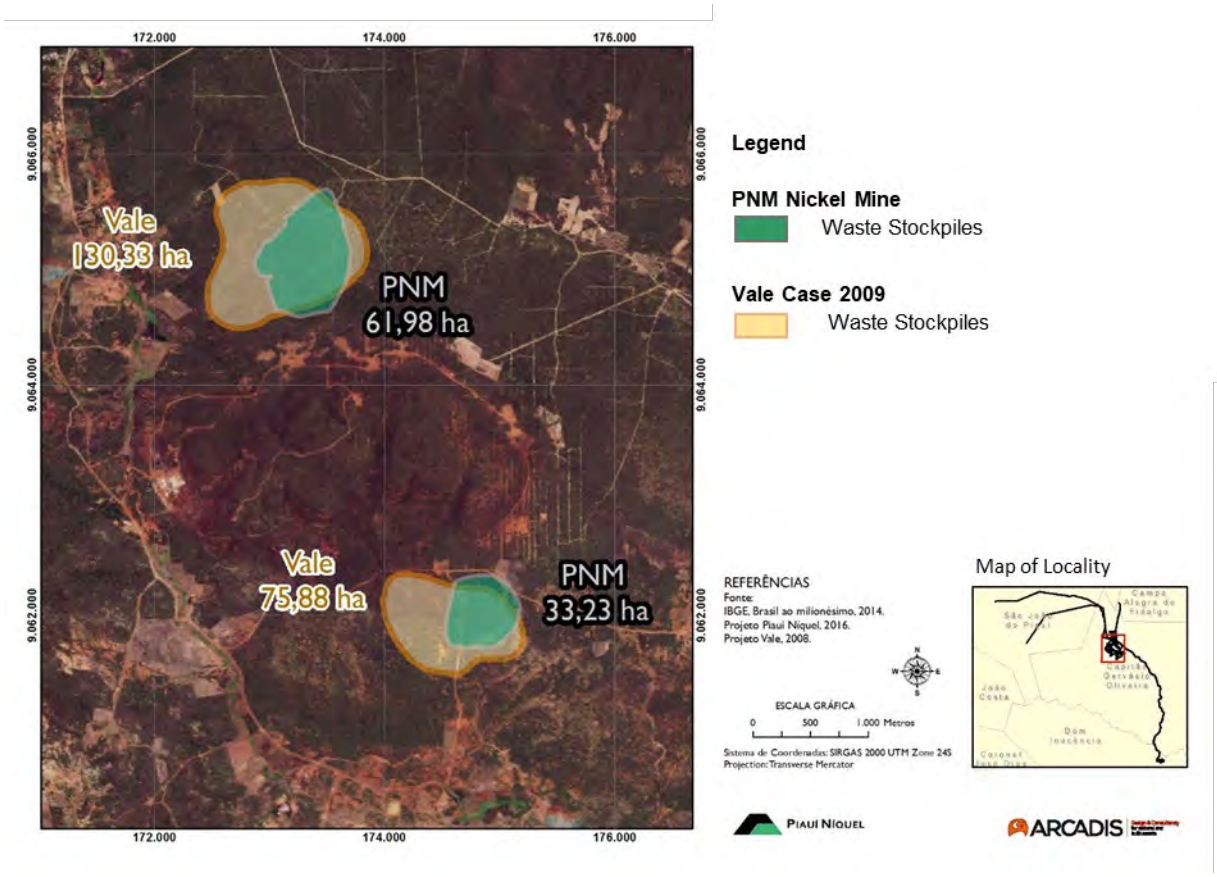


Source: PNM, 2017 & Arcadis Tetraplan, 2008 (ESIA/RIMA Vale).

Preparation: Arcadis, 2017.

Similarly, waste stockpiles (overburden) reduced the total area from 206 ha to around 95 ha, a reduction of about 53% in the intervention area (Map 2.5-5).

Map 2.5-5 – Comparison of waste stockpiles proposed in the project Vale & PNM.

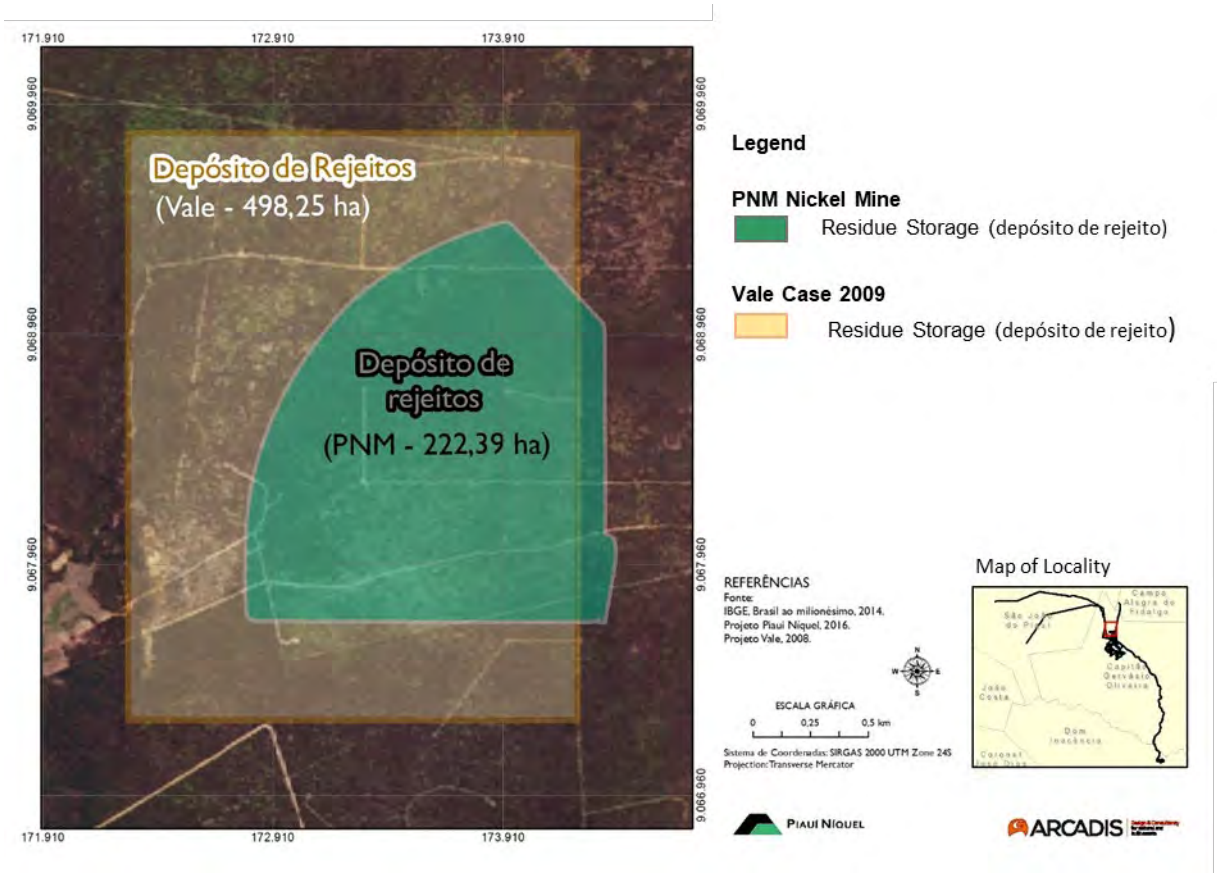


Source: PNM, 2017 e Arcadis Tetraplan, 2008 (ESIA/RIMA Vale).

Preparation: Arcadis, 2017.

The residue storage area proposed in the Vale project occupied an area of 498.25 ha, while in the PNM project it occupies only 222.39 ha, reducing 55.4% of the original project (Map 2.5-6).

Map 2.5-6 – Comparison of the residue storage proposed in the projects Vale & PNM.



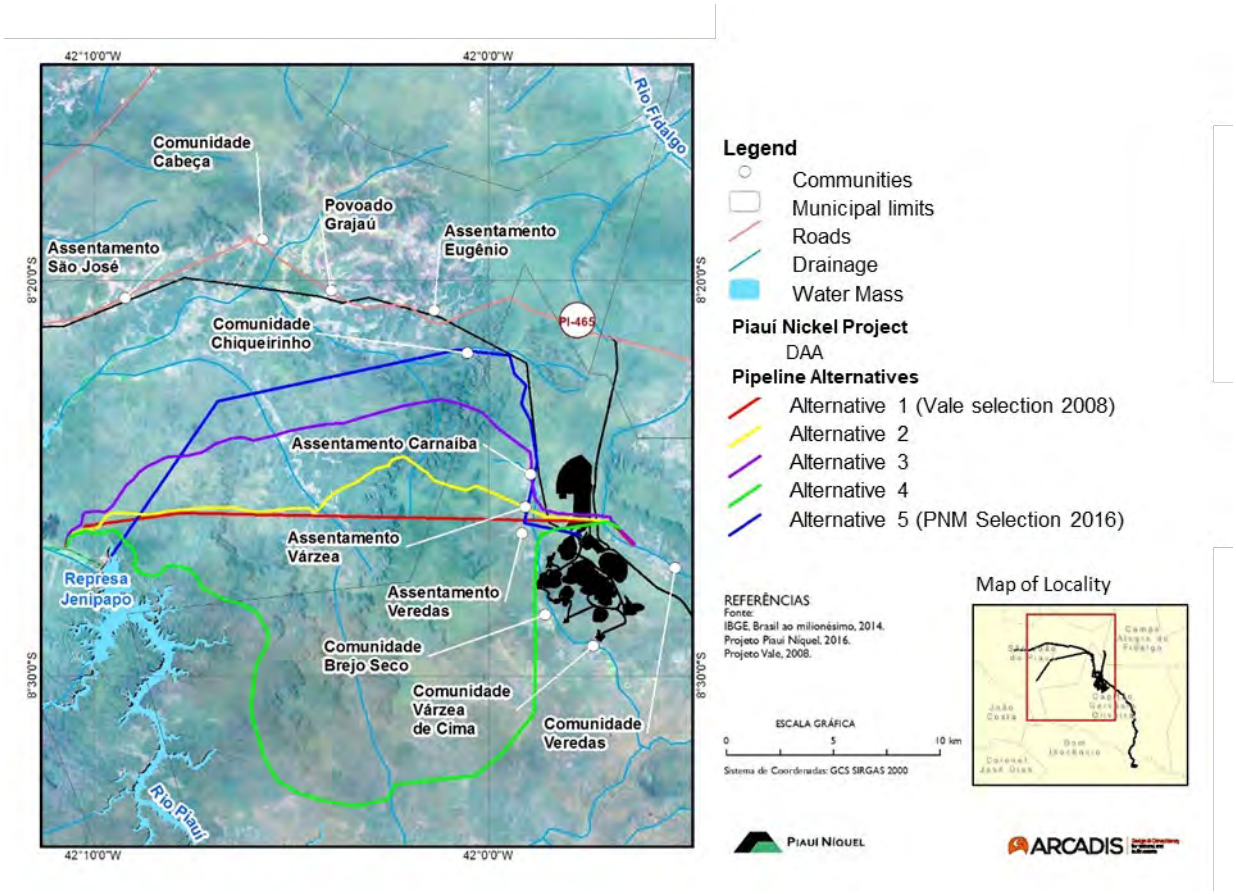
Source: PNM, 2017 & Arcadis Tetraplan, 2008 (ESIA/RIMA Vale).

Preparation: Arcadis, 2017.

PNM reassessed the route proposed by Vale for the water pipeline that will connect the Jenipapo reservoir to the project, selecting a route with less environmental impact on preserved areas, prioritizing anthropized environments. In defining the new layout of the pipeline, PNM considered alternatives defined in the Vale project. As can be seen in the Map 2.5-7, the previous project foresaw the crossing of the plateau of São Francisco, while a new route, although of greater length, proposes a path that goes around the plateau to the north, close to the PI-465 highway, thus reducing interventions in the plateau and taking advantage of the open roads and terrain already deforested.

This alteration of the route, in addition to providing an engineering work of less complexity and cost, since it will avoid crossing the plateau and large relief gaps, reduces impacts on the local flora and fauna, avoiding the removal of Caatinga in Chapadas, which was envisaged in the original route proposed by Vale in 2009.

Map 2.5-7 – Comparison of the pipeline layout proposed in the project Vale & PNM.

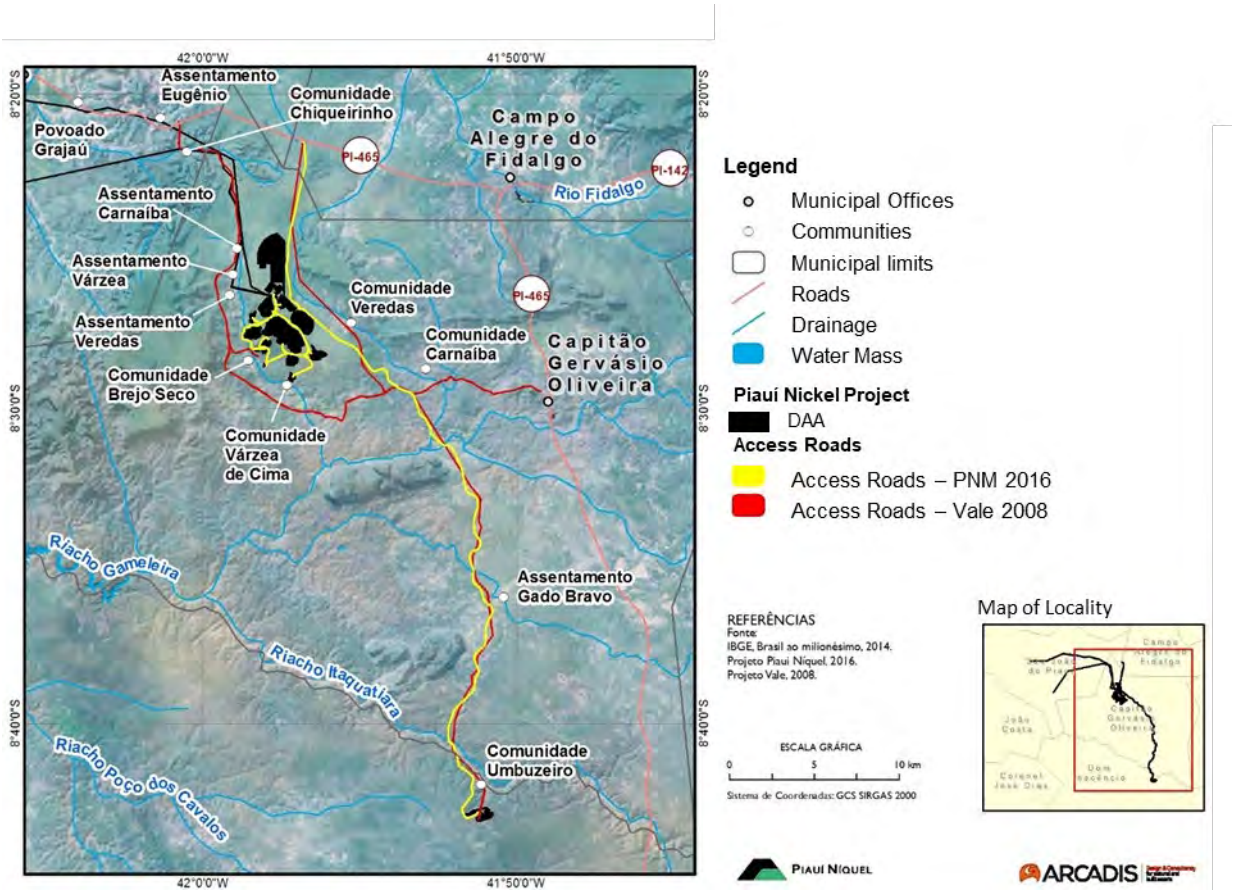


Source: PNM, 2017 & Arcadis Tetraplan, 2008 (ESIA/RIMA Vale).

Preparation: Arcadis, 2017.

PNM also projected improvements in relation to the access routes to the project provided for in the old Vale project. Noteworthy is the forecast for the construction of a new exclusive connection road between the project and the PI-465 road (instead of using the pre-existing secondary unpaved access roads), thus aiming to eliminate inconveniences to the local communities by the traffic of input and product trucks, and reduce the risk of accidents. The new route that connects the limestone mine to the nickel production area has also undergone some adjustments. Map 2.5-8 presents the location of these new access roads, as well as showing the distances to communities, settlements and existing local roads.

Map 2.5-8 – Comparison of the layout of the access route proposed in the project Vale & PNM.



Source: PNM, 2017 & Arcadis Tetraplan, 2008 (ESIA/RIMA Vale).

Preparation: Arcadis, 2017.

Such optimization of the areas occupied by the structures of the project and adjustments in the layout of the water pipeline result in a significant reduction in the interventions planned in areas covered with native vegetation (Caatinga), which were estimated at approximately 2,321.44 ha in the Vale project and reduce to around 1,121.33 ha foreseen in the PNM project. This comparison was made by overlapping the structures provided by Vale (2009) and PNM (2017) to the land use mapping prepared by Arcadis (2017), which will be presented in section 5.2.3.1 of this ESIA. The comparison of areas by typology estimated in the two projects is shown in the table below.

Data Table 2.5-1 – Comparison of Removal of Native Vegetation.

Type	Area (hectares)	
	PNM (2017)	Vale (2008)
Open arboreal-shrubbery Caatinga	728.29	1,708.54
Dense arboreal-shrubbery Caatinga	339.67	588.91
Sparse arboreal-shrubbery Caatinga	53.37	23.99
Total	**1,121.33**	**2,321.44**

Preparation: Arcadis, 2017.

Considering the aforementioned factors, the alternative proposed by PNM was selected as the most suitable for the implementation of the project because it presents the least impactful design from the socio-environmental point of view and still allows the economic viability of the project.

2.6. Investment

The investment required for the project was estimated with a precision level (margin of error) of approximately 25% (within that acceptable for Preliminary Budgeting of Projects at FEL2 level, as the present project), calculated from the companies' databases, Brazilian engineering companies and the costs of two similar heap leach projects in 2009 and 2010, adjusted for 2016 and for specific project circumstances.

The estimated investment cost for the construction of the project is of the order of US$ 520 million, considering taxes and without considering costs with socioenvironmental actions.

It will be possible to present the costs for implementing the project with greater precision and accuracy when the stage of preparing the Bankable feasibility and FEL3 engineering studies of the project as a whole is complete. This is expected to occur in the next stage of environmental licensing - obtaining Installation License - LI of the project. PNM is already looking for the resources and investors needed to develop these studies.

2.7. General Project Schedule

The project schedule (Table 2.7-1) includes licensing activities, funding, preparation of Bankable feasibility studies and development of the engineering project at FEL3 level, in addition to the construction and operation of the mine and processing complex.

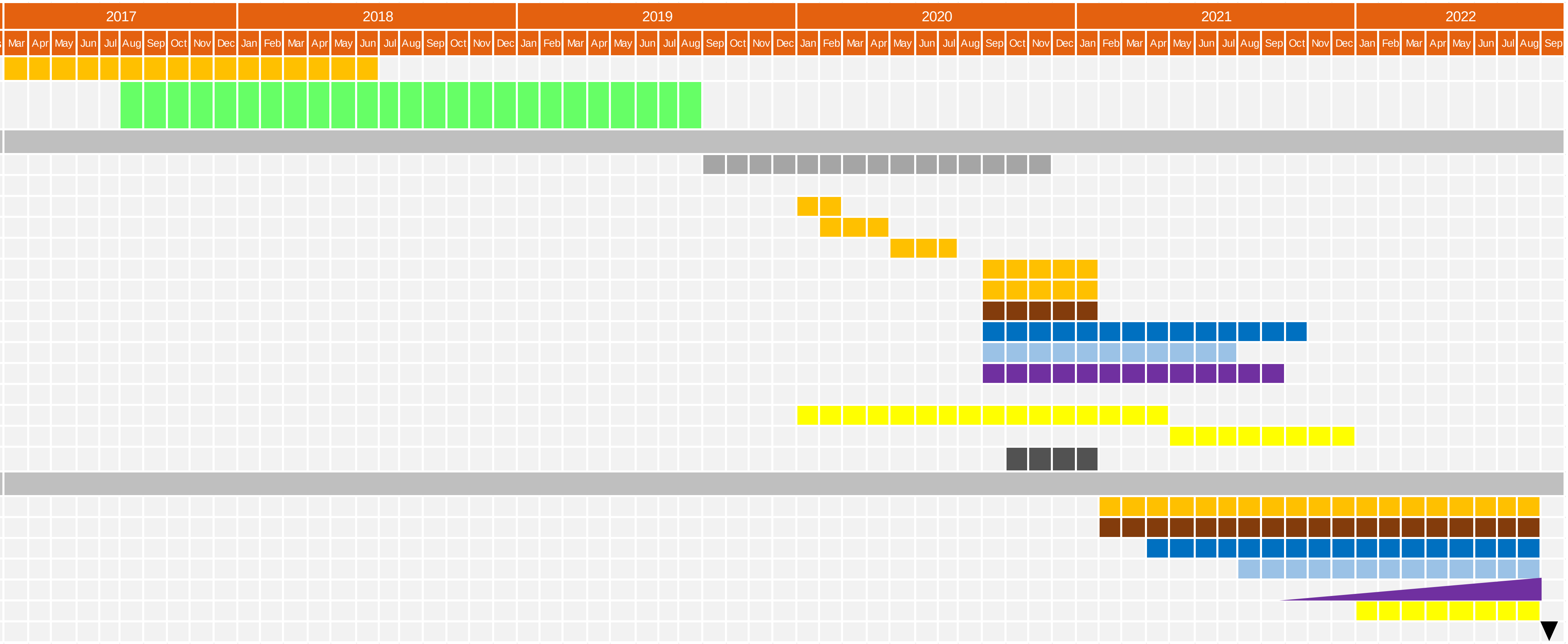
To be implemented, the project depends on the contribution of financial resources from future investors, which PNM is still looking for. Obtaining the Preliminary License (LP) is of great importance to prove the feasibility of the project and to improve the chances of gathering investors to finance the stages of land negotiation, Detailed Engineering, and Construction of the project as a whole.

Likewise, obtaining the Installation License as soon as possible becomes very important to guarantee investment and release of resources by investors for project construction on the industrial commercial scale envisaged.

In Table 2.7-1 the general schedule of the project is presented with all the activities of each Phase detailed.

Table 2.7-1 – General Project Schedule (Months).

	Overall Schedule	Months
1	***Licença Prévia - LP***	
2	***Fundraising; BFS / FEL3 Eng.; Installation License - LI***	
3	***Construction Phase***	24
3.1	**Quotation and Contracting suppliers**	15
3.2	**Support Intrastructure**	13
	- Site access road	2
	- Low voltage electricity connection	3
	- Construction Building sites / camp	3
	- Water pipeline (Jenipapo)	5
	- 69kV Transmission Line	5
3.3	**Nickel Mine**	5
3.4	**Leaching Area**	14
3.5	**Limestone Mine - Umbuzeiro**	11
3.6	**Precipitation Plant**	13
3.7	**Acid Plant**	24
	- Long-lead item fabrication (external)	16
	- Erection at site	8
4	***Operation License - LO***	
5	***Operation Phase***	
5.1	**Support Intrastructure**	
5.2	**Nickel Mine**	
5.3	**Leaching Area**	
5.4	**Limestone Mine - Umbuzeiro**	
5.5	**Precipitation Plant (Ramp-up)**	
5.6	**Acid Plant**	
5.7	**Full Nickel production capacity**	19



Source: PNM, 2017. Prepared by: Arcadis, 2017.

2.8. Implementation (Construction) Phase

This chapter presents the construction schedule, the labor to be employed, the characteristics of the necessary inputs and equipment, the actions for clearing the land, removing vegetation, earthworks, civil works and electromechanical assemblies.

The construction phase of the project is the moment when all the necessary infrastructure will be built or improved to allow the operation of the future project.

The main component structures of the project add up to a total occupation area of 1,164.12 ha, calculated by the sum of each individual unit. In Data Table 2.1-1 the area (in hectares) to be occupied by each of the project's structures is presented.

The initial works plan for the construction of the Piauí Nickel Project structures comprises the following activities:

- Execution of Preliminary Infrastructure Services (removal of vegetation, topsoil stripping and earthworks);
- Installation of infrastructure to support the construction:
  - Offices and construction sites in the internal area: preparation of the contractors' construction site area;
  - Provisional accommodation;
  - Adaptation of the existing energy distribution line that feeds the Demonstration Plant and distribution of energy from the Demo Plant to meet the needs of construction sites;
  - Implementation and improvement of access roads;
  - Preparation for supplying aggregates and concrete.
- Implementation of operational and support structures;
- Deactivation of Temporary Structures.

2.8.1. Preliminary Infrastructure Services

Preliminary operations and services are the first actions to modify the land in order to adapt it to receive the planned structures. This is the initial preparation of the land.

Among the actions of preliminary operations are the removal of vegetation, the stripping and storage of soil, earthworks, in addition to the construction of roads and preliminary accesses. Such actions are detailed below.

A) Vegetation Removal

The removal of vegetation includes the activities of land clearing, cutting, removing, transporting and storing wood, in all areas planned for the implementation of the project. This activity will be carried out after the authorization is issued by SEMAR, and will follow best practices aiming at clearing only the necessary and authorized areas, with PNM’s supervision.

The steps to be followed in the process of clearing vegetation in the Directly Affected Area (DAA) of the Piauí Nickel Project are:

- Mowing;
- Felling of trees;
- De-shearing;
- Splitting of the trunk;
- Selection of woody material;
- Stacking;
- Volume measurement;
- Transport of wood material.

The removed wood material will be temporarily stored in the areas planned to be the ore stockpiles already provided for in the layout, and should be separated by class (commercial and non-commercial). Later the material will be destined either for the wood industry or for use as firewood and/or charcoal.

B) Stripping and Topsoil Storage

After vegetation removal, all areas where cut, landfill, maintenance roads, area for depositing surplus material, stock area and support facilities will be cleared.

During the implementation, there will be a need to remove the existing topsoil layer in the areas where the structures will be installed.

The stripping and clearing works will be carried out in stages, in the minimum amount necessary for the release of each corresponding earthmoving front, in order to avoid prolonged exposure of the soil without cover, which could lead to erosion processes.

So that the upper layers of soil, precisely those that are richer in organic matter, are not lost, during the stripping activities, the work must be conducted carefully.

The layer of soil removed (with an approximate height of 30 cm) in the land clearing operations will be stored in small rows, in areas planned as ore stockpiles.

C) Earthworks

Earthmoving operations will aim to meet the project's implementation quotas, as defined in the engineering design of the facilities, aiming at the greatest possible balance of cut and fill volumes, in order not to need further areas for additional fill or to store cut.

If necessary, excess volumes of soil may be stored within the operational areas, such as the ore or waste stockpile areas.

The volume of earthmoving involved in the earthworks will be detailed in the next stage of environmental licensing (LI), taking into account the engineering studies that are yet to be carried out. However, since the Piauí Nickel project will occupy a smaller area than the one foreseen in the Vale project, it is estimated that the amount of 3,000,000 m³ will not be exceeded, a volume previously estimated by Logos Engenharia for Vale's Project.

2.8.2. Support Structures

The structures that will be built and used to support the construction phase are described below.

2.8.2.1. Construction Sites

A) Construction Site - BrejoSeco

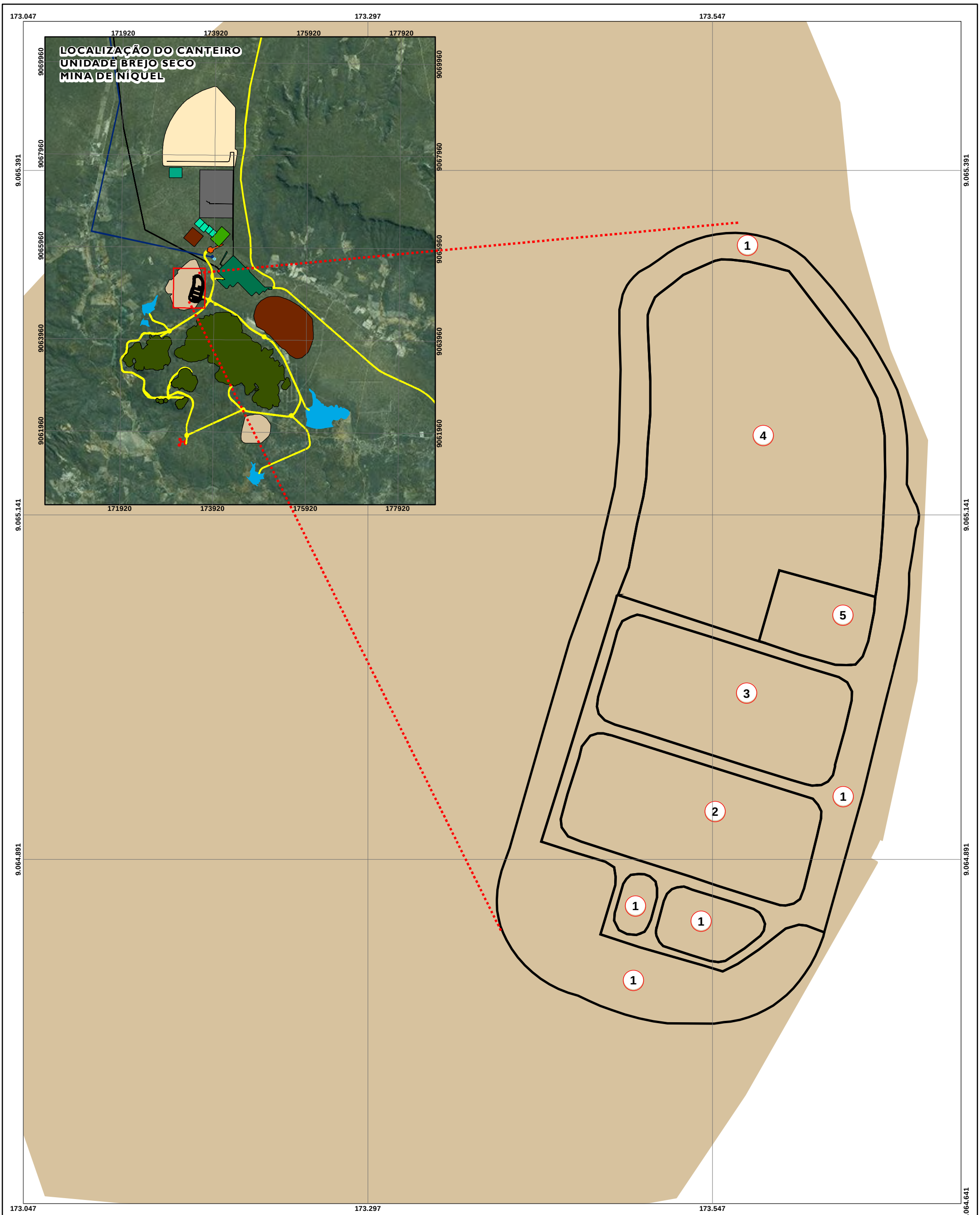
The construction site to be implemented in the Brejo Seco area of the project, will occupy an area of about 10.4 ha, and it will be installed in the area planned to be the northern waste dump, thus reducing the need for vegetation removal from new areas. The construction site will comprise construction offices, cafeteria and toilets, an outpatient clinic, patios for storing materials and assembling equipment. The workshops of the contractors responsible for building the project will also be located on this jobsite. This area should also house the fuel storage and vehicle and machinery supply station and the equipment and vehicle washing area.

The following distribution of the area is estimated:

- Deforestation and earthmoving site, with 20,000 m²;
- Construction site for civil works, with 20,000 m²;
- Electromechanical assembly sites, with 20,000 m²;
- Electromechanical Equipment storage yard with 40,000 m²;
- PNM construction site, with 4,000 m².

Map 2.8-1 presents the layout of the construction site.

Map 2.8-1 – Layout of the construction site - Brejo Seco



LEGENDA CANTEIRO DE OBRAS

Waste Dump

Construction Site

Construction Site Elements

1) Earthworks – 20,000 m²
2) Civil works – 20,000 m²
3) Electro-mechanical – 20,000 m²
4) Stockyard/warehouse – 40,000 m²
5) Construction – 4,000 m²

REFERÊNCIAS

Fontes:
IBGE, Base Contínua 1:250.000, 2015.
Projeto Piauí Níquel, 2016

ESCALA GRÁFICA
0 25 50 Metros

Sistema de Coordenadas: SIRGAS 2000 UTM Zone 24S
Projeção: Transverse Mercator

LOCALIZAÇÃO

PIAUÍ NÍQUEL

ARCADIS

EIA/RIMA – PROJETO PIAUÍ NÍQUEL

MAPA 2.8-1 – CANTEIRO DE OBRAS
COMPLEXO MÍNERO-INDUSTRIAL
BREJO SECO

EXECUTADO POR:	ESCALA	FORMATO:	FOLHA:	DATA:
ARCADIS	1:2.500	A3	ÚNICA	MAI /2017

Mechanical contractors, welding, oxy-cutting, machining and general assembly of parts and equipment will be carried out at the contractors' workshops. The construction site will also include equipment for the production of concrete and an area for storage of aggregates.

An area of the construction site will be used for the temporary storage of construction scrap and waste, before final disposal, which will be carried out properly, according to the solid waste management plan to be implemented.

Considering the parameters established by the ABNT standard, NBR 7,229 / 82, during the peak workforce (1,875 employees), it is estimated an average generation of approximately 13.5 m³ of sanitary effluents / day, which will be sent to the septic tank and anaerobic filter systems. An average generation of about 800 kg / day of household waste is also estimated.

The supply of electricity will come from the existing distribution network that currently powers the Demo Plant. The water consumed at the Brejo Seco construction site will come from already permitted boreholes and water trucks.

B) Construction site - Umbuzeiro

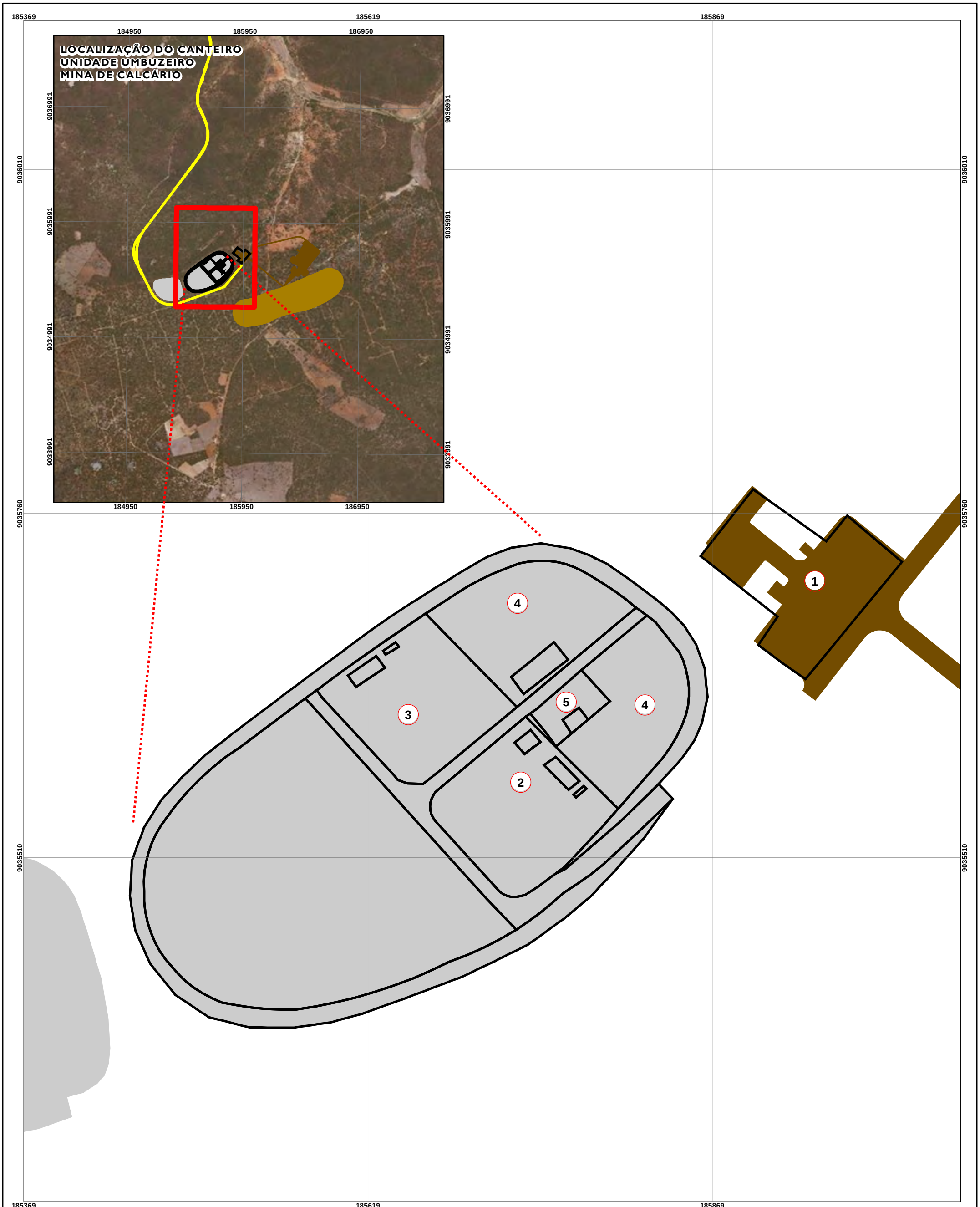
At the site of Umbuzeiro there will be a smaller construction site that will occupy about 5 ha to serve the works and assemblies of local equipment.

Map 2.8-2 presents the layout of the construction site, which will be within the area planned for the future deposit of limestone waste, in such a way as to avoid vegetation removal in new areas for its installation and operation. The following distribution of areas is estimated:

- Deforestation and earthmoving site, with 10,000 m²;
- Construction site, with 10,000 m²;
- Electromechanical assembly sites, with 10,000 m²;
- Electromechanical equipment storage yard, with 15,700 m²;
- PNM construction site with 1,500 m².

The contractors will be responsible for the construction and operation of the field buildings (offices, workshop, cafeteria, dressing room, first aid room, effluent treatment system, storage of raw and drinking water, implementation of the communication system for their construction sites and fuel storage). The energy used to implement the structures in Umbuzeiro will be provided by temporary generators.

Map 2.8-1 – Layout of the Construction Site Umbuzeiro



LEGENDA CANTEIRO DE OBRAS

REFERÊNCIAS

Fontes:
IBGE, Base Contínua 1:250.000, 2015.
Projeto Piauí Níquel, 2016

ESCALA GRÁFICA
0 25 50 m

Sistema de Coordenadas: SIRGAS 2000 UTM Zone 24S
Projeção: Transverse Mercator

LOCALIZAÇÃO

PIAUÍ NÍQUEL
ARCADIS

EIA/RIMA – PROJETO PIAUÍ NÍQUEL

MAPA 2.8-2– LAYOUT DO CANTEIRO DE OBRAS
COMPLEXO MÍNERO-INDUSTRIAL
UMBUZEIRO

EXECUTADO POR:	ESCALA	FORMATO:	FOLHA:	DATA:
ARCADIS	1:2.500	A3	ÚNICA	OUT /2017

2.8.2.2. Accommodation

If necessary, a small accommodation for workers will be built, located in the area that will be the north waste dump at the Brejo Seco site in the future, reducing the distance of workers' travel time and reducing interference with the life of the local community.

Considering that about 30% of the labor employed in the implementation works will be local workers, the accommodation capacity will be reduced in relation to the total number of workers.

Details of accommodation, if necessary, will be pesented in the next stages after discussions in a participatory manner with public authorities and local communities, aiming at favoring the occupation of homes, hotels and local accommodations, strengthening the local economy.

No accommodation is planned for the Umbuzeiro area.

2.8.2.3. Access Roads

As presented in Map 2.1-1, internal access roads will be built to the Brejo Seco mine and the Umbuzeiro limestone quarry, in addition to a new connection road between the process plant and the PI-465 highway for the exclusive use of the project, for the flow of labor, transportation of inputs and equipment, and product outlets.

This new connection route between the industrial plant and the PI-465 road will be approximately 10.5 km long, approximately 14 m wide, and will be paved to increase operational safety, reduce the risk of accidents, and avoid dispersion of dust and particulates with the flow of trucks of inputs and products. It is worth noting that this road was planned precisely to prevent the flow of project vehicles on pre-existing local roads, and to stay away from existing local communities and settlements, in order to reduce inconvenience, ensure greater operational safety and prevent accidents.

The transportation of the limestone to the Process Plant, will be done by a new route to be built connecting Umbuzeiro and Brejo Seco.

2.8.3. Implementation of Operational Structures

For areas planned to be buildings and industrial installations, there will be foundation works, civil works and electromechanical assemblies.

The construction characteristics of the transmission line, water pipeline, pits, waste and ore stockpiles and residue storage are described in the subsequent paragraphs.

2.8.3.1. Transmission Line

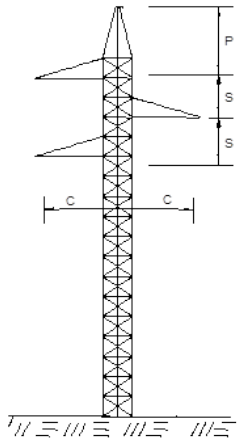
In order to connect the project to the existing electric grid, a new 69kV Transmission Line - LT will be constructed with an exit point at the substation of the Companhia Hidro Elétrica do São Francisco - CHESF in São João do Piauí, heading towards Campo Alegre do Fidalgo parallel to the PI-465 road, then heading towards the process plant in the Brejo Seco Complex, and ending at the main substation of the project, as shown in Figure 2.1-1, of section 2.1.1..

The LT voltage will be 69 kV three-phase, its length will be approximately 42.63 km, with some 103 metallic towers, with aluminum conductors with steel core. Other technical characteristics of the LT are:

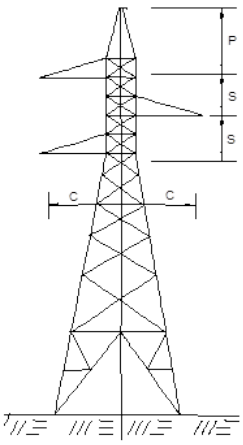
- Spacing between towers of about 400 m;
- Conductor cable: CAA-336 MCM - “LINNET”
- Number of surge arresters: 1;
- Lightning rod cables: Galvanized steel, 5/16 ”HS
- Insulators: suspension, tempered glass, CB 254x146 mm, class 8,000 kgf;
- Grounding: copper steel wire (Copperweld) - No. 4 AWG - radial arrangement;
- Number of circuits: 1;

The structures of the towers will be metallic, latticed, of galvanized steel, self-supporting, of simple circuit, with a base of 15 m by 15 m. Figure 2.8-1 presents the outline of the towers and their predicted dimensions.

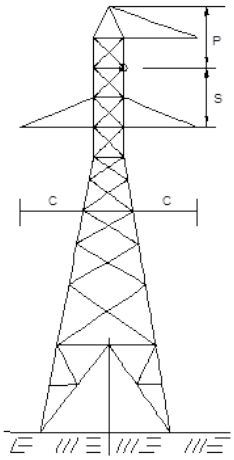
Figure 2.8-1 – Outline of the Metallic Tower Structure.



NPS2



NPS3



NPA30 e NPA60F

Type of Structure	Dimensions (mm)		
	P	C	S
NPS2	2,075	2,900	1,450
NPS3	2,225	3,200	1,450
NPA30	2,500	2,500	3,200
NPA60F	2,500	2,600	3,200

Source: Dalben, 2008.

The main stages of the construction work for the TL 69kV SE São João do Piauí - SE Piauí Níquel, include:

- Clearing the security strip;
- Marking of Towers' location;
- Opening pits for foundations for the towers;
- Assembly of structures;
- Installation of insulator chains and hardware to fix cables;
- Launch and traction of conductor cables and lightning rods;
- Installation of the structures earthing system;
- Fencing the area;
- Installation of signaling and warning systems;
- Installation of vibration dampers.

According to a survey carried out by the company Dalben Consultoria em Eng. Elétrica e Formação Ltda. during the preparation of the conceptual design of this LT, about 70% of its layout should be developed over a predominantly small shrubland area (Caatinga vegetation with 2 to 5m high), interspersed with fields, pastures and some crop areas.

Thus, for the implementation of the LT, vegetation removal will be necessary only along the 3 meter wide easement strip along the 42 km route of the LT (for cabling traction), and in the locations of the 103 towers whose bases will occupy an area of 225m^2 each, thus totaling an intervention of approximately 11.26 ha and 2.31 ha for the implementation of the TL and the towers, respectively.

2.8.3.2. Water Pipeline

The implementation of the pumping system and water pipeline between the Jenipapo dam and the future industrial plant, will require the occupation of approximately 33.52 linear km and the construction of maintenance access tracks, as shown in Figure 2.1-1 of section2.1.

At this stage of the project, it is anticipated that the the water pipeline will be buried and a pipe offset of 8 m (4 m on each side of the axis) has been defined, considering 3 m of the pipe strip and 5 m of access and maintenance tracks. Thus, an intervention of 26.73 ha is planned along its route, highlighting the existence of local access roads that can be used, and thus reducing part of the planned interventions.

2.8.3.3. Nickel Mine and Limestone Quarry

Among the classic mining engineering exploitation methodologies and the characteristics of the geological body, the most suitable method for the development of both mines would be open pit.

This methodology implies opening a pit to gain access to the mineral body, there is also the need to remove rock adjacent to the orebody, which has no economic value, called waste rock.

The development of the Nickel and Limestone mine areas will begin during the construction Phase, lasting throughout the Operational Phase and following the scheduled mining sequences, interfering in total areas of approximately 330 ha and 24.5 ha, respectively. During this process, deforestation works, removal of the topsoil, removal of waste rock, transportation and disposal of waste to stockpiles in areas previously prepared and presented in section 2.1.

2.8.3.4. Waste Rock and Ore Stockpiles

This mining project contemplates the construction of two areas for disposal of the waste rock and two for the ore stockpiles, as shown in Map 2.1-2.

The selection of waste rock deposits was made in order to minimize the material transport path and ensure long-term stability. It was also considered to avoid possible interference with drainage systems or other infrastructure, such as roads and power lines. Likewise, one of the areas of ore stock is located next to the pit and the other next to the heaps, reducing the transport route of the material and the dispersion of particulate material and dust.

The construction of the waste rock deposits and ore stockpiles will start during the construction Phase, continuing during the operation, as the materials from the respective areas are being produced. In these areas, clearing and removal of the topsoil, construction of base drains and compacting the base or the areas will be carried out. The material of the topsoil will be stored for later use in revegetation actions.

The geometric design of the waste dumps provides for a maximum height of 100 m, a face angle of 30º and a bench height of 10 m.

The waste deposition will be done in an upward direction, in successive layers of small thickness, in such a way that it allows the transport and spreading equipment (trucks, tractors and motor graders) to pass, promoting the necessary compaction and ensuring the stability of the deposit.

In the waste rock deposits, drainage ditches will be built at the feet of the banks. The catchment boxes will be built in the lower parts, at the meeting of two ditches with slopes in opposite directions. From these boxes ditches will emerge about 2 m wide and 0.5 m deep, across the shoulders, up to the crest of the benches. These ditches will continue on the banks until they find the lower bench. The ditches will be filled with stones of different sizes which, in addition to preventing erosion, will have a semi-filtering function. The water from this drainage system will be directed to the predicted dykes containing fine solids, and, subsequently, to natural drainage.

As the waste slopes reach their final configurations, they will be covered with stocked topsoil and revegetated.

2.8.3.5. Heaps

The leaching heaps, located in the northern portion of the project (Map 2.1-2), will be constructed in an area prepared as the leach pad. This pad is composed (from bottom to top) by a low permeability protective layer (such as clay), an impermeable plastic coating (HDPE geomembrane), solution collection systems (tubes) and gravel.

The base of the pad will be constructed with a small slope in order to direct the leach solution to the solution collection ponds.

The crushed and agglomerated ore will be transported by a fixed belt conveyor and transferred to a series of mobile belt conveyors (known as "grasshoppers"), which are coupled to each other, composing a dynamic and flexible path, which allows the transport of the agglomerates to the various possible stacking points on the leaching area. The "grasshoppers" will take the ore to a radial stacker, which will constantly stack, forming a heap in the shape of a low-height pyramid

trunk (up to 4m) and a wide rectangular base, with a fixed width and increasing length, as the stack progresses along the pad.

The construction of the leaching heaps will start during the construction Phase, continuing during the operation, as the ore is being mined and the leaching processes are completed.

2.8.3.6. Residue Storage Area

To receive the solid residues from the process plant and the spent ore from the heaps after leaching, both in solid form with little humidity and low permeability, a residue storage facility will be constructed, adjacent to the heaps (Map 2.1-2). The storage area will be built on compacted soil and double lined (geomembrane on clay), with a drainage system that directs the percolated water to a containment pond (control measure).

A stabilizing berm will be built around the perimeter of the residue storage area and the containment area will be covered with HDPE geomembrane. The stability berm can be built with available waste rock.

It is worth noting that the construction guidelines presented here for this residue storage area represent a high commitment by PNM with operational and socio-environmental safety, as it includes preventive measures (compaction and lining of the soil) and control measures (drainage system and containment pond) adequate to the engineering needs for this structure, since the solid waste that will be stacked will have low humidity and a small propensity for liquid drainage.

2.8.4. Required Supplies for the Work

2.8.4.1. Fuel Supply

Fuel supply, vehicle washing, maintenance, oil change, tire repair and similar services will be carried out at the construction site or directed to the existing infrastructure in the municipalities closest to the project, as required and under the responsibility of the contracted companies. For earthmoving services, convoy trucks will be used to supply the machines in operation.

With the existence of a mobile fleet of equipment and light vehicles, it will be necessary to supply diesel and gasoline / ethanol fuel. Each contractor to be hired will be responsible for adequate storage and supply, observing CONAMA resolution nº 273/2000 and NBR 7505/2000.

2.8.4.2. Concrete Plant and Supply

The concrete plant (batch plant) will be installed in Brejo Seco and will be managed by the civil construction company for industrial works. This company must meet the demand for concrete and aggregates for the entire project, as from its mobilization.

The gravel to be used in the concrete will come from the Umbuzeiro limestone deposit. The plant should have a production capacity of approximately 40 m³ / h in order to meet the expected peak consumption of 4,500 m³ / month.

2.8.4.3. Aggregate

Umbuzeiro processing of aggregates is expected to be sufficient to meet the demands of civil works. For the leach pad, the gravel will be purchased from previously licensed local suppliers, given that the gravel from Umbuzeiro does not meet the specifications for dimensions and chemical resistance to sulfuric acid.

The aggregates will be stored in the area planned for the installation of the crushing and concrete plant, at the Brejo Seco site.

2.8.5. Required Utilities for the Works

2.8.5.1. Electrical Power

During the construction phase, the electricity supply to the Brejo Seco area will come from the existing distribution network that currently feeds the Demo Plant. It will be adapted, by cabling, to the new energy demand by the local energy company, Eletrobras. In Umbuzeiro, electric power for the construction site will be provided by diesel generators.

2.8.5.2. Water

Water will be used for human and general sanitary use, and to meet environmental control systems (sprinkling access roads and washing equipment and structures). The estimated consumption during the peak of the works, which has 1,875 employees, is 5.5 m³/h, considering consumption of 60L/day/employee, as established in NR 24 - Sanitary and Comfort Conditions in the Workplaces, and 10 L / day / employee for human consumption and meal preparation.

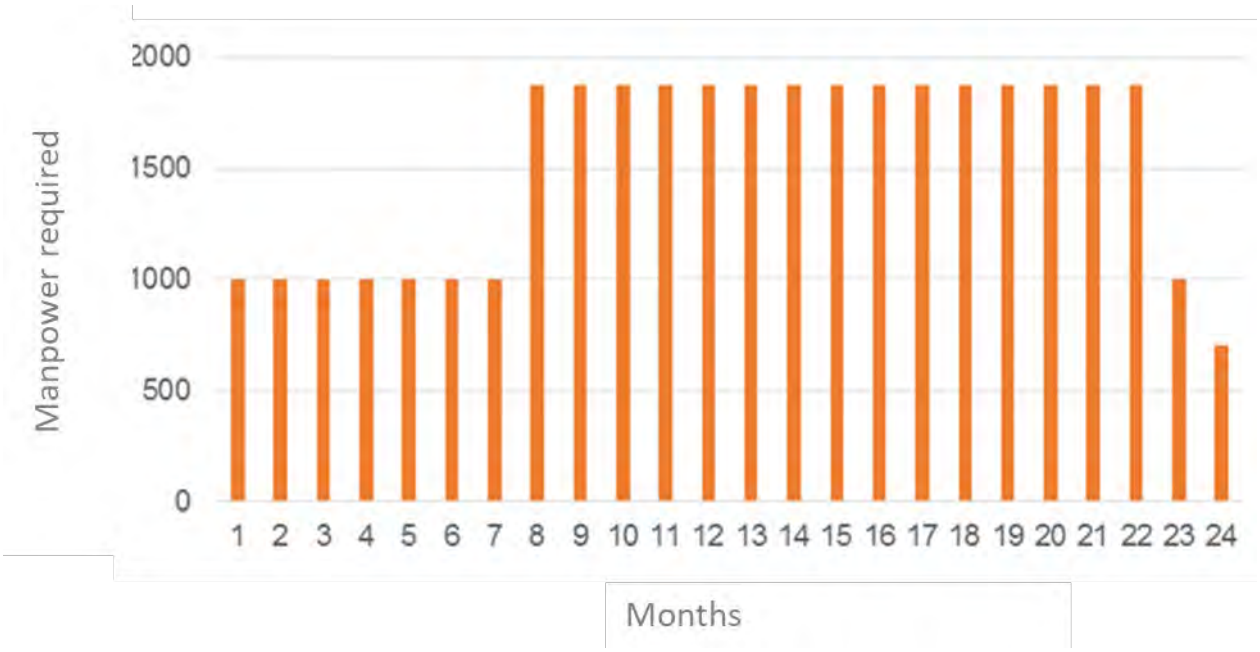
During the construction period, the water supply will be from water trucks and the capture from two boreholes that currently serve the Demo plant. The licenses for the use of these boreholes, authorize the flow rates of 2.5 m³/h and 2.0 m³/h and are valid until March 2019. If necessary, other boreholes can be used, once their licenses have been obtained.

2.8.6. Labor for Construction

For the construction phase, with an estimated duration of two years, a peak labor force of up to 1,875 workers is expected. PNM is committed and will make every effort to prioritize the hiring of local labor during the construction phase of the project. In the current phase of development of this project, it is estimated that it will be possible to find about 30% of the workforce needed locally, depending on the availability of interested people and their minimum technical qualification to meet the different work demands of the project. .

The histogram foreseen for labor in the Construction Phase is shown in Figure 2.8-2.

Figure 2.8-2 – Construction Phase Histogram of Manpower.



Source: PNM, 2017.

2.8.7. Removal of Temporary Structures

After the completion of the construction works, all the provisional installations and buildings used in the Brejo Seco and Umbuzeiro construction sites will be removed. This step involves cleaning and finishing works of the work areas and permanent structures, and the removal of debris and unserviceable materials.

All residues generated from the removal of temporary structures will be temporarily stored and disposed of in accordance with the standards ABNT NBR 10.004 / 2004, NBR 12.235 / 1992, NBR 7.500 / 2011 and NBR 13.221 / 2007.

2.8.8. Control System

2.8.8.1. Effluents

The main effluent emissions planned for the construction of the Piauí Nickel Project are rainwater drainage, oily effluents and sanitary effluents.

Rainwater drainage is basically characterized by the incidence of rainfall over exposed areas and over those with exposed disaggregated material.

The oily effluents foreseen for the construction phase of the project should be those from the vehicle and equipment maintenance workshops where activities such as oil change, maintenance and washing of vehicles and equipment will take place.

The sanitary/domestic effluents, on the other hand, will come from the cafeteria and sanitary facilities (bathrooms and changing rooms) by the workers involved with the works in general. Sanitary effluents and wastewater will be generated in all areas where people circulate, especially at the construction sites.

Table 2.8-1 presents the main sources of emission of liquid effluents in the construction phase of the project.

Table 2.8-1 – Analysis of effluent emissions foreseen in the construction phase of the Piauí Nickel Project.

Type of effluent	Source	Principal Characteristics	Proposed environmental control system
Rainwater Drainage	Cuts and landfills in general Access Roads Maneuvering and parking areas Construction site area	Effluent basically characterized by water and sediments from soil breakdown where there is an impact of rain on unprotected surfaces such as roads, accesses, embankments and other areas without vegetation cover. Sediment transport via surface runoff to the bottom of valleys where the water bodies are located.	Use of an efficient drainage system in the access areas and construction site. The drainage system must consist of adequate devices for collecting and controlling rainwater until its final disposal in natural drains. In general, channels are built that will lead the flow of water to manholes and concrete water channels until its final disposal in the natural land in a controlled manner, without creating concentrated flows. Vegetation recovery of exposed areas. Controlled deforestation of the areas necessary for the works (removal by blocks). Avoid removing vegetation beyond that specified in the project, even if authorized.

Type of effluent	Source	Principal Characteristics	Proposed environmental control system
Oily Effluents	Workshop / Washer / Construction Site Lubrication Area Storage areas for oils and lubricants (risk of leakage / spillage)	Effluents characterized mainly by water, oils and greases, sediments and cleaning products in general from vehicles and equipment maintenance areas where there will be activities such as oil change, maintenance and washing. Effluents composed of fuels and lubricants in the supply areas subject to the risk of leaks and possible spills.	Use of containment boxes and impermeable floors around tanks and other fuel and lubricant storage devices. Waterproofing the floor of areas where maintenance and washing activities for equipment and parts will be carried out. Use of solids decanting boxes and water-oil separators.
Sanitary/ domestic effluents	Construction site Service areas at specific points on the site Accommodation for employees	Effluents from the use of kitchen and sanitary facilities (fixed and mobile toilets, and changing rooms) by workers in the construction works.	In the initial installation phase of the construction site, the septic tank and anaerobic filter systems will be built, which will be used both in the construction phase of the project and in the operation phase. The final treated effluent will be released into the natural drainage, permitted. Use of a fat box for effluents from the cafeteria.

2.8.8.2. Solid Wastes

The generation of waste during the construction phase is mainly related to civil works, with solid waste containing oils and greases, paints, packaging and construction waste (masonry, cement, gravel, etc.), generated mainly in the assembly of building structure type components of the project, as well as the decommissioning of the construction site. In addition, there will be the generation of domestic waste at the construction site, by the employees who will participate in the works.

The solid residues foreseen for the construction phase will be all those solid or semi-solid residues, resulting from the activities to be developed both inside the construction sites and those carried out outside these locations.

Table 2.8-2 presents a general analysis of the main residues planned for the construction phase of the mining-processing complex.

Table 2.8-2 – Analysis of the generation of solid waste foreseen in the construction phase of the Piauí Nickel Project.

Type of residue	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Non-inert / hazardous waste in general	Class I	They will be generated in several areas of the project. They are those that can bring some environmental risk, for example, acid batteries, fluorescent lamps, batteries, packaging and residues of chemical reagents, for example.	These wastes will be stored and disposed of properly in accordance with the procedures established in the Waste Management Program to be prepared in the future.
Oily residues	Class I	The lubricating oil and grease used, after the planned changes, in the engines of the machines and trucks, generated in the maintenance workshops.	The oil must be collected in drums, with a hermetically closed lid, and must be safely stored until it is transported for re-refining with a certified company. In these drums, all the waste to be collected routinely from the water / oil separator box should also be stored. The floor of the workshop will be waterproof, and should be kept free of cracks that may allow percolation of this residue.
Waste contaminated with oil and grease	Class I	Waste generated in the vehicle and equipment maintenance workshop.	These wastes will be properly classified and sent to duly licensed controlled landfills, in accordance with standard NBR10.004.
Hazardous decommissioning wastes	Class I	Wastes basically composed of contaminated materials, oil residues, greases, other chemical substances, heavy metals, etc., resulting from the decommissioning of the construction site.	These wastes will be properly classified and sent to duly licensed controlled landfills, in accordance with standard NBR10.004.

Type of residue	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Medical waste	Class I	These will be generated at the construction site medical/first aid room. It will generate a small amount of waste classified as hazardous.	The packaging of the waste will be in “Sharps” segregation boxes, suitable for sharp or cutting materials, which will be sent to the correct final destination. The storage will be in an appropriate place, adjacent to the clinic, in a white PVC wheeled drum, with a lid, locked with the keys under the responsibility of the responsible health professional. The packaging, internal and external collection containers, internal and external transport containers, and in the waste storage locations must be properly identified and in easy-to-see locations, using symbols, colors and phrases, meeting the parameters referenced in the Standards ABNT NBR 12809/1993 and NBR 7500/11.
Canteen waste, domestic and industrial	Class I & II	In the cafeteria, organic waste, plastics, glass, wood and packaging in general will be generated. In the administrative and operational areas, there will be the generation of other types of recyclable waste such as ferrous and non-ferrous scrap, glass, plastics, rubbers; and non-	For recyclable waste, the implementation of a selective collection system and reuse of waste generated in the various areas is planned. To this end, the Solid Waste Management Program should systematically assess the points of generation and types of waste, thus allowing for better planning and adoption of measures to optimize

Type of residue	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
		recyclables, mainly from equipment and plant maintenance activities, and even from the demobilization of the construction site.	resources, reduce waste generation and define final destinations for each type of waste. Non-recyclable waste will be duly conditioned temporarily and periodically sent to final destination. Organic waste consisting of food scraps and leftovers will be sent to a controlled / sanitary landfill, or planned for composting.
Deforestation waste	Class II A	Vegetation removal areas	Temporary storage to wait for the appropriate final destination as defined in the Deforestation Plan.
Organic soil waste	Class II A	In areas where foundation preparation and land regularization with earthwork will be necessary, the topsoil will be removed.	The topsoil of the organic soil will be removed and transported for temporary storage in a previously defined location to be used later together with the remains of the removed vegetation in the recovery of degraded areas.

Type of residue	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Waste from civil works and electromechanical assembly	Class II B	Assembly of the project's structures or the decommissioning of the construction site. The waste from civil works will consist basically of rubble, remains of concrete or similar material, forms of wood, bags of cement, etc..	They will be temporarily stored in the yard and buckets, and then destined for landfills/ controlled areas. Wooden material can be donated for reuse. The packaging materials for equipment, leftovers and various shavings of electromechanical assembly will be segregated as to the type of waste, recyclable and non-recyclable, for later reuse.
Sanitary and sweeping wastes	Class II A	These will be generated in several areas where there is a circulation of personnel. They will consist of toilet paper, common sweeping garbage, prunings of vegetation and sludge from septic tanks and waste from chemical toilets.	These residues will be sent to the sanitary / controlled landfill, or destined for composting. Waste from septic tanks and chemical toilets will be collected by a specialized company licensed for this purpose.
Waste Rock (mine)	Class II B	This is the overburden generated in the mine stripping.	This waste will be disposed of in the waste dumps near the mine pit.

2.8.8.3. Atmospheric emissions

The main atmospheric emissions planned for the project's construction works are limited to particulate emissions and gaseous emissions.

The most likely particulate emissions for the construction of the project under study would be in the form of dust and soot. Dust, originating from the mechanical breakdown of materials, should be the main source of particulates in the project and will be generated mainly by traffic of vehicles and equipment, cargo transportation and by the operations of modification of accesses and earthworks. Soot, on the other hand, will come from the exhaust of vehicles and equipment in operation.

Gaseous emissions will basically consist of gases such as carbon oxides (CO and CO_2), nitrogen oxides (NOx), sulfur oxides (SOx) and hydrocarbons, from the operation of light and heavy vehicles (automobiles, vans, trucks, etc.), light and heavy equipment (compressors, excavators, loaders, etc.) that use engines based on the burning of fossil fuels as the driving force.

Table 2.8-3 presents an analysis of the projected atmospheric emissions for the project.

Table 2.8-3 – Analysis of atmospheric emissions foreseen in the construction - fixed and mobile sources.

Type of Emission	Sources	Principal Characteristics	Proposed environmental control system
Particulate Material	Operation of cut and landfill in general Opening of accesses Opening of areas for construction sites and service areas Mine stripping Truck loading operation Transport of disaggregated material Handling of light and heavy vehicles	Particulate material in the form of dust due to the generation of material broken down mechanically by heavy equipment, transportation of disaggregated material and due to the movement of vehicles and equipment on roads and accesses. These particles are released into the atmosphere by the action of the wind and the movement of vehicles and equipment. Generation of smoke from the combustion engines of vehicles and equipment.	Use of sensible sprinkling via water truck in all exposed areas that are created, whenever necessary. Vegetation covering of exposed areas as soon as they are released. Adoption of a periodic maintenance program for fixed equipment. Use of new or good condition equipment and vehicles, regulated according to the manufacturer's instructions. During transportation, cargo should be protected by tarpaulin, when possible and appropriate. Reduce the speed of travel at points with the highest concentration of disaggregated material. Application of an efficient vehicle traffic plan and periodic equipment maintenance.

Type of Emission	Sources	Principal Characteristics	Proposed environmental control system
Gaseous	Compressor operation Operation of light and heavy vehicles Light and heavy equipment operation	Gaseous emissions characterized by gases such as carbon monoxide and dioxide, nitrous oxide, hydrocarbons, sulfur oxides, etc. generated from the burning of fossil fuels for the operation of equipment and vehicles..	Adoption of a periodic maintenance program for this equipment and vehicles. Use of new or in good condition equipment, regulated according to the manufacturer's instructions.

Source: Arcadis, 2017.

2.8.8.4. Noise and Vibration

The main sources of noise and vibration emissions planned for the construction phase of the Piauí Nickel Project will be:

- Handling and operation of equipment;
- Electromechanical assembly of structures;
- Civil works in general;
- Operation of compressors;

The movement and operation of heavy equipment, mainly in the activities of modifications and opening of accesses, preliminary services, earthworks, mine stripping and the start of construction of the waste dumps and stockpiles, will be an important source of noise and vibration emissions on the ground. This is due to the traffic of loaded heavy trucks, excavation and landfill operations, loading and unloading of material, in addition to clearing and regularizing the terrain.

The electromechanical assembly of the structures will emit noise from the use of electric or manual drilling, cutting, grinding, impact tools, for example.

Civil works, in general, will also depend on the use of tools and equipment for assembling concrete structures.

The operation of compressors, necessary in this phase for the generation of compressed air and electricity, will emit noise that cannot be completely eliminated.

Table 2.8-4 shows an analysis of the sources of noise and vibrations expected for the construction of the project.

Table 2.8-4 – Analysis of noise and vibration emissions foreseen in the construction - mobile and fixed sources.

Type of Emission	Sources	Principal Characteristics	Proposed environmental control system
Noise	Handling and operation of light and heavy vehicles Compressor operation Electromechanical assemblies and civil works	Noises caused mainly by the operation of engines and, secondarily, by friction between moving parts of the equipment and friction against the ground / rock. Noises generated from the assembly of structures and equipment from sectors such as process plant, operational and administrative support area.	For compressors: use of new equipment and adoption of a maintenance program for equipment of this nature. In extreme cases, enclosure of the equipment is suggested. For assembly works: use of new and regulated manual equipment and adoption of a maintenance program for these equipment. Occupational noise should be controlled with the use of PPE. There is no way to eliminate noise completely. But it can be mitigated by adopting an efficient vehicle and equipment maintenance program and using them in good condition.
Vibration	Handling and operation of heavy vehicles and equipment	Vibrations caused due to the weight of vehicles and heavy equipment being transferred by roads and accesses.	Vibrations can be attenuated through the adoption of a traffic planning program, and maintenance of vehicles and heavy equipment focusing on alignment, balancing, replacement of defective parts, tightening of loose parts, etc..

Source: Arcadis, 2017.

2.8.9. Construction Schedule

The construction schedule includes all the tasks planned for the construction of the project, including the planning of the works, as presented in Table 2.8-5.

24 months of construction are foreseen, from the construction of the support infrastructures to the completion of construction work for the mineral-processing complex.

The first works to start are the opening of access roads to the project and modification of the electrical distribution network based on the structure that currently feeds the Demo plant.

Finally, the construction of the Jenipapo Pipeline, the LT 69kV, the Nickel mine, the leach pad area, the process plant, and the limestone quarry in Umbuzeiro are initiated. The acid plant will be the last unit to be completed, and it will be prefabricated externally to the site by a third-party supplier to be contracted.

Table 2.8-5 – Construction schedule for the Piauí Nickel Project (Months).

Structure	Year 1												Year 2											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Support Infrastructure																								
Site access road																								
Low voltage electricity connection																								
Construction Building sites / camp																								
Water pipeline (Jenipapo)																								
69kV Transmission Line																								
Nickel Mine – Brejo Seco																								
Land clearing and earthworks																								
Mine roads development																								
Run-off & Env. control structures																								
Waste dump preparation																								
Crusher and commissioning																								
Pre-stripping																								
Heap Leach Pad																								
Land clearing and earthworks																								
Civil works																								
Electrical and Mechanical Installation																								
Initial Irrigation Piping																								
Limestone Quarry - Umbuzeiro																								
Access roads																								
Land clearing and earthworks																								
Civil works																								
Electrical and Mechanical Installation																								
Pre-stripping																								
Hydrometallurgical plant																								
Land clearing and earthworks																								
Civil works																								
Electrical and Mechanical Installation																								
Commissioning																								
Acid Plant																								
Long-lead item fabrication (external)																								
Erection at site																								

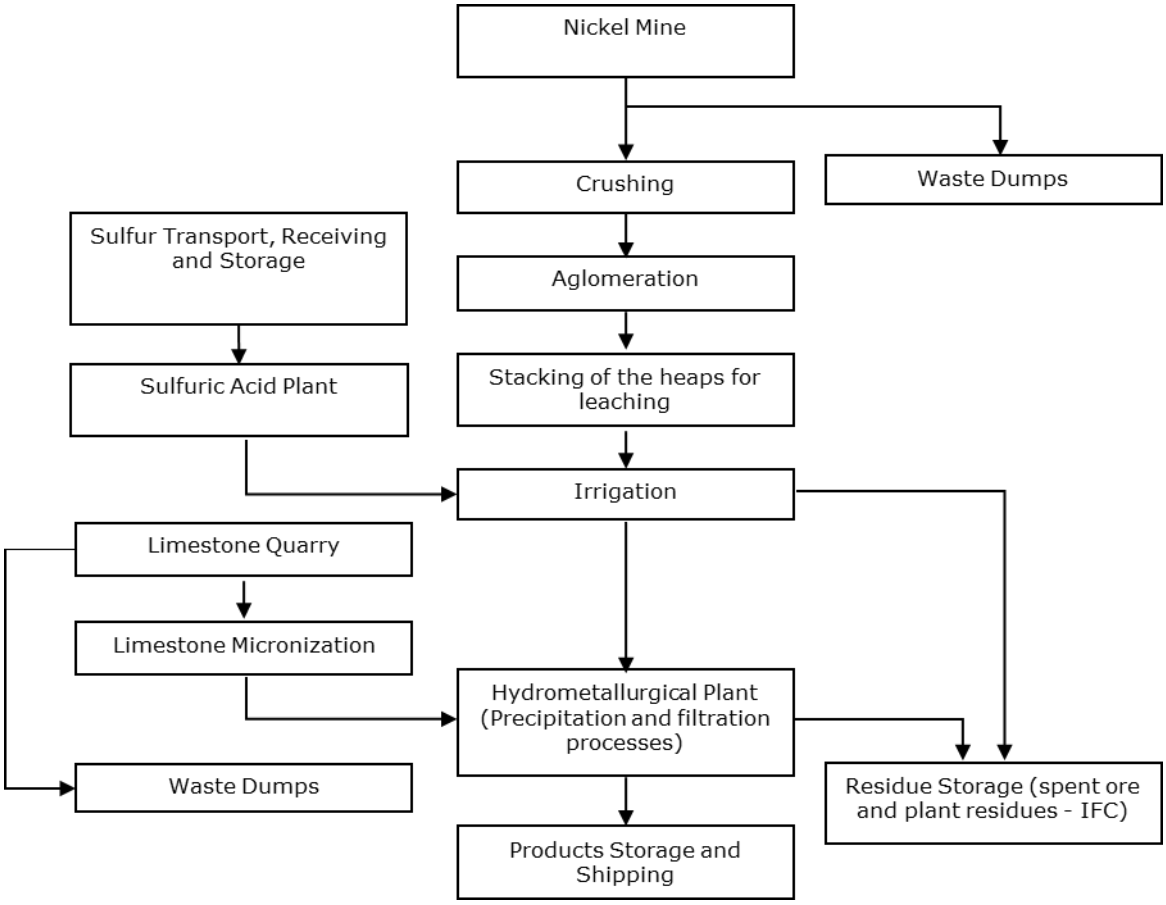
Source: PNM 2017

2.9. Operational Phase

The Piauí Nickel Project consists of the operation of the Mine-processing Complex on the Brejo Seco hill (mining and processing of nickel and cobalt) in the municipality of Capitão Gervásio Oliveira, and in the location known as Umbuzeiro (mining and processing of limestone), in the municipality of Dom Inocêncio.

Figure 2.9-1 outlines the block diagram of the main activities involved in the operation of the nickel mine and processing plant, and of the limestone quarry, characterized by the activities of exploitation and processing of nickel ore, formation of the leaching heaps, hydrometallurgy for the precipitation of metals, sulfuric acid manufacturing and mining and limestone crushing. These activities are detailed in the subsequent sections.

Figure 2.9-1 – Block Diagram of the Activities of the Proposed Project.



In addition to the activities mentioned in Figure 2.9-1, the utilities structures for the operation are also described below, such as the capture and supply of water from the Jenipapo Dam, a 69kV electric power transmission line, and the units responsible for supplying the necessary infrastructure for the project, comprising offices, restaurants and cafeterias, various workshops, among other items.

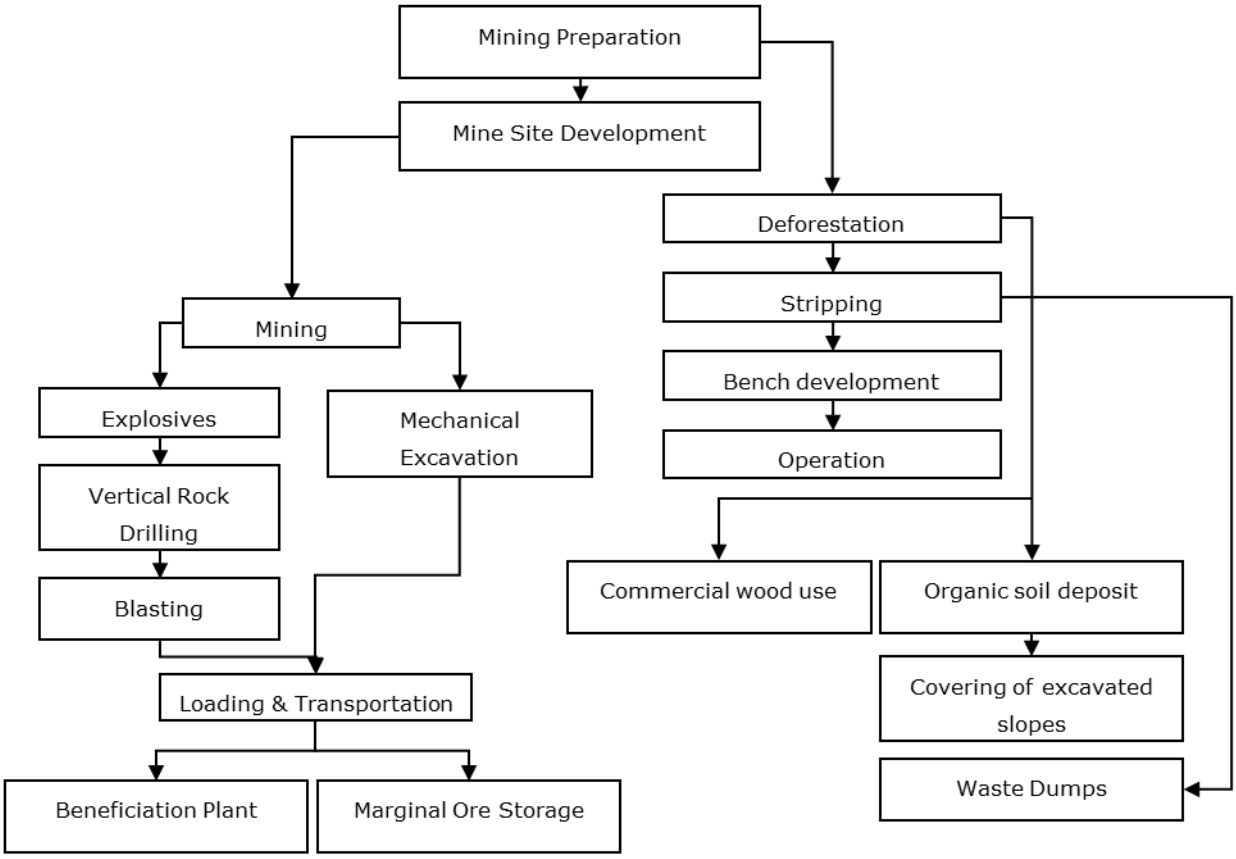
Finally, the environmental quality control measures are detailed, to be implemented and operated together with the support units. These measures include a water treatment plant, particulate matter emission control systems, gas emission control systems, noise and vibration emission control systems, sanitary sewage treatment systems, water and oil separators, systems and sediment containment dykes, drainage systems in general, intermediate and final deposits of waste and others.

2.9.1. Nickel Mine

The nickel ore will be extracted from the future Brejo Seco mine, which will then feed the crushing plant which in turn feeds the processing plant where the final product will be obtained.

The details of extraction, processing and auxiliary activities around the mining are presented in the Figure 2.9-2, as follows.

Figure 2.9-2 – Block Diagram of Nickel Ore Mining Activities.



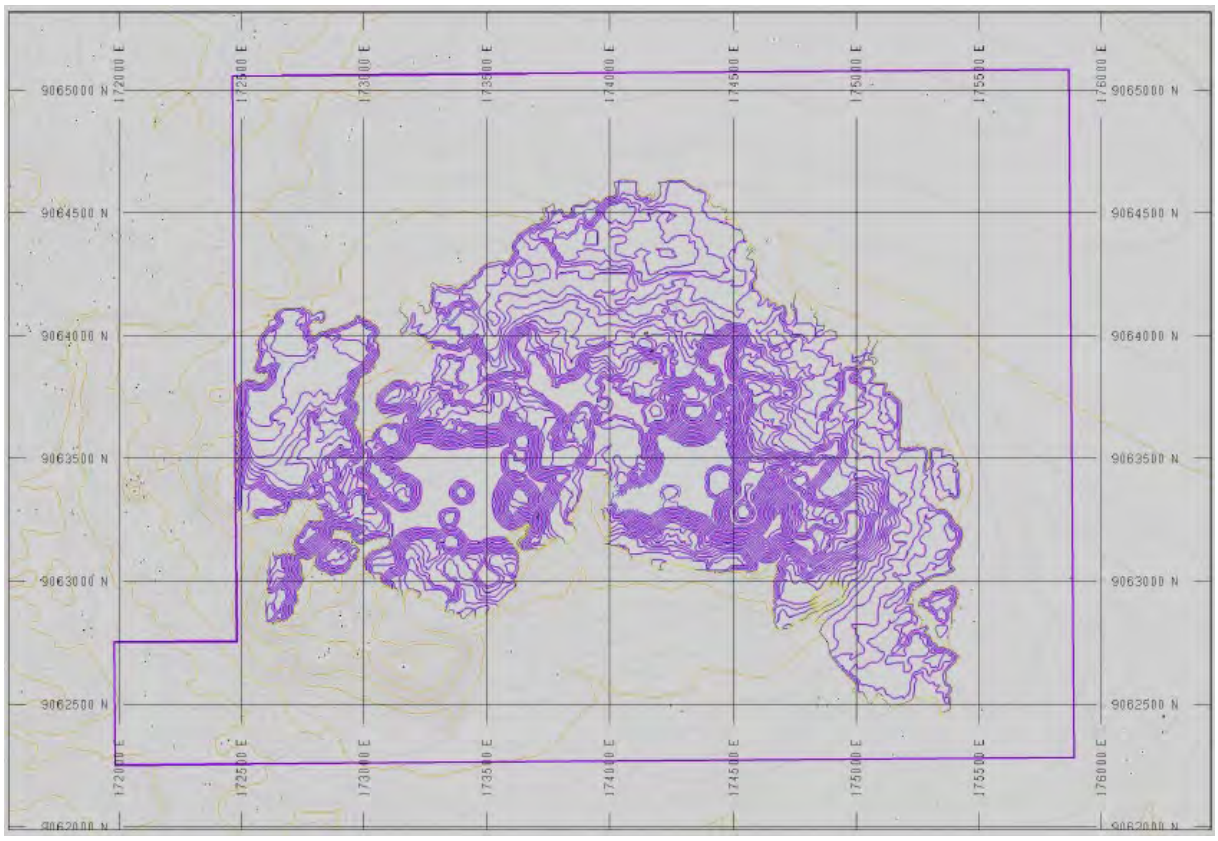
2.9.1.1. Mine Plan

The deposit corresponds to an elevation in the form of a plateau, where the weathered and mineralized nickel portion will be mined, up to the level close to that of the surrounding topography. Mining will take place in succession from the top to the bottom of the deposit.

The final pit was defined using the Whittle 4D ® software, a system aimed at determining pit optimization, by the company CSA Global. The basis used for the optimization was the block

model and the respective resource inventory. For the purpose of mining planning, the deposit was split into blocks of 12.5 m x 12.5 m x 3 m, the only criterion for determining ore being nickel above the limit (0.6%). Figure 2.9-3 shows the contours of the resulting final pit.

Figure 2.9-3 – Final Pit - Brejo Seco Complex.



Source: PNM, 2017.

The mining schedule was then adjusted by PNM, based on a mining rate of 3 million dry tonnes per year (ROM), so that not only high quality nickel is extracted in the first years. In addition, adjustments were also made to maintain a more or less constant rate over the life of the mine, thus facilitating the selection of the mining fleet and the number of equipment.

The mining consists of removing the upper portion of the hill that constitutes the nickel deposit, so that, at the end of its useful life, there will be few places left in the form a pit. It is expected that the level of the water table will not be reached, since, according to the report on the stability analysis of the slopes of the nickel pit, prepared by BVP Engenharia (2009), the water level was not identified in the surveys analyzed in the mining area, even in those with great penetration (85-95m). These geometry conditions simplify drainage solutions in the mine area.

In order to prevent rainwater from entering mining areas, diversion channels will be constructed around these areas, which will direct the water to sediment containment dikes and, subsequently, to natural drains.

In some places where small pits are formed, rainwater will be directed to open tanks at suitable points, from where they will be pumped, by means of diesel pump sets, to the sediment containment dikes and then directed to the natural drains.

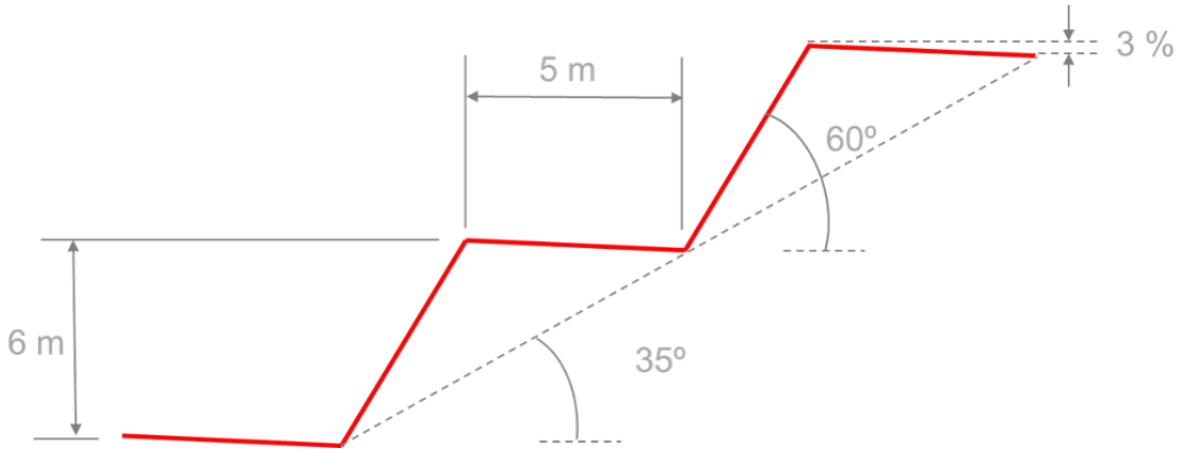
The pit design was made using the parameters shown in the Table 2.9-1, as outlined in the Figure 2.9-4.

Table 2.9-1 – Parameters for Pit Design - Nickel Mine.

Parameters	Unit	Value
Bench Height	m	6
Angle of Inclination of the Face	Degrees	60
Global slope angle	Degrees	35
Edge width on the final slope	m	5
Berm gradient (transverse)	%	3
Berm gradient (longitudinal)	%	1
Minimum dimension of pit base	m	40
Road width	m	10
Access ramp gradient	%	8

Source: PNM, 2017.

Figure 2.9-4 – Typical Geometry of the Pit Construction.



Source: PNM, 2017.

A) Activity Planning and Mine Preparation

The extraction of ore will not require much attention in terms of mining planning and inventory management, since unit operations are those characteristics of open pit mining, described in this section.

Mining operations must rely on auxiliary services, such as tracked excavators, wheeled excavators, motor graders, irrigation tanker trucks, wheel loaders, lubrication trucks, support vehicles and other smaller equipment.

Deforestation operations will be carried out by bull dozers and chainsaw. The wood will be marked and separated for commercial use. The trunks and roots will be cut and removed to the edges of the clearing areas or to areas already cleared. Topsoil, branches and roots will be stored for later removal. This material will be provisionally stored in the stockpile area to the northeast of the nickel pit. (Map 2.1-2), to then be used to recover mined out areas.

B) Mining

Excavation and loading operations will be carried out with hydraulic excavators, which will load dump trucks. These will transport the material to its respective destinations: primary crushing, marginal ore stockpile or waste rock dumps.

The mining of the deposit consists of the removal of the part comprised of the weathering mantle. Thus, part of the material, both waste and ore, will be removed with hydraulic excavators, without the need for prior blasting using explosives.

Due to the physical characteristics of the material, it is estimated that about 10% of the total volume of the deposit will require blasting with explosives. Information about the Fire Plan and use of explosives can be found in section 5.1.10 of Volume II.

a) Fire Plan for the Blasting of Nickel Ore

The material that will require the use of explosives for blasting consists of (i) a more siliceous portion; (ii) less weathered portion (at the base of the deposit) and (iii) parcels interspersed within the deposit. Thus, the fire plan should vary from one location to another, depending on the type of material, structure, geometry and humidity of the holes. The fire plan of the project will be adjusted and adapted at the time of its execution, according to the conditions found in the field.

The drilling will be vertical, made with electro-hydraulic equipment, with a diameter of 76 mm. The holes will be loaded with heavy ANFO type explosives or explosive emulsion, depending on the moisture condition of the hole.

The holes will be loaded with a truck adapted for the preparation and loading of explosives. Eventually, emulsified explosives may be used, arranged in cartridges.

To detonate the load of the holes, non-electric fuses will be used, initiated by detonating cord and fuse.

Information about the Fire Plan and use of explosives provided for is presented in section 5.1.10 of Volume II, together with the simulation carried out to assess potential levels of Vibration and Acoustic Overpressure arising from the use of explosives in the Nickel and Limestone mines.

2.9.1.2. Mine Sequencing

The strategy of sequencing the mining was used, that is, advancing the mining in relation to the leaching and feeding of the plant, building the heaps with the best material available at the moment - the one with the greatest economic benefit, considering the revenues and expenses - and

stockpiling the marginal ore surpluses of lesser benefit to feed the heaps in later periods of the operation. This strategy is common in low grade deposits such as nickel laterites.

The storage of ores in different stockpiles with different average nickel contents and the storage of marginal ore, also in stockpiles, in the initial years of the project, allows the optimization of the cut content, by maximizing the feed content of the plant. The strategy also allows to manage acid consumption, which must remain constant.

For mine planning and sequencing, annual intervals compatible with the current knowledge of the deposit and the degree of definition of the engineering project were used. In future stages, short-term actions will be simulated, with shorter intervals.

The average annual production will be three million dry metric tonnes of ore mined and processed and production of around 24,500 tonnes of nickel contained in an intermediate product of nickel hydroxide (NHP). In the first year of mining operations, the required ore production rate will be 1,050,000 tonnes to allow the heaps to start the operating ramp up.

For the conditions studied, the useful life of the project will be 17.6 years.

Table 2.9-2 shows the results of the production sequencing and the movement profile is shown in Figure 2.9-5.

Table 2.9-2 – Optimized Mine Production Schedule.

Production	Year																		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
Ore (kt) [1]	1,050	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	1,477	50,527
Waste (kt) [1]	2,725	5,450	5,450	5,450	5,450	5,450	5,450	5,450	5,450	5,450	5,450	5,450	5,450	5,450	5,450	4,844			83,869
Ni (%)	1.29	1.30	1.24	1.09	1.11	1.06	0.97	0.97	1.02	1.03	0.96	0.90	0.96	1.02	1.01	1.04	1.14	1.12	1.06
Co (%)	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.05	0.05	0.05
Al (%)	20.70	21.50	22.10	17.60	18.90	21.40	18.60	18.40	22.10	22.80	20.60	17.20	19.10	18.20	17.10	21.70	23.70	23.70	20.20
Cr (%)	1.80	1.80	2.00	2.20	2.10	1.90	2.40	2.30	1.90	2.10	1.90	2.50	2.10	2.10	2.30	2.00	1.80	1.80	2.10
Fe2O3 (%)	18.80	18.30	17.20	18.40	18.20	17.60	17.90	17.90	17.70	17.80	17.60	17.60	17.40	17.50	17.80	17.10	17.30	17.30	17.70
MgO (%)	10.30	10.60	11.40	11.00	11.60	10.90	10.90	11.00	11.50	11.20	11.00	10.80	11.60	12.10	12.00	11.10	11.40	11.40	11.20
MnO (%)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
SiO2 (%)	47.00	46.70	46.30	47.70	46.80	47.20	47.30	47.60	46.40	45.60	47.60	47.60	47.20	47.20	47.40	47.10	45.90	45.90	46.90

1 = 1 thousand dry metric tonnes.
Source: Piauí Níquel, 2017.

Figure 2.9-5 – Mine Material Movement - Composition.

Source: Piauí Níquel, 2017. Prepared by: Arcadis, 2017.

2.9.1.3. Mining Support Structures

A) Waste Rock Dumps

The waste will be removed at the rate necessary for the exposure of the ore that will feed the leach pad. The waste will be disposed of in two stockpiles, one NW and the other SE of the ore deposit (Map 2.1-2), with 61.98 ha and 33.23 ha respectively. The construction and maintenance methodologies were described in section 2.8.3.4.

B) Ore Stockpiles

The mining is advanced in relation to the leaching process, making it necessary to have intermediate stockpiles, formed by marginal material which will feed the process plant in the later years of the operation.

Two areas are planned for ore stockpiles, as shown in Map 2.1-2 and section 2.1, the first is located northeast of the mine with 115.39 ha, in order to facilitate the shortest distance for transfer of material. The second storage area will be installed near the leach solution ponds, with an area of 9 ha. Stockpile areas will have the same geotechnical criteria and parameters as the waste dump.

C) Drainage

The drainage system provides for intercepting channels around the active mining areas (waste disposal and ROM stockpile areas) to better direct rainwater away from the operational areas,

minimizing erosion and transport of fine material washing to adjacent areas. The channels will be excavated with a positive slope of 3%, with manholes placed in strategic locations.

The rainwater from the mine and from the waste disposal areas will be channeled through these ditches to sedimentation tanks where it will be decanted and filtered. 4 sedimentation dikes will be built at each site with adequate dimensions to allow sufficient decantation, depending on the drainage characteristics of the site. These dikes were positioned as close as possible to the locations related to mining operations to reduce the size of the excavation and ensure water control in the respective channels.

D) Workshops

Maintenance services will take place in covered and properly waterproofed areas, preventing contamination of the soil with oils and greases. Due to the system adopted for maintenance and the location of the central maintenance workshop, mobile equipment will only be moved to that workshop in case of heavy maintenance or preventive interventions, which represent more than one day of equipment shutdown. For other situations, mobile equipment was provided to service all equipment in the mine in the field, as described below:

- Lubrication tankers: these vehicles will have the function of periodically topping up the levels of lubricating oil, hydraulic oil, cooling water and greases from the centralized lubrication systems of all equipment in the mine; they will also check and calibrate the tires of off-road trucks;
- Trucks with mobile workshop: these vehicles have tools for minor repairs (corrective maintenance) to be carried out in the field for the mining equipment; they will be able to carry out repairs on welding, hydraulic and compressed air pipes and hoses, as well as replacing light parts;
- Water supply for the irrigation truck: the irrigation tanker trucks will have their water supply at a service point located close to the main pit access, in a position that will allow gravity supply from the mine water reservoir.

It is planned that the checks and controls will be daily. The problems related to changing tires will be attended to at the central workshop. The central workshop will also have a welding area, maintenance unit, lubrication compartment, and an equipment inspection compartment.

The workshop will be equipped with power points, water and compressed air distribution lines. The workshop floor will have a smooth non-slip finish to reduce any accumulation of fuels, lubricants and greases.

There will be a reinforced concrete floor designed to support the weight of the largest excavator in the mine, in addition to having drains to collect used oil.

E) Explosives Plant / Warehouse

At this stage of the project's development, the construction and operation of a small explosives factory is expected to meet the blasting needs of the Nickel mine and the limestone quarry in Umbuzeiro. However, it is important to note that after the development of the detailed mining and engineering plans for the 2 mines for the next stage of environmental licensing for this project, and due to the small amount currently expected of blasting of rocks using explosives from the 2 mines,

there is a possibility that the factory may not be necessary and can therefore be replaced by an explosives storage warehouse (a scenario with less socio-environmental risk).

The currently planned explosives plant will be located south of the mine and west of the controlled waste rock dump, as shown in Map 2.1-2. The plant will have separate buildings for the storage of cartons, fuses and accessories. The entire area will be surrounded, with a guardhouse to control the entry and exit of personnel.

The buildings will be built according to the rules of the Ministry of the Brazilian Army, regarding the materials used, protection barriers and safety distances.

For the next stage of licensing, a Risk Analysis Study should be carried out, taking into account the details of the operation of the Explosives Plant (or storage warehouse).

F) Fuel Installations

Trucks and other mobile equipment will be refueled at the installation / filling station. Excavators, drills, loaders and lighting vehicles will be refueled by tanker trucks and lubricated at their workplace.

G) Washing of Tires

The distribution and size of the tire wash compartment are dictated by the largest existing tire size, which will be that of the 50t loader with standard 35 / 65R33 tires. This location will be built next to the workshop and will also be used for the storage of spare parts and tools, connected to the plant's compressed air distribution system.

H) Vehicle Wash Station

The vehicle washing site will consist of a concrete platform controlling the draining of the washing effluent into an oil and water separation system. The area will be equipped with high flow water hoses on both sides.

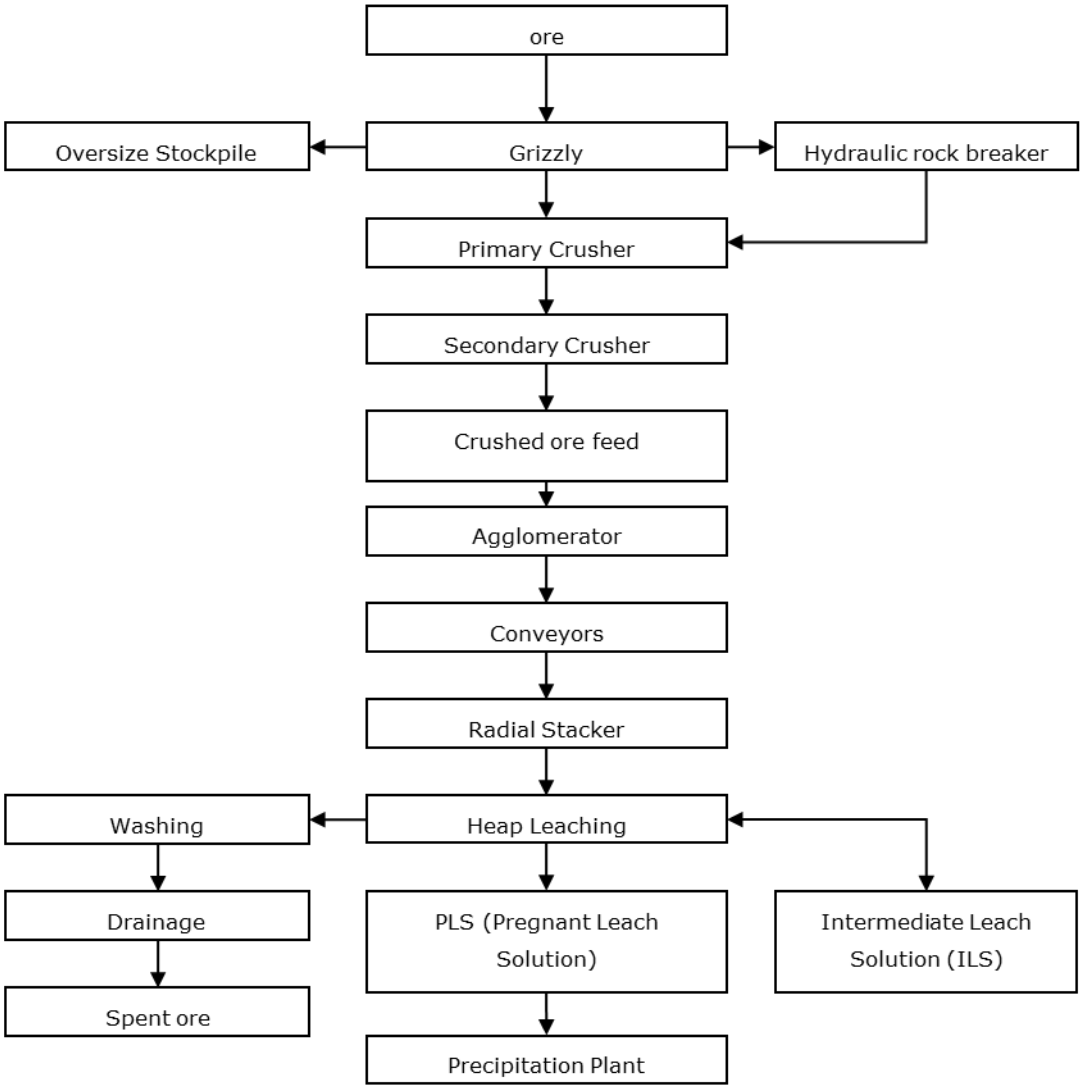
2.9.2. Nickel Ore Processing

The processing of ore from the Piauí Nickel Project with an average content of 1.076% nickel aims to produce 100,000 tonnes per year of hydroxide precipitate.

The selected process route for obtaining the final nickel intermediate consists of a physical treatment of the ROM, a hydrometallurgical step of sulfuric leaching in heaps followed by various steps of removing impurities through precipitation, as Figure 2.9-6.

In the sequence, the activities of crushing, agglomeration and heap leaching will be described.

Figure 2.9-6 – Block Diagram of Nickel Ore Processing.



Source: PNM, 2017.

2.9.2.1. Ore Preparation - Crushing

The mined ore will be crushed in two stages, in order to adjust the maximum size of the particles to optimize the extraction in leaching.

The ore, from the mine or from stockpiles, will be discharged directly into a fixed grizzly. The material retained on the grizzly will be broken with the help of a hydraulic rock breaker. In the case of being waste or very hard material, it will be rejected. This material will later be transported by front end loader and truck to the waste dumps.

A conveyor will feed the first crushing stage, consisting of a toothed roller crusher, or sizer, generating a material with a maximum size of 200 mm. The product of this crusher will feed, by gravity, a second crushing stage, consisting of one or two secondary toothed roller crushers.

The crushed material, with a maximum size of 70 mm, will be conveyed to the ore agglomeration stage.

2.9.2.2. Agglomeration

The agglomeration stage consists of the formation of agglomerates by joining of fine and coarse particles of the ore with the addition of process water and sulfuric acid solution. When stacked, these wet agglomerates produce a bed highly permeable to the leaching solution, favoring the leaching of the ore in the next step, in addition to providing stability to the heaps.

The ore previously crushed to a particle size of less than 70 mm will be discharged into the feed silo of the agglomerator drum, a cylindrical rotating drum made of carbon steel, coated with a material resistant to sulfuric acid (Figure 2.9-7 to Figure 2.9-9). The feeder belts are equipped with speed variators and scales that will keep the agglomerator drum feeding rate as stable as possible. The drum will be dimensioned with sufficient volume to allow a residence time within the agglomerator of around three minutes.

Figure 2.9-7 – Demo plant agglomerator in use.

Figure 2.9-8 – Demo Plant Agglomerator.

Figure 2.9-9 – Example of an Industrial size Agglomerator, from another project in Chile.

Source: PNM, 2017.

The binding agents, process water and sulfuric acid solution will be sprayed on the ore inside the agglomerating drum. The amount of water is constantly regulated in order to obtain the best humidity for the formation of agglomerates.

The agglomerated product will be continuously discharged onto the agglomerate collection belt, which will feed this material to the stacking system for the formation of the heaps.

2.9.2.3. Heap Leaching

After the ore is crushed, agglomerated and moistened, 4 meter high heaps are stacked for the leaching process with sulfuric acid solution. As presented in Map 2.1-2, the heaps will be located to the north of the project, adjacent to the residue disposal area.

The heaps will be stacked in a specific area for leaching, called the leach pad. This area was designed to be built in order to provide maximum security in the operation and recovery of the solution (and consequently nickel), in addition to preventing contamination of the external areas. For that, the area shall undergo earthworks so that the pad is smooth and inclined, directing the percolated solution to the collection channels without any points of accumulation.

The lining of this area, which is essential to guarantee the recovery of the solution, will be carried out by a double protective layer, composed of compacted clay and a layer of waterproof synthetic material (high density polyethylene geomembrane - HDPE or equivalent). In addition, a drainage system will be designed on the pad, composed of spaced tubes and, optionally, an acid-inert gravel layer, which allows a high permeability of the solution to the base.

The flow of percolated solutions over the base, with a minimum of retention or accumulation, avoids the increase of the hydratic level of solution inside the heap, which is essential for the flow of solution through the heap and for the stability of the slopes. In addition, the proper dimensioning of the drainage system will avoid pressure of the liquid on the pad, which could potentiate percolation through the protective layer. (Photo 2.9-1).

An acid leaching irrigation/sprinkler piping system is installed over the flat area at the top of the heaps (Photo 2.9-2). Due to the relatively fragile nature of nickel ore pellets, and to avoid water

loss through evaporation, the project provides for irrigation of the heaps by perforated tubes (hoses), similar to an agricultural micro-drip system. This irrigation system consists of a network with spacing calculated according to the irrigation rate, connected to a central distribution pipe.

The system is fed from the ponds of new or intermediate sulfuric acid solution, depending on the time the ore has been leaching and consequently the metal content contained (Photo 2.9-3). Sulfuric acid percolates by gravity from the top to the bottom of the heap, reacting with the ore and leaching (solubilizing) the metals present in the ore, including nickel, the metal of interest. The initial concentration of the dripped sulfuric acid solution will be 60 g / L, requiring 250 kg of acid for each tonne of ore.

Photo 2.9-1 – Heaps (Demo Plant)

Photo 2.9-2 – Dripping of sulfuric acid solution onto the heaps (Demo Plant)

Photo 2.9-3 – Leach Solution Ponds (Demo Plant)

Source: PNM, 2017.

In order to obtain the desired nickel concentration in the solution, the system will allow two-stage leaching in countercurrent. This means that the leach solution will pass through the ore twice during the leach cycle, the first being when the solution concentration is strongest and at the end of the cycle, when the nickel content is lowest in the ore and leaching more difficult. The last

passage of the solution through the ore heap will occur in the new heap, right after the ore is stacked, when there is more nickel in the ore, but less acid in the solution.

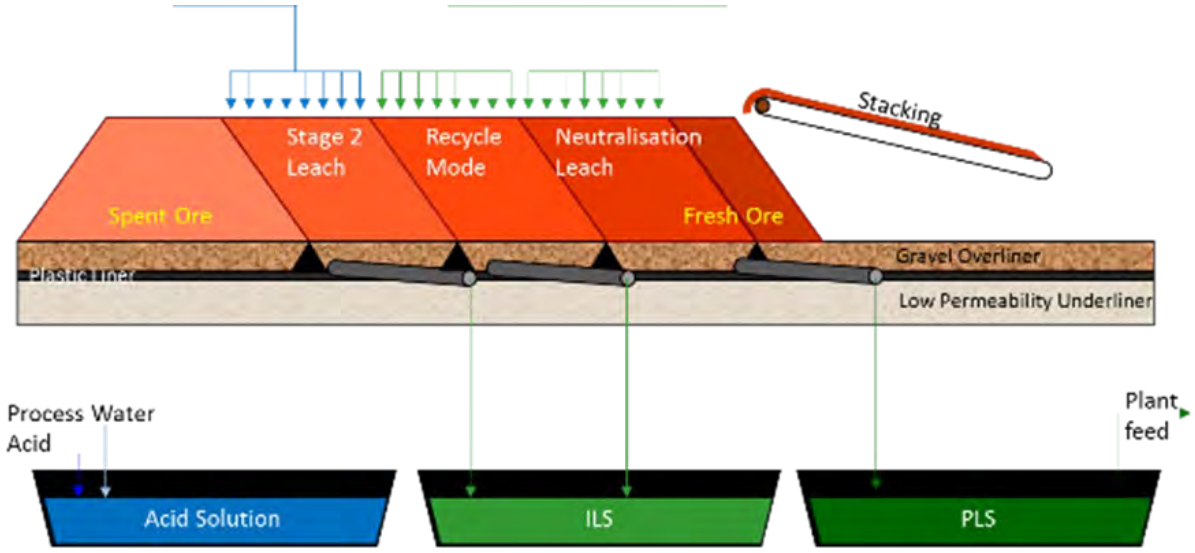
The solution passes through the heap, where the sulfuric acid solution is consumed in exchange for the loading of metals, it then flows through the drainage system, at the base of the heap to the drainage channels. Then, it is directed to the relevant solution pond, and can be recirculated through the heap until it reaches the ideal nickel content.

The solutions that will be irrigated in recycle on the heap are called Intermediate Leach Solution (ILS). ILS is a solution with an acceptable concentration of nickel, but with a high sulfuric acid content, which would require excessive amounts of limestone to neutralize the acid.

After reaching the desired nickel concentration and acceptable acidity, the solution is now called PLS (Pregnant Leach Solution), or simply rich solution, being stored in the PLS pond and then pumped to the solution treatment plant.

The leaching process with recirculation of the leaching solution is outlined in Figure 2.9-10.

Figure 2.9-10 – Heap Leaching Process.



Source: PNM, 2017.

After the end of the leaching cycle, the ore will continue to be washed with water in order to recover the acid remaining in the ore's moisture. After washing, irrigation is closed and the ore is completely drained by gravity. The effluent from this stage will be directed to the PLS pond, since the nickel content is sufficiently high to be considered capable of being fed into the plant, and later to be redirected to the ILS circuit as circuit water.

The total cycle, including stacking, assembling the irrigation tubes, leaching, washing and draining should take approximately 301 days, as described below:

- Installation of tubing, drainage, gravel base: 5 days;
- Stacking of agglomerated ore: 12 days;

- Installation of the irrigation network: 5 days;
- Leaching Neutralization: 50 days;
- Primary Leaching: 60 days;
- Secondary drying: 90 days;
- Wash: 25 days;
- Rinse: 20 days;
- Drainage: 20 days;
- Removal of exhausted residual ore (Spent ore): 14 days.

Upon completion of the leaching cycle, the cells with the spent ore will be removed by a front end loader and the spent ore will be transported by conveyor belts to be stacked in the residues disposal area, located north of the leach pad.

2.9.3. Components of the Mining- Processing Complex

In this section, the structures of the processing plants referring to the sulfuric acid plant, hydrometallurgical downstream plant and limestone quarry are presented in greater detail.

2.9.3.1. Precipitation Plant

The hydrometallurgical precipitation plant has the function of treating the rich solution (PLS), which will be produced in the heap leaching stage.

PLS is fed to the precipitation plant, where it is treated with limestone to remove unwanted metals (iron, chromium, aluminum). The resulting precipitate is then separated from the solution containing nickel and cobalt in a thickener, then washed, and finally filtered to remove water, generating a dry residue (Iron Filter Cake - IFC).

The nickel and cobalt contained in the resulting solution are separated in an ion exchange unit. Sodium carbonate is added to raise the pH again and precipitate nickel (NHP) and cobalt hydroxides. These are filtered and bagged for sale.

The hydrometallurgical plant process is detailed in subsequent sections.

A) Impurity Removal (Iron Precipitation)

a) Iron Removal Tanks

The PLS from the heaps is fed to a series of 6 iron removal tanks at room temperature and pressure.

A solution of micronized limestone and water is added to the first two tanks to obtain an indicated outlet pH. The residual sulfuric acid contained in the feed PLS reacts with the limestone to form gypsum, carbon dioxide and impurities such as iron, aluminum and chromium are precipitated in the form of hydroxides. Each tank is mechanically agitated to mix and suspend the precipitate. Air is sprayed into the tanks to keep the iron as ferric (Fe^{3+}) and to facilitate the removal (and potential capture and storage) of carbon dioxide gases formed as a by-product of the neutralization reactions that occur within these tanks. The solution advances through to the remaining tanks.

The total residence time in the iron removal tanks is approximately 24 hours.

b) Iron Removal Thickening and Filtration

The discharge of the iron removal tanks overflows into the thickener feed tank, and then flows by gravity, into an epoxy-coated thickener, where the paste is thickened to 40% by weight of solids. The flocculant is added in order to improve sedimentation.

As the flocculated mixture is deposited in the thickener, the solids concentration and viscosity increase. Part of the thickener underflow is reused in the iron removal circuit in order to increase the precipitation.

The thickener underflow is directed through vacuum filters. The filter product is discharged in the form of a filter cake with 60% solids weight and collected at the discharge end of the filter. The remaining solution ("filtrate") is directed back to the thickener, and the thickener overflows by gravity into the nickel precipitation circuit.

c) Iron Filter Cake – IFC

The solid product collected from the filter, Iron Filter Cake (IFC), composed mainly of iron, aluminum hydroxides and gypsum, has a humidity of approximately 40%. It should be noted that laboratory analyzes, performed for 17 IFC samples obtained from the operation of the Demo plant, indicated 35.3% humidity. The reports of these analyzes are presented in Annex I - Volume IV.

The IFC will be removed by the front loader and stacked in the residue disposal area. It is emphasized again that the residue storage facility will be fully compacted and waterproofed with HDPE geomembrane (and drainage system with containment pond), thus preventing any eventual percolation of substances into the local soil and subsoil.

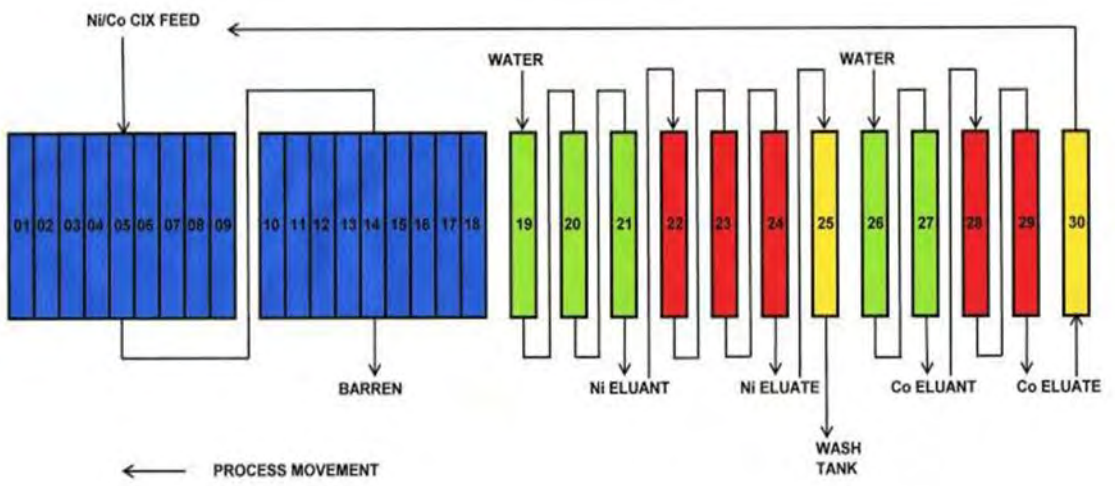
B) Ion Exchange (IX) Unit

The nickel and cobalt solution is then transferred to an ion exchange unit. This unit is arranged as a column carousel, each of which contains a resin manufactured to capture nickel and cobalt from the solution (Figure 2.9-11).

This resin was selected to be used in the Piauí Nickel Project because it is able to selectively capture the transition metal ions from acidic solutions.

When nickel is separated from cobalt, the nickel ion is more strongly retained by the resin. This affinity difference is used during split elution, the process of extracting one material from another by washing with a solvent. Nickel, which is more strongly retained by the resin, will require a higher eluate concentration than cobalt.

Figure 2.9-11 - Process flow in the ion exchange unit.



Source: PNM, 2017.

The adsorption of nickel and cobalt is done in two or three phases, thus providing an increased area and, consequently, an increased mass transfer zone.

After split elution, the nickel and cobalt flows, now separated, go to their respective precipitation circuits. It should be noted that a portion of the water from the inlet solution in the ion exchange circuit will be recovered from this process, in such a way that the separate Nickel and Cobalt outlet solutions are more concentrated than in the process inlet. (Photo 2.9-4).

Photo 2.9-4 – From left to right, flasks containing: feed mixed nickel and cobalt solution (light green), nickel eluate (dark green) and cobalt eluate (pink) separated and concentrated after split elution by the Demo Plant Ion Exchange Unit.

Source: PNM, 2017.

C) Nickel precipitation & Filtration

The ion exchange outputs feeds a single-phase nickel precipitation circuit, with nickel being the only product generated.

The eluate is pumped into the nickel precipitation circuit, where it is mixed with sodium carbonate solution (soda ash) and recycled thickener underflow from the nickel precipitation circuit at room temperature and pressure. Nickel is precipitated as a mixture of hydroxy carbonates with nickel sulfate, together with small concentrations of other metals.

The nickel eluate from the ion exchange unit is fed by gravity to a series of four tanks. Each tank is mechanically agitated to help mix and suspend precipitates. This sludge moves through the tanks and the sodium carbonate solution is added to any of the four tanks. The total time spent on the circuit is approximately 6 hours.

The sludge overflows into a thickener feed tank, and then flows by gravity to a thickener, where the paste is thickened until 10% of the weight is solids. Flocculant is added in order to improve sedimentation.

Part of the thickener underflow is reused in the circuit to increase the precipitation and the rest of the underflow passes through filters with a pressing membrane to remove solution (Photo 2.9-5). The filter product is discharged as a filter cake with 65% of the weight in solids, it is then bagged for transport to the customer.

Photo 2.9-5 – MHP slurry passing through the Demo Plant filter.

Photo 2.9-6 – Detail of the MHP cake at the end of filtration in the Demo Plant filter.

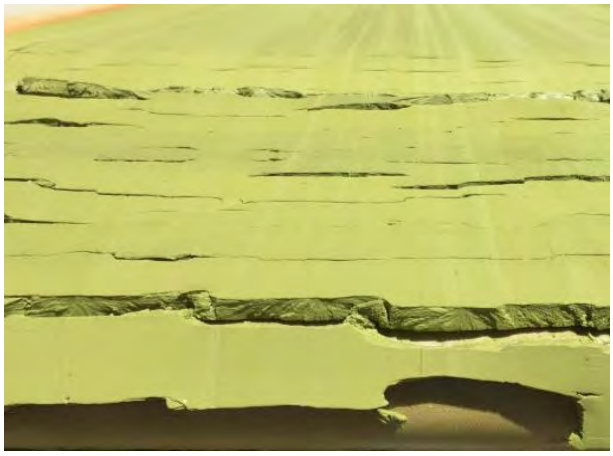


Photo 2.9-7 – MHP product ready and bagged for distribution (Demo Plant).

Photo 2.9-8 – Example of a working nickel-cobalt separation (IX) plant, Zambia.

Source: PNM, 2017.

The nickel precipitation (NP) phase recovers a high-quality nickel hydroxycarbonate, a nickel hydroxide product (NHP). The nickel product will contain more than 40% Ni and less than 0.2% Co. The table below shows the expected NHP specifications.

Table 2.9-3 – NHP Specification.

Element	Nickel Intermediate Product - NHP		
	% Typical	% Minimum	% Maximum
Nickel (Ni)	40	40	50
Cobalt (Co)	0.1	0.05	0.2
Chrome (Cr)	0.005	0.002	0.05

Element	Nickel Intermediate Product - NHP		
	% Typical	% Minimum	% Maximum
Magnesium (Mg)	2	1	4
Aluminum (Al)	0.3	0.05	0.5
Sulfur (S)	1	0.5	2
Manganese (Mn)	0.3	0.05	0.5
Zinc (Zn)	0.09	0.05	0.15
Calcium (Ca)	0.035	0.015	0.95
Copper (Cu)	0.05	0.01	0.1
Arsenic (As)	0		
Sodium (Na)	0		
Lead (Pb)	0		
Carbon (C)	2.5	1.6	4

Source: PNM, 2017.

D) Cobalt Precipitation & Filtration

Cobalt Precipitation and Filtration mirror the nickel precipitation process described above, albeit in much smaller volumes.

E) Product Bagging

The nickel and cobalt products will be transported to a bagging unit where both will be packed in 1 or 2 tonne bulk bags for shipment. Full bulk bags will be collected by a forklift for loading to containers.

2.9.3.2. Limestone Quarry

The project's limestone demand is 476,000 tonnes per year. An estimate of the resources of the deposit located in Umbuzeiro, located about 33 km south of the plant site in the Brejo Seco region, indicated an extraction capacity of 20 Mt of calcitic limestone (that is, not containing high amounts of magnesium, iron or silica and therefore suitable as a reagent source).

This section presents the project's activities aimed at the extraction of limestone, one of the main inputs used in nickel processing.

A) Mine Plan

The mining method to be used in the quarry of the Umbuzeiro target is open pit on benches.

In the development and opening of the quarry, with the operation of stripping and removing the topsoil, the benches will have a maximum height of 10 meters, average slope of 45º and operational widths of 15 to 20 meters wide. The final width on the ground will be 10 meters wide.

Soil removal will be done using loaders, excavators and trucks. It is noteworthy that the soil was not modeled, as its thickness is very small in relation to the height of the blocks used and, therefore, it was not defined in DATAMINE.

The limestone extraction will take place in the pit after removing the cap and exposing the top of the limestone layer. The removal of limestone, to allow its extraction, will be carried out by explosives on benches 10 m high, with the slope of the slope face of 75º and with minimum operational shoulders of 20 m wide. When a certain level reaches its final configuration, the rock edge will be 10 meters wide on the NW / N / NE walls. On the walls located in the SW / S / SE portion, the edges will be 13 meters wide in order to geometrically compensate for the loss of space resulting from the likely landslides of the limestone bedding of these walls - when each mine level reaches the end of its life.

The access ramps for the transportation of limestone will have a maximum slope of 8% and a minimum width of 15 meters, greater than about 3 times the width of the largest truck to be used in mining, allowing operation with an adequate level of safety.

The final pit was defined using the DATAMINE software, using the block model and respective resource inventory as the basis for the project.

For the purpose of the mining project and mining planning, the deposit was split into blocks of 25 x 25 x 5 m. Dilution and limestone loss were not considered at this stage of the studies.

The pit design adopted the parameters shown in the Table 2.9-4 and represented in the schematic profile (Figure 2.9-12).

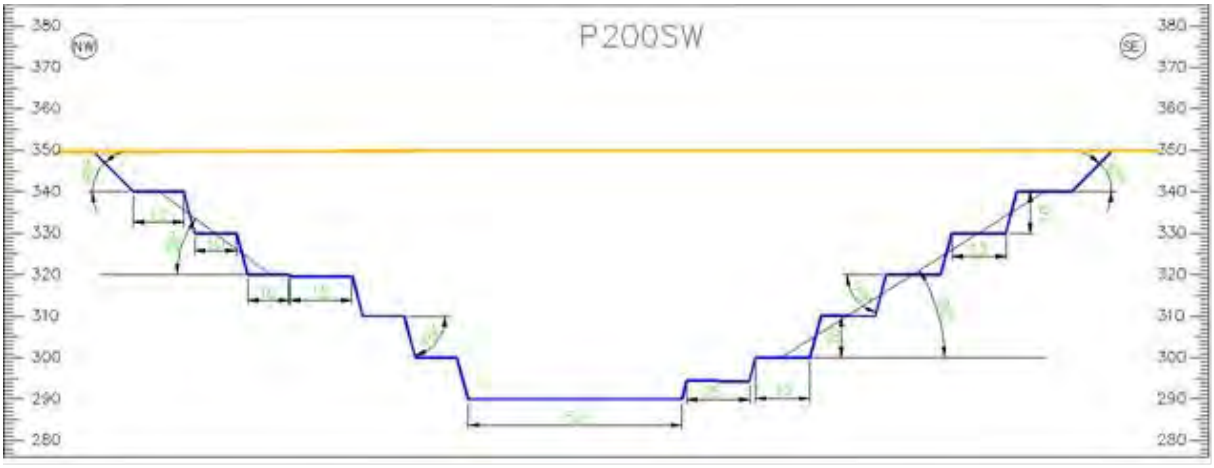
Table 2.9-4 – Parameters Used in the Pit Design - Limestone Quarry.

Parameter		Unit	Value
Rock slopes	Slope angle on face	degrees	75
	Operational edge on any side	m	20
	NW/N/NE side end edge	m	10
	SW/S/SE side end edge	m	13
	Access ramp - width	m	15
	Maximum slope of the access ramp	%	8
	General slope angle - SE side	degrees	32
	General slope angle - NW side	degrees	36
Soil Slopes	Individual slope angle	degrees	45
	Final Width	m	12
	Individual bench height	m	10

Parameter		Unit	Value
	Access ramp - width	m	15
	Maximum slope of the access ramp	%	8

Source: Procalcim, 2008.

Figure 2.9-12 – Schematic of pit design parameters - Limestone Quarry.



Source: Procalcim, 2008.

The operations in this mining method are as follows:

- Up front quarry preparation and clearing:
  - Preparation of areas for mining;
  - Removal of soil, by bull dozer or backhoe. Blasting of waste rock with explosives: dolomitic limestone, magnesian limestone, siliceous limestone, marl and shale;
  - Loading of waste, dolomitic limestone, magnesian limestone, siliceous limestone, marl and shale;
  - Transport of waste - to the waste dump;
  - Transport of waste rock - dolomitic limestone, magnesian limestone, siliceous limestone, marl and shale - to the waste dump;
  - Controlled stacking of waste.

- Limestone production area:
  - Drilling of blasting holes;
  - Detonation of holes;
  - Limestone loading on trucks;
  - Transport of limestone to the crusher;
  - Transport of waste to the respective waste dump;

- Control of waste in the respective waste dump;
- Maintenance of benches, ramps, waste dumps, accesses and roads.

For carrying out these unitary operations, more appropriate sized equipment was selected. The indicated model is only used to estimate productivity, dimensioning, installed power and fuel consumption. At the time of purchase, a specific price will be taken for this purpose.

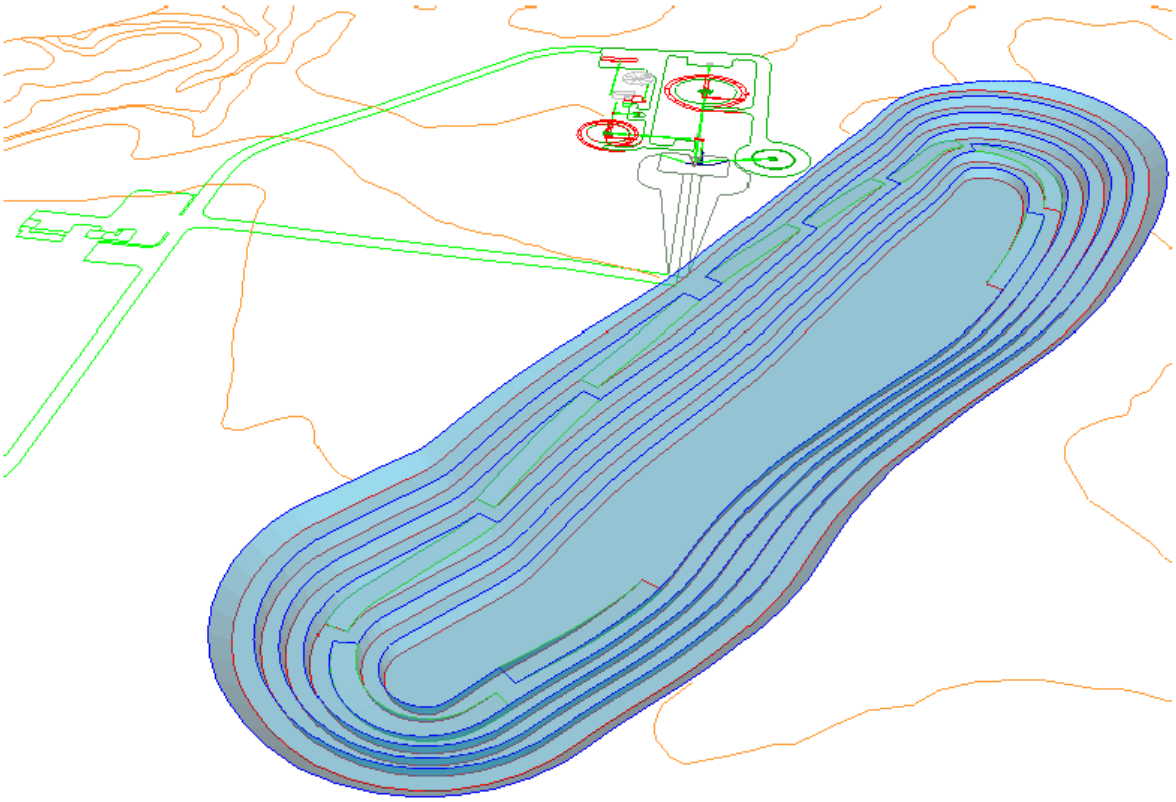
The parameters used to define the final pit were as follows:

- Consumption of precipitants (limestone) for processing Ni ore from the Brejo Seco Complex during its period of operation;
- Mining costs;
- Process costs;
- General and administrative costs, and
- Geotechnical parameters.

The production schedule was made using the limestone consumption design criteria at the plant, depending on the needs for impurity removal in the nickel processing plant, provided by the mass and the concentrations of the elements that consume limestone (Al and Fe) in the plant feed.

Figure 2.9-3, shows the isometric projection of the final pit of the Umbuzeiro limestone deposit.

Figure 2.9-13 – Isometric projection of the final pit of the Umbuzeiro Limestone Quarry.



Source: Procalcim, 2008.

a) Blasting of the Rock

The blasting will be carried out with the adoption of an inclined face of 15º (referred to the vertical plane) providing significant gains with respect to the better use of energy from the charge, with consequent improvement of the floor, elimination of curtains and obtaining well finished faces and, therefore, greater security for subsequent operations.

The explosive will be produced and/or stored in storerooms at the nickel plant, for application at the Brejo Seco nickel mine and will be shared with the Umbuzeiro limestone quarry, as will the exclusive and specific truck for transporting explosives. In the Umbuzeiro quarry, the explosive will be applied directly to the holes, there are no storerooms.

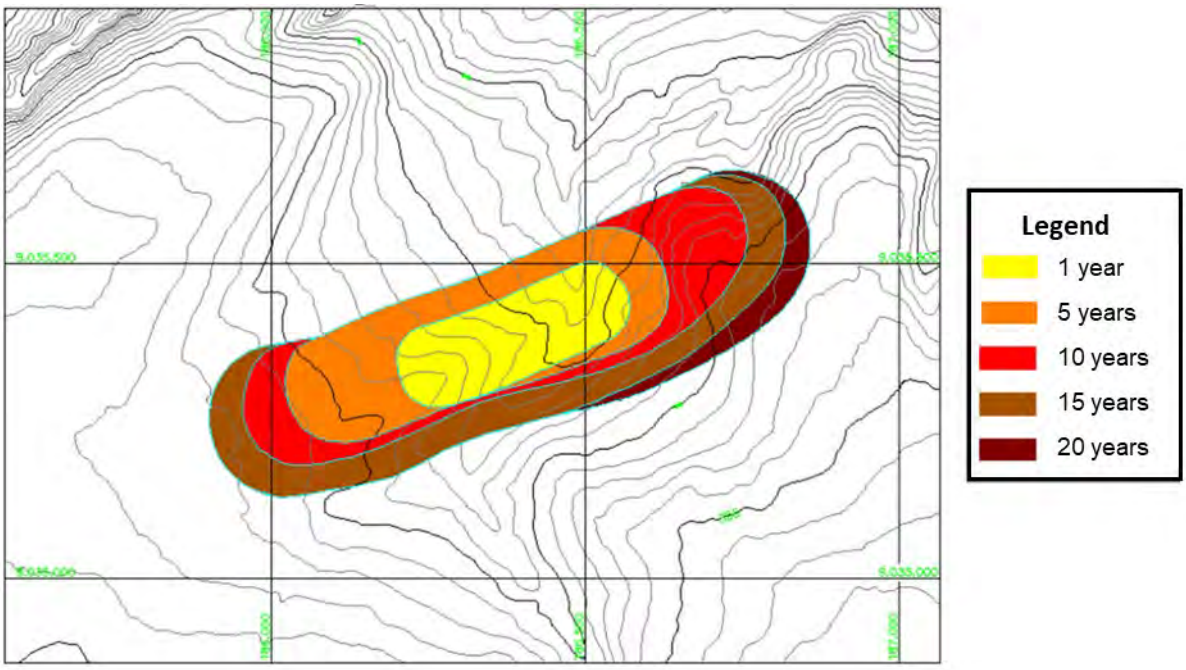
Information about the Fire Plan and use of explosives can be found in section 5.1.10 of Volume II, together with the simulation carried out to assess potential levels of Vibration and Acoustic Overpressure arising from the use of explosives in the Nickel mine and Limestone quarry.

B) Mine Sequencing

The estimated limestone quarrying at Umbuzeiro is 476,000 tonnes per year, for 17 years. Bearing in mind that the limestone quarry starts operating about six months after the nickel mining, in the

first year of operation of the project, the mining will be smaller than the other years. Figure 2.9-14 shows the progress of the quarrying phases during the operation.

Figure 2.9-14 – Movement of the Umbuzeiro Quarry.



Source: Procalcim, 2008.

C) Waste Rock Dump

The stockpiling of the waste generated by the limestone mining operations will be carried out in a place with a small slope, on benches superimposed one by one, ascending, with height and inclination of the face angle fixed, respectively, at 10 meters and 33.69º, for the soil and 38º in waste rock. Complementary measures will be adopted to control erosion and slippage of the benches.

In order to guarantee the stability of the waste dumps, general angles of safe slopes will be adopted (safety factor greater than 1.4) calculated by geotechnical parameters already used successfully in the construction of similar dumps.

In order to minimize the environmental impact resulting from the transport of solid material by stormwater, vegetation will be planted on the various slopes and final shoulders of the waste dumps.

To increase the stability of the stockpiles, complementary measures will be adopted for the internal drainage. The table below details the parameters of the waste dumps.

Table 2.9-5 – Project Parameters - Umbuzeiro Quarry Waste Dumps.

Parameter		Unit	Value
Soil Waste Dump	Individual slope angle	Degrees	34
	Final Width	m	12
	Individual bench height	m	10
	Access ramp - width	m	15
	Maximum slope of the access ramp	%	8
	General slope angle	Degrees	20
Rock Waste Dump	Individual slope angle	Degrees	38
	Final Width	m	12
	Individual bench height	m	10
	Access ramp - width	m	15
	Maximum slope of the access ramp	%	8
	General slope angle	Degrees	23

Source: Procalcim, 2008.

In the construction of the waste rock dumps, the spreading and transit operations of heavy trucks, in addition to providing a compaction of the landfill, promote waterproofing of each level built. As the landfill is built upwards, this factor is reinforced.

The following additional measures will also be adopted for the construction of dumps:

- Previous clearing of the deposition area, with deforestation, removal of the vegetation cover, with the objective of eliminating weakness planes and preventing the dump slippage. The removed material will be properly stored for later use;
- Construction of the dumps with the deposition in an upward direction, in successive layers of small thickness, in such a way that the passage of the transport and spreading equipment (trucks, tractors and graders) promote the necessary compaction, ensuring the stability of the dump;
- Drainage ditches will be built at the feet of the benches and, in the lower parts, at the meeting of two ditches with slopes in opposite directions, collection boxes will be built. From these boxes channels will emerge about 2 m wide and 0.5 m deep, across the shoulders, up to the crest of the benches. These ditches will continue on the faces of the benches until they find the lower bench, being filled with stones of different granulometries, preventing erosion and having a semi-filtering function. In the event that these ditches present any type of problem, they may be replaced by PVC pipes. Bypassing the waste deposits and the marginal ore stockpile, upstream, ditches will be opened to divert rainwater. The waters coming from this drainage system will be directed to small areas for the containment of solids, and, subsequently, to natural drainage;
- Construction of berms between the benches with a 3% slope, from the crest to the foot of the slope, to allow rapid drainage of rainwater.

- Use of soil rich in humus, prepared with material removed for clearing the area, covering the slopes and the final edges, allowing the revegetation of exposed areas, preventing or hindering the erosion of the dump and the loading of solid material in the area's rain flow.

2.9.3.3. Limestone Processing (Crushing)

The limestone beneficiation circuit, whose objective is limestone comminution, begins with the unloading of run of mine, by trucks, in the existing hopper on the vibrating feeder. The hopper, or pre-silo, whose capacity is 180 t of limestone, is important to avoid crushing paralysis when the truck cycle is delayed for any reason.

The ore then passes through the crushing (primary and secondary), proceeding to the screening, carried out by the classification screen composed of 3 (three) screening decks, with 100 mm, 50 mm and 30 mm opening meshes, respectively.

The crushed limestone will be sent to Brejo Seco for micronisation, where it will be used in neutralization. The material in the crushing waste stockpile, as it contains clay and rock, will preferably be used for the access road coating.

2.9.3.4. Sulfuric Acid Plant (SAP)

To meet the consumption of sulfuric acid, it will be necessary to install a specific industrial plant that produces the acid by burning sulfur.

The acid plant will contain the sulfur burning unit, a tower with conventional water cooling evaporators, and sufficient storage to store 10 days of acid consumption. The plant will be designed, assembled and commissioned by external suppliers (EPC package).

The production process is based on three chemical reactions: (i) production of gaseous sulfur dioxide; (ii) catalytic oxidation of sulfur dioxide to produce the trioxide; and (iii) absorption of sulfur trioxide in concentrated sulfuric acid.

The oxidation and absorption processes at the sulfuric acid plant are highly exothermic. The excess heat generated at each stage of the process will be recovered in a heat boiler, in the form of superheated high pressure steam that is exported to a project power plant for power generation. A single turbo steam generator (STG) will be used to generate 29.7 MW of energy, of which 21 MW will be used in the activities of the complex itself. The surplus energy generated will be made available to the national electrical system, through the 69kV TL to be built for this project.

A diesel generator will also be installed in the area of the power plant to supply energy on time, when the acid plant is undergoing routine maintenance, as well as during the construction and decommissioning of the project.

The main inputs used to produce the acid are sulfur, water and oxygen from the air. Estimated consumption of 250,000 tonnes of sulfur per year is expected.

During the first months of operation of the project, the demand for sulfuric acid will be met by external sources, since the acid plant will still be in assembly and commissioning.

2.9.3.5. Residue Storage Area

The Piauí Nickel Project contemplates the construction of a residue storage area with an area of 222.39 ha, north of the nickel pit (Map 2.2-1), for dry disposal of waste from the hydrometallurgical plant (IFC) and spent ore from the heaps. According to the project's Economic Utilization Plan, the planned waste is classified as class II B waste (non-hazardous and inert) according to the ABNT NBR 10.004 / 2004 standard (GEOMIL, 2013).

In advanced stacking, the forklift operates at the top of the active lift and advances as the stack is formed. The elevations will be 5 to 20 m high, depending on the geotechnical properties of the material, the development of pore pressure and the location of the slope inside the deposit (for example, internal slopes can be stacked more coarsely, since the internal stability is not really a problem). The average annual rise rate will be determined from the stability analyzes and may vary annually.

As mentioned in section 2.1.1 the deposit area will be compacted and waterproofed with geomembrane over clay.

Any rainwater incidents in the residue storage area will be collected by the surface drainage system, and considering the potential for sediment transport in this process, it will be directed to the sediment precipitation system. Water percolated through the residues and collected in the impermeable layer is directed to a containment pond and later reused as process water or destined for a properly licensed disposal.

2.9.4. Utilities Necessary for Operation

The auxiliary operating units, responsible for directly supplying the main units, are represented by the quarry and limestone processing at the Umbuzeiro deposit, the water intake and supply system from the Jenipapo dam, waste and residue storage areas, transmission line 69kV electricity and access routes.

To assist workers in the operation phase of the Piauí Nickel Project, it will be necessary to install an adequate infrastructure, in addition to supporting the operational activities of the mine, plant, sulfuric acid plant and administrative services.

2.9.4.1. Raw Water Collection and Supply

The project will require water consumption of around 460 m³/h for its operation, and the water supply for the project will be provided by the extraction from the Jenipapo water dam, through the construction of a 33.52 km pipeline. To this end, ANA - National Water Agency - has already granted a permit to take 603 m³/h of water (Resolution No. 1,340 / 2014), valid until 2024.

In the Brejo Seco Complex, water will be used in the industrial process, for human consumption, sanitation, sulfuric acid plant, sprinkling of roads, and firefighting, according to the specifications below.

A) Process Water

The untreated water will supply the industrial areas through pipes, from the plant's storage tank, with a capacity to supply 8 hours of consumption.

This water will be used in the stages of agglomeration, leaching and neutralization, by pumping it into the drum, tanks and heaps.

Process water will also be used in cleaning points. Water consumption at the acid plant is directed to supplement losses from the steam generation system and to replace losses from evaporation of the refrigeration system.

B) Treated Water

Part of the water will be treated in a reverse osmosis plant, to produce water with the required quality in the sulfuric acid plant (ARCADIS LOGOS, 2008). The storage tank will have the capacity to supply 24 hours of consumption.

The stored treated water will be pumped into the hot water generator system. The accumulator is used for constant pressurization of the intermittent consumption system.

C) Potable Water

Drinking water will be obtained through chlorination treatment of the water captured from the Jenipapo dam and distributed to the consumption of toilets, canteen and drinking fountains, fed by storage tanks, with capacity to supply 24 hours of consumption.

The water distribution system will consist of pumps that pressurize the pipes, from the storage tank, equipped with systems for maintaining and stabilizing the pressure in the lines.

D) Fire Fighting Water

The fire-fighting system will be supplied by a process water tank, which will have a reserve of 500 m^3, enough to simultaneously serve, for an hour, three consumption points with hoses, for a flow of 1 m^3/min.

The system will consist of three pumps: one electric, one diesel and the third of the Jockey type, which has the function of maintaining the system permanently pressurized.

The project foresees fire water distribution in the different industrial areas, including the plant, tank yard, reagent area and auxiliary buildings.

E) Demineralized Water

The project foresees the need to use demineralized water that will be used in the boilers of the acid plant and supplied by the auxiliary unit of the sulfuric acid plant.

F) Umbuzeiro Quarry

The water to supply the needs of the facilities of the Umbuzeiro Quarry (industrial water, for human and sanitary consumption) will be captured in underground boreholes which will be properly permitted.

The consumption of industrial water is directed towards the abatement of dust in the quarry, in the accesses, in the transfers and formation of stockpiles in the crushing, also in the washing of the machines and equipment.

2.9.4.2. Electricity Transmission Line

The demand of approximately 21 MW of electric power required for the operation of the project as a whole will be met by the energy to be generated at the sulfuric acid plant. As previously presented, the sulfuric acid plant will be equipped with a cogeneration unit to convert the heat from burning sulfur into steam, generating electricity. This unit will have a generating capacity of 29.7 MW, so that the excess energy generated, of 8.7 MW, will be sold to the Eletrobras Distribuição Piauí network, through the 69kV transmission line to be installed.

The LT will also meet the demand for electricity in the event of an outage or decreased production at the acid plant.

The distribution and receipt of energy at the industrial plant will be at the main arrival substation, in a fenced yard and with a gravel layer on the floor. The distribution to the load centers of the industrial plant, mine/crushing and warehouse/workshop, laboratory and administrative buildings, will be through a compact aerial network for distant areas and in a pipeline network for the nearby points, all in 13.8 kV . The feeder circuits will be derived from distribution boards, installed in the electrical room of the main substation.

All the energy distribution of the plant will be made from closed electrical rooms, with restricted access, signposted and with protection and alarm devices according to ABNT standards.

The installation of an emergency power system is foreseen, in the event of a power failure by the concessionaire and/or cogeneration in the areas considered to be priority, such as emergency lighting, fire water and some process equipment.

2.9.4.3. Administration

A) Offices

The built area will include offices, storage, toilets, control room and administrative buildings. In the area of the mine, the construction of offices for the operation teams is planned, in addition to sanitary facilities.

B) Security Services

The project contemplates the fencing of certain areas, for patrimonial and security control, with the installation of gates in the main accesses.

Located at the entrance to the industrial plant, close to the clinic and fire brigade, surveillance supervision will be responsible for controlling access to the area and inspecting the security of vehicles entering and leaving the project.

Specialized surveillance will be carried out by a contracting company, responsible for personal and property security 24 hours a day.

C) Reception

The reception will be located on the new access road to the project, to be built. It will be equipped with a room for the inspector and a room for security. Next to the parking lot, a support area will

be built for waiting for drivers, equipped with sanitary facilities and a treatment system composed of an anaerobic fossa-filter.

D) Security center, firefighters and weighbridge

The security and fire station will be located close to the area of greatest potential risk, ensuring ease of access.

The center will be used for work safety, maintenance and storage of safety equipment. On the side of the building, under a covered area, there will be a fire fighting truck equipped with a pressurized water jet.

A weighbridge will be installed at the main gate to weigh inputs and products.

E) Fire Brigade

The building will house a fire fighting vehicle and spaces planned for stock and equipment repairs related to the area. The location of this building will be close to the workshop, with easy access in all directions.

F) General Services

In the building intended for general services, activities to control bus services, light vehicles, surveillance and general services will be allocated, with an administration area, personnel locker room and warehouses.

2.9.4.4. Common Use Units

A) Medical Clinic

The clinic will house the doctor's office, where first aid will be provided in case of need. The rest room will be equipped for routine care and first aid. More serious cases will be referred to hospitals in nearby cities.

The emergency transport will be performed by ambulance that will be permanently parked next to the clinic, with a driver ready.

B) Canteen

A cafeteria will be built near the industrial plant. Meals will be prepared in an industrial kitchen, attached to the canteen.

C) Bus Terminal & Changing rooms

The bus terminal will be located next to the administrative buildings and the restaurant. It provides space for the parking of six buses, having been dimensioned to attend the busiest shift, which is 275 people. In the same place, a point for employees and changing rooms is provided for changing clothes, guarding uniforms and personal protective equipment.

2.9.4.5. Infrastructure

A) Maintenance and support for equipment and machinery

Due to the system adopted for maintenance and the location of the central maintenance workshop, mobile equipment will only be moved to that workshop in case of heavy maintenance or preventive

interventions, which represent more than one day of equipment shutdown. For other situations, mobile equipment was provided to service all equipment in the mine in the field, as described below:

- Lubrication tanker trucks: these vehicles will have the function of periodically topping up the levels of lubricating oil, hydraulic oil, cooling water and greases from the centralized lubrication systems of all equipment in the mine; they will also check and calibrate the tires of off-road trucks;
- Trucks with mobile workshop: these vehicles have tools for minor repairs (corrective maintenance) to be carried out in the field for the equipment of the mine; they will be able to carry out repairs on welding, hydraulic and compressed air pipes and hoses, as well as replacing light parts;
- Water supply to the irrigation truck: the irrigation tanker trucks will have their water supply at a service point located near the main pit access, in a position that will allow gravity supply from the mine's water reservoir.

B) Light Vehicle Fuel Station

The light vehicle filling station will have a projected area of 40 m^2, with two elevated fuel tanks, seated on concrete cradles and protected by concrete dikes (height of 1 m), for fuel storage.

It is planned to install a water and oil separator system at the filling station, in order to separate the eventual oily effluent.

C) Washing of Machines and Trucks

The washer will have its structure composed of an area of approximately 500 m^2, with concrete floors and channels for collecting water for washing machines and trucks.

Two elevated side walkways are provided for operators to access the water cannons. The installation of a water and oil separator system is also planned.

D) Signage

The roads and access roads of the mine and internal to the industrial area will have signs indicating direction, preference and maximum speeds. Also, risk areas, such as storage of toxic, explosive or combustible materials, will be signed with warning and prohibition signs applicable to each case. The beneficiation plant area will have well-identified and signposted access and circulation routes, and hazardous locations will be protected.

E) Lighting

All equipment at the mine will have its own lighting systems, kept in perfect condition at all times. There will also be lighting of the mining areas through mobile towers.

The crushing circuit will be illuminated by spotlights installed on poles properly located in the circulation areas of people and equipped with an emergency lighting system that will automatically switch on in the event of a power outage at the site.

F) Intermediate Waste Deposit

The construction of an intermediate waste deposit in the area of the project is planned, including: yards for storing scrap and various non-hazardous waste, a shed for hazardous waste, a shed for sorting, pressing and baling recyclable waste such as: paper, cardboard , plastics, pet bottles, etc. Shed for composting organic waste and shed for storage of hazardous waste. For these facilities a total area of 20,000 m^2 is planned.

G) Sanitary Sewage Treatment Station (SSTS)

The construction of a SSTS for the treatment of sanitary sewage to be generated in the project is planned. The treatment principle should be forced aeration and activated sludge. The sludge resulting from the SSTS should go to a drying bed and will subsequently be added to the organic compost product for use as plant fertilizer in the area of the project. The approximate area of the SSTS will be 2,500 m^2.

2.9.4.6. Production Support Units

A) Mine Support Units

The mine is located close to the other units of the project, in order to allow the movement of employees to the offices and the restaurant. At the mine, only one support building was planned, with sanitary facilities, rooms for changing shifts and supporting the topography.

B) Laboratory

The laboratory will be equipped for routine analysis, such as wet analysis, atomic absorption and organic drag determination.

C) Reagent Storage

A metal structured shed will be built for the storage of reagents. The structure will consist of six porches with a span of 10 m, concrete floor and will be covered, with lateral and frontal closure in trapezoidal aluminum tiles. The use of an overhead crane is not foreseen, since all reagent handling operations will be carried out with a “Hyster” type crane.

D) Core Shed

Two warehouses will be built for the storage of drill core. The warehouses will have reinforced concrete floors, 4 m high ceiling, will be covered with trapezoidal aluminum tiles and should be closed laterally with a screen.

2.9.4.7. Auxiliary Units of the Acid Plant

A) Water demineralization system

The water demineralization system consists of removing the positive and negative ions present in the treated water, in the form of salts, when passing through cationic and anionic resins.

The demineralized water will be used in the supply of the heat recovery boiler and in the auxiliary boiler at startup and as replacement water, in normal operation, for the deaerator.

For the supply of the demineralized water system, the treated water will be pumped by two pumps. Initially, the treated water passes through the active carbon filter and goes to cationic and anionic

columns. The resulting flow will be fed to a mixed bed column, containing cationic and anionic resins, which removes the remaining dissolved salts, not fully absorbed, in the previous columns. In the mixed bed column, the condensate, formed from exhausted steam from the cogeneration system turbine, will be fed.

Upon leaving the polishing column, the demineralized water passes through a filter that retains the resins to prevent escape from the system columns and only then will it supply the Demineralized Water Tank.

The effluents resulting from the regeneration and backwashing steps of the columns go through channels to the effluent collection well.

B) Feed water production and condensate recovery system

The boiler feed water production system will consist of a deaerator, feed pumps and treatment system. The condensate will be replaced with demineralized water.

The deaerator will be fed with condensate that has passed through the polishing column, containing cationic and anionic ion exchange resins, and this column will be fed in part by condensate from the condensation of exhaust steam from the turbogenerator into the surface condenser and transferred to the deaerator by the pumps. The rest of the condensate that feeds the mixed bed column will come from the process unit (sulfur melting and heating).

2.9.4.8. Cooling Water System

The cooling water system will consist of a cooling tower, four cooling water pumps (one being a reserve), and a system for adding chemical products for water treatment. The cooling water treatment system foresees the installation of three tanks for preparing chemical solutions, namely:

- Zinc phosphate solution tank, this product being a corrosion inhibitor;
- Sulfuric acid solution tank, for pH control;
- Sodium hypochlorite solution tank, with this product having a dispersing and biocidal action.

The solutions will be prepared in batches, using treated water; these products will be added by gravity. The control of the addition of the three products will be done manually, according to the periodic analyzes of the water.

2.9.5. Required Inputs for Operation

The main inputs of the proposed project are presented below.

2.9.5.1. Compressed Air

Due to the distance between the areas, two compressor systems are planned for the project. The air compressors will supply service points for the plant, the precipitation tanks and the water pressurization system. The compressed air, before being distributed, will be stored in an accumulator.

The greatest demand for compressed air will be given by the pond suction pumps and the filters. The compressed air system will consist of screw-type compressors, which will provide a nominal supply pressure of 690 kPa.

2.9.5.2. Fuels & Lubricants

The main fuel to be used will be diesel oil no 2, to be transported by road in self-unloading tank trucks. This will be stored in a cylindrical, vertical tank, with a capacity for 15 days of consumption, which has a fire protection system. The storage tank will be located close to the acid plant. In the beneficiation plant, the oil will be used to feed the boiler and the sulfur combustion furnace, when necessary (ARCADIS LOGOS, 2008).

To meet the need for fuel supply for heavy mine equipment, such as off-road trucks and motor graders, which require large volumes and flow rates to be supplied, the use of a vehicle equipped with a tank and pump is planned. The truck's tank will have a capacity of 20,000 liters.

In addition to diesel oil, lubricating oils will be used for vehicles and equipment with engines, oils in reducers and fixed equipment drives, hydraulic oils in mobile machines and hydraulic drive systems. The greases will be used in mobile and fixed equipment, in the various operational areas of the project.

Total diesel consumption for the project is estimated at 7 million liters per year.

2.9.5.3. Explosives

The explosives to be used in the mining activities of the project will come from the explosives plant (or storage warehouse). The materials and supplies foreseen for the manufacture of the explosive are:

- Packaged emulsion, 1 1/2 "x 24", ready for application;
- Ammonia nitrate;
- Sodium nitrate;
- Diesel oil;
- Sensitizing and emulsifying agents;
- Non-electric delay fuses with 6 m;
- Non-electrical delay fuses for connection with 4 m;
- Fuses;
- Detonating cord NP-10;

The project includes the following activities related to the blasting of rock:

- Manufacture, storage and transport of explosives;
- Application of explosives and accessories;
- Maintenance and management of facilities;
- Obtained permissions from the Ministry of the Army.

The rock blasting process will be the responsibility of a specialized third party.

2.9.5.4. Soda ash

Soda ash (sodium carbonate) will be used to precipitate nickel and cobalt in the precipitation circuits. The sodium carbonate solution is prepared by mixing it with filtered water in a specific tank.

Soda ash will be imported, by sea, in bags of 1 tonne by mass. The material will be discharged into the sodium carbonate mixing tanks. A predetermined volume of water is added to the tanks, and the mixture is then stirred until the sodium carbonate is completely dissolved. The sodium carbonate solution then proceeds to the nickel and cobalt precipitation circuits.

The estimated consumption of ash soda is 112,340 tonnes per year.

2.9.5.5. Flocculants

The flocculants will be used to help sedimentation in all thickeners in the precipitation plant and to improve filtration in removing iron and magnesium. The flocculants will be delivered to the site in 25 kg palletized bags.

The required flocculants will be prepared, mixed and supplied as needed to the relevant circuits.

2.9.5.6. Lime

It is estimated that 50,000 tonnes of lime will be required per year for the precipitation process at the plant, which will be purchased from external suppliers or produced from the limestone extracted from the Umbuzeiro Mine.

In the case of internal production, the limestone calcination plant, or lime plant, will be composed mainly of limestone reception, kiln calcination, storage and shipping operations.

The limestone, with granulometry between 50 and 100 mm, will be fed into the two vertical chambers of the furnace responsible for calcination. The process will be continuous, with the entry of limestone proportional to the output of lime in each chamber.

The unloading hoppers, located at the furnace exits, will collect the calcined materials, directing them to the loading and dispatch silos, where they will wait for loading on the transport trucks to the plant.

For the operation of the calcination furnace, a dust collector and separator system (set of filters) will be installed. The material retained in these filters will be stored and redirected to the limestone dump for neutralization.

2.9.5.7. Sulfur

The sulfur used at the Sulfuric Acid Plant, whose consumption is estimated at 250,000 tonnes per year, will be brought by road by trucks of 28 tonnes.

2.9.5.8. Sulfuric Acid

Sulfuric acid, the most used reagent in the process, will be produced in a plant installed in the project itself, as previously described. All production will be stored in tanks that will feed the plant

through pumps powered by electric motors. A consumption of 750.00 tonnes of sulfuric acid is estimated per year.

2.9.6. Machinery & Equipment

The main mining equipment will be necessary for drilling, digging, loading and transporting ore and waste.

For drilling, due to the characteristics of the operation, the rig will be of tracked type. For excavation and loading, hydraulic excavators will be used, given their selectivity and flexibility. Rear unloading dump trucks will be used for transportation.

As auxiliary equipment, tracked and wheeled bulldozers, wheeled loaders, motor graders, irrigation tank trucks and lubrication trucks will be used, among others. It is also planned to use a specific drill and trucks for the preparation and loading of explosives, for blasting.

The following is a list of equipment to be used in mining:

- Main Fleet:
  - Caterpillar 390D excavator, with a capacity of 4.1 m^3 and a gross power of 523 hp;
  - Hydraulic drill;
  - Caterpillar 770 truck, with a capacity of 35 tonnes and gross power of 511 hp;
  - Caterpillar 988H loader, with 555 hp power;
  - Caterpillar 14M Motor Grader.

- Auxiliary Fleet:
  - D9 Bulldozer;
  - 844H Wheel Dozer;
  - Caterpillar M316 hydraulic breaker;
  - Explosives truck;
  - Mobile maintenance trucks;
  - Tanker truck
  - Semi-trailer;
  - Caterpillar 725 water truck;
  - Caterpillar 307 small excavator (environment);
  - Caterpillar 725 small trucks;
  - Grade control drill;
  - Plank truck;
  - Lighting equipment;
  - Submersible pumps;
  - 4x2 support vehicles;

- 4x4 support vehicles.

2.9.6.1. Mineral Processing Equipment

The crushing will be carried out using the following equipment:

- Vibrating feeder;
- Conveyor belt;
- Purge system (cleaning);
- Sizer type Crushers
- Conveyor belt;
- Classifying sieve;
- Conveyor belt.

2.9.7. Transport of Inputs and Products

For the transportation of crushed limestone for the precipitation plant, composite tipping trailers - with two trailers (semi-trailer) will be used, forming the B-train set.

Considering that this transport will be done only during the dry season (9 months per year) and that the capacity of the B-train set is 70 tonnes, it is estimated that 25 trips between Brejo Seco and Umbuzeiro will be necessary per day.

Sulfur will be brought by road by 28-ton trucks, thus providing for approximately 24 trips per day to supply the project with an annual demand of 250,000 tonnes.

The products, NHP and Cobalt precipitate, will be shipped daily from the site by road to port terminals. The transport will be through big bags with a capacity of one or two tonnes, totaling 28 tonnes to be transported per trip, which is the maximum load of the truck determined for this project.

Considering the annual production of 100,000 tonnes of NHP and 5,000 tonnes of cobalt precipitate, it is estimated that approximately 3,750 trips per year will be required to ship the products, or approximately 10 trips / day.

The product's transport flow will be reversed to that of soda ash, taking advantage of the return of transport means that what have been empty will be loaded, thus reducing truck traffic in the region.

Finally, the possibility of this project to carry out the future transportation of a good part of its inputs and products foreseen from the port terminals to the Brejo Seco complex (and vice versa) through the future Transnordestina Railway is highlighted, when the works in Piauí are finished and it is operational. This alternative can be better evaluated in the next stages of development of both projects.

2.9.8. Labor

The main municipalities supporting the project will be São João do Piauí, Capitão Gervásio Oliveira, Campo Alegre do Fidalgo and Dom Inocêncio. As the project's premise is to hire mostly

local labor for the operation, thus seeking sustainable development for the region, and workers will be able to reside in any of these cities. The municipality of São João do Piauí has better infrastructure resources and, therefore, should accommodate most of the labor from other locations, with the occupation of pre-existing residences, also aiming at generating local income.

The recruitment and selection process for the operation of the project will be coordinated by a specialized company that will give priority to the selection of human resources in the region of influence of the project, later on, in the other regions of the country. The following criteria will be adopted:

- Higher education professionals: priority will be given to those from the Federal University of Piauí, through the Project Monitoring Talents, contemplating students in business administration, economics, accounting and, mainly, engineering;
- Technical level: priority will be given to students from technical schools in the region;
- Middle and fundamental levels: priority will be given to the workforce already established in the project's areas of influence.

The recruitment and selection of experienced personnel will be focused on the search for professionals who have worked or work in companies that have some similarity or relationship with the operations of the Piauí Nickel Project. In addition, staff already mobilized in activities from previous phases of the project can be used.

The selection and recruitment process for operating personnel should start a few months before the actual start of work, in order to enable a thorough search and even initial qualification of the labor and service providers to be hired.

During operation, the qualification/training process of labor and service providers may involve formal education institutions, in addition to training provided by equipment suppliers, consultancy, and technical cooperation agreements with similar companies, etc.

When fully operational, the project is expected to employ 668 people with 15 management positions, 37 supervisors and 616 operational workers. Table 2.9-6 presents the labor demanded in different areas of the project, considering both Brejo Seco and Umbuzeiro.

Table 2.9-6 – Project workforce by department.

Department	Employees
Nickel Mine	268
Limestone Quarry	61
Hydrometallurgical Plant	207
Acid Plant	21
General Management	2
Health, Safety, Environment	26
Engineering	20
Finance dept.	10
HR & Administration	27
Logistics Department	26
Total	**668**

Source: PNM, 2017.

The mine, the hydrometallurgical plant and the acid plant will operate 24 hours a day, 365 days a year, employing a three-shift system with four teams of rotating operations between day, afternoon, night and rest shifts. Management and support services will work with only one team, working only 5 days a week. The limestone quarry will operate 5 days a week, only during the day shift, but the transportation of crushed limestone will be a continuous operation for four teams. The transport of sulfur and soda ash will operate 2 shifts a day in a transport operation by contracted trucks.

2.9.9. Environmental Control Systems

2.9.9.1. Effluents

The main effluent emissions planned for the operation of the Piauí Nickel project are summarized in rain drainage, oily and sanitary effluents.

As in the construction phase, rainwater drainage is basically characterized by the incidence of rainfall over exposed areas and over those with exposed disaggregated material. Added to this are the rainfall over the administrative and operational support area.

The rainwater incident in the mining areas, waste dumps, residue storage and ore stock will be collected by the surface drainage system, and considering the potential for transporting sediment in this process, it will be directed to the system of sediment dikes, located downstream of these structures. In the dikes, fine solid waste will precipitate and be contained. The clean water effluent, after physical-chemical monitoring, will be sent to the natural drains, with an energy dissipator.

The water percolated in the residue storage area and collected in the lined system will be directed to a containment pond and later reused as process water or directed to a suitable and licensed place for that purpose.

The project also provides for a lined emergency pond adjacent to the leach solution ponds, as a control measure in the event of overflow of the ponds.

The oily effluents expected for the operation phase are those from the vehicle and equipment maintenance workshop where activities such as oil change, maintenance and washing of vehicles and equipment will take place. The oily effluent will basically consist of water, oils, greases, sediments and various cleaning products. The area of use of these vehicles and equipment can also be considered, where there will be fuel tanks and storage of lubricants, which, in the event of a leak, may constitute a liquid effluent contaminating soil and water.

Maintenance services will be performed in the mechanical workshop, with a waterproof floor and side channel system for collecting and directing liquid effluents to a system of oil and water separating boxes. In addition, the oily effluents generated at the plant, construction site, workshops and washing places for off-road trucks, auxiliary vehicles, equipment and parts, will be taken to oil and grease separating boxes.

The final effluents from the separating boxes (water) will be released next to the respective collecting networks of the nearby rain drains, which, in turn, will be directed to the rain drain.

The sanitary effluents, coming from the restaurant and building facilities, will be treated in a sewage treatment plant installed in the area of the project. The treatment principle should be forced aeration and activated sludge.

During the development of the process route, the aim is to maximize the recirculation of solutions within the hydrometallurgical plant, which is why the generation of effluents from the plant's production activities is not foreseen. Any contaminated effluents containing residues from the production process or control systems will be temporarily stored in specific waterproofed areas for contaminated effluents, and directed to properly licensed landfills.

In addition, there will also be periodic monitoring of groundwater through boreholes installed around the main structures of the project, in order to ensure that the surface control systems are being effective and there are no effluents and liquids infiltrating the soil or groundwater.

Table 2.9-7 presents the main sources of generation of liquid effluents in the operation phase of the project.

Table 2.9-7 – Analysis of effluent emissions in the Operation Phase of the Piauí Nickel Project.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Rain water Drainage	Access Roads Leach Pads Administrative and operational support area Stockpiles & Waste Rock Dumps Residue Disposal Area Mine Areas Pumping water from inside the pits	Effluent basically characterized by water and sediments from the breakdown of soils where there is an impact of rain on unprotected surfaces such as roads, accesses, embankments and areas without vegetation cover or areas with exposed ore. Sediment transport via runoff to valley areas. The water percolated through the residues may contain traces of acid or other chemicals from the industrial process. Effluent characterized, at first, by water and sediments from the internal area of the pit due to rainfall.	Use of efficient drainage systems. Revegetation of exposed areas. Controlled deforestation of the areas following the plans for sequencing the mine and stockpile and waste dumps. The water can be incorporated into the industrial process without being discharged into the environment or, if discarded, it must pass through a control system such as containment dikes, water quality monitoring and energy dissipation devices. The water percolated in the tailings and collected in the waterproofing mat will be directed to a containment pond and later reused as process water or destined for a duly licensed landfill. Periodic monitoring of groundwater through installed wells, in order to ensure that no effluents and liquids are infiltrating the soil or groundwater.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Oily Effluents	Mine Workshop	Effluents characterized mainly by oils and greases from the vehicle and equipment maintenance workshop of the mine where there will be activities such as oil change, maintenance and washing of vehicles and equipment. Effluents (which may occur) composed of fuels and lubricants stored in tanks / drums in the supply areas subject to the risk of eventual leakage.	The machines will be subjected to mechanical maintenance only on waterproofed floor with side channel system for collection. From this floor, the area will be drained into a system of oil and water separating boxes, where they will be concentrated in the boxes and, as they are filled, will be stored in sealed drums, for soon after being marketed to the recycling industry or others uses, evidently for customers who have an environmental license. Eventual oil leaks from the machines outside the workshop area must be contained in an oil drum that will be available in the workshops. Use of fuel and lubricant containment basins for protection in case of accidental leakage. Adoption of a preventive overhaul program on the machines, in order to prevent leaks. In the event of leaks, the affected points will be isolated and treated using sand and sawdust so that the excess oil can be removed, avoiding carrying the contaminant to the natural drains. This contaminated material, after scraping, will be collected and temporarily disposed in waterproofed areas, for later final storage in approved areas .

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Sanitary effluents	Administrative Area	Effluents from the use of cafeteria and sanitary facilities by workers.	Domestic sewage from bathrooms will be treated at the project's Sewage Treatment Plant, with the final treated effluent being discharged into the natural drainage. Use of a fat box in the cafeteria for its separation and subsequent destination for composting or licensed landfill.

2.9.9.2. Solid Waste

During the operation phase, various types of solid waste related to the administrative and operational support areas of the Piauí Nickel Project should be generated.

The solid residues foreseen for this phase will be all those solid or semi-solid residues, resulting from activities related to the operation of the project such as equipment maintenance, ore and waste mining, heap leaching, hydrometallurgical plant, use of restaurant, dressing room and social areas , sewage treatment plant, among others.

The waste will be classified according to the ABNT NBR 10.004 / 2004 standard, and temporarily stored and destined following the standards NBR 12.235 / 1992, NBR 7.500 / 2011 and NBR 13.221 / 2007.

The waste generated during the operation phase is presented and characterized below, in Table 2.9-8.

Table 2.9-8 – Analysis of waste generation in the Project's operational areas.

Type of Waste	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Organic Waste (sludge)	Class I	Sewage Treatment Plant Sludge	The sludge from the sewage treatment plant will be collected by a specialized and qualified company, which will be responsible for its final destination.
Non-inert / hazardous waste in general	Class I	These will be generated in several areas of the project. They may bring some environmental risk, for example, acid batteries, fluorescent lamps, batteries, packaging and residues of chemical reagents, among others.	These wastes will be stored and disposed of properly according to the procedures established in the Waste Management Program to be prepared in the future.
Oily Waste	Class I	The lubricating oil and grease used, after the planned changes, in the engines of the machines and trucks, generated in the maintenance workshops.	The oil must be collected in drums, with a hermetically closed lid, and must be safely stored until it is transported for re-refining with a certified company. In these drums, all the waste to be collected routinely from the water / oil separator box should also be stored. The floor of the workshop will be waterproof, and should be kept free of cracks that could allow percolation of this residue.

Type of Waste	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Waste contaminated with oil and grease	Class I	Waste generated in the vehicle and equipment maintenance workshop.	These wastes will be duly classified and sent to duly licensed controlled landfills, in accordance with standard NBR10.004.
Medical/Health Care Waste	Class I	They will be generated at the site medical clinic. It may generate a small amount of waste classified as hazardous.	The packaging of the waste will be in “Sharps” segregation boxes, suitable for sharp or cutting materials, which will be sent to the correct final destination. The storage will be in an appropriate place, adjacent to the clinic, in a white self-wheeled PVC drum, with a lid, locked with keys under the responsibility of the responsible physician or nursing assistant delegated by them. The packaging, internal and external collection containers, internal and external transport containers, and in the waste storage locations must be properly identified and in easy-to-see locations, using symbols, colors and phrases, meeting the parameters referenced in the Standards ABNT NBR 12809/1993 and NBR 7500/11.

Type of Waste	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Canteen waste, domestic and industrial	Class I & II	In the cafeteria, organic waste, plastics, glass, wood and packaging in general will be generated. In the administrative and operational areas, there will be the generation of other types of recyclable waste such as ferrous and non-ferrous scrap, glass, plastics, rubber; and non-recyclables, mainly from equipment and plant maintenance activities.	For recyclable waste, the implementation of a selective collection system and reuse of waste generated in the various areas is planned. To this end, the Waste Management Program should systematically assess the points of generation and types of waste, thus allowing for better planning and adoption of measures to optimize resources, reduce waste generation and define final destinations for each type of waste. Non-recyclable waste will be duly conditioned temporarily and periodically sent to final destination. Organic waste consisting of food scraps and leftovers will be sent for composting, or to a sanitary / controlled landfill.
Deforestation waste	Class II A	Vegetation clearing areas for mining	Temporary storage to wait for the appropriate final destination as defined in the Deforestation Plan.
Sanitary and sweeping wastes	Class II A	They will be generated in several areas where there is a circulation of personnel. They will consist of toilet paper, common sweeping garbage, prunings of vegetation and sludge from septic tanks and waste from chemical toilets.	These residues will be destined for composting, or for sanitary / controlled landfills. Waste from septic tanks and chemical toilets will be collected by a specialized company licensed for this purpose.
Mine Rock Waste	Class II B	Material generated at the mine below the ore cut-off content.	This waste will be disposed of in the dumps near the mine pit.

Type of Waste	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Plant residues	Class II B	Spent ore from the heap leach and solid filtered wastes generated at the Hydrometallurgical Plant.	It will be disposed of in the residue storage area that will be on compacted material with a protective HDPE liner, in addition to having a containment pond also waterproofed to collect any kind of solution from the residues and avoid any infiltration into the soil.

2.9.9.3. Atmospheric Emissions

The main atmospheric emissions expected for the project's operating works are limited to emissions of particulate materials and gas emissions.

In the project in question, the most likely particulate matter expected will be dust and soot from activities and equipment that load and transport solid materials and, mainly, in unpaved roads and mine areas, due to the movement of vehicles.

Gaseous emissions are basically composed of gases such as carbon oxide (CO and CO_2), nitrogen oxides (NO_x), sulfur oxides (SO_x) and hydrocarbons. The gaseous effluents characteristic of the project consist of the fumes and gases produced in the operation of light and heavy vehicles (automobiles, vans, trucks, trucks, etc.), light and heavy, fixed and mobile equipment (compressors, dozers, loaders, etc.), that use fossil fuel burning engines as the driving force, basically diesel oil. In addition, the fumes and gases generated in detonations for rock blasting must be considered.

Sulfuric acid (H_2SO_4) mist emissions are also considered, depending on the activities of the sulfuric acid plant at the nickel processing plant.

Table 2.9-9 presents an analysis of the projected atmospheric emissions for the project.

Table 2.9-9 – Analysis of atmospheric emissions in the project operation - fixed and mobile sources.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Particulate Material	Road and access maintenance operation Stripping and opening new mining fronts Handling of light and heavy vehicles on unpaved roads Action of winds on exposed surfaces in the areas of stockpiles roads, accesses and embankments of the mine. Mine loading operation in the mine Ore and waste transportation Unloading ore and waste into stockpiles Drilling, clearing blast holes Blasting by explosives	Particulate material in the form of dust due to the generation of material mechanically broken down by heavy equipment, and the loading of solid material. These particles are released into the atmosphere by the action of the wind and by the operation and movement of vehicles and equipment. Particulate material in the form of dust and rock fragments released into the atmosphere after rock blasting by explosives and mechanical excavation in the mine. Particulate material in the form of soot from vehicle exhaust and operating equipment. Processing Plant: emission of dust during the unloading of ore from trucks at the beneficiation plant or during the breaking of coarse material at the same location.	Use of periodic spraying with water trucks in all workplaces and access roads. The periodicity of the truck passages cycle will be defined according to weather conditions such as air humidity, insolation and rainfall. In the ROM storage yards and in the crushing and screening area, the sprinkler system will be through fixed sprinklers and will be necessary due to the generation of dust and particulate material. The accesses must be lined with lateritic soil, to constitute a good rolling base and reduce the generation of dust. Revegetation of exposed areas as soon as they are cleared. The material can leave the mine with a minimum of natural moisture enough to mitigate the generation of particulates from the buckets. Use of equipment and vehicles in good mechanical condition Detonations in suitable atmospheric conditions to avoid great dispersion.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
	Ore crushing Processing plant Operation of light and heavy equipment moving around the mine area		Use of dust collectors or wet drilling operation. The powder produced in the processing will be insignificant. However, water sprinklers can be used in the sieves.
Gaseous	Blasting by explosives Operation of equipment and traffic light and heavy vehicles Sulfuric Acid Plant Operation	Gaseous emissions from explosive detonations characterized by gases such as carbon dioxide and nitrogen and, in some cases, SOx, CO and NOx compounds. Gaseous emissions characterized by gases such as CO, CO_2, NOx, SOx and hydrocarbons, generated from the burning of fossil fuels for the operation of fixed and mobile equipment. Emission of a sulfuric acid (H_2SO_4) mist	Periodic maintenance of light and heavy equipment and vehicles. Use of new equipment or in good condition, regulated, as well as maintenance and periodic replacement of filters as instructed by the manufacturer. Detonations in suitable atmospheric conditions to avoid large dispersion.

Source: Arcadis, 2017.

2.9.9.4. Noise & Vibration

The main sources of noise and vibration emissions expected for the project's operating phase are:

- Traffic of light and heavy vehicles on roads and accesses;
- Handling and operation of light and heavy equipment and vehicles;
- Operation of the industrial complex;
- Operation of fixed equipment;
- Mechanical maintenance activities;
- Detonation by intermittent explosives.

Traffic of light and heavy vehicles on roads and accesses will be a source of noise, which may affect workers, nearby communities and local fauna.

The handling and operation of heavy equipment in the mine and in the vicinity will be an important source of noise and vibration emissions on the ground. This is due to the traffic of loaded heavy trucks, the operations of road maintenance and environmental recovery, the loading and unloading of material, in addition to the stripping and opening of new mining fronts.

The operation of process equipment is a typical source of noise. The industrial plant, when in continuous operation, is characterized as a source of noise in the mineral processing environment.

The operation of fixed equipment in various operations, both in the mine and in the areas of administrative and operational support, will emit noises that cannot be completely eliminated, but can be reduced. The same case applies to drilling rigs whose function will be to drill the holes for blasting by explosives.

Mechanical maintenance activities are sources of noise generated mainly in the project's maintenance workshop. These activities can be summarized in percussion, scraping, drilling, cutting, grinding, turning of motors, twisting, use of compressed air and other movements necessary for the exchange and / or adjustment of parts, general repairs and use of manual or electric tools.

Noises and sound pressure from rock blasting are those from the detonation of explosives at points where the rock exhibits great resistance to excavating mechanically. The noise and, above all, the over acoustic pressure are caused by the release of gases through fractures of the rock and also by the upper part of the explosive column.

Constant monitoring will be carried out during the operation, using engineering seismographs to define the optimum load for waiting. Adherence to planning and monitoring is expected to minimize the effects and impacts generated by detonation, such as noise and air pressure (air blast); propagation and vibrations in the ground and surrounding air.

Table 2.9-10 shows an analysis of the sources of noise and vibrations expected for the operation of the mineral-processing complex.

Table 2.9-10 – Analysis of the noise and vibrations expected at the Operation Phase – fixed and mobile sources.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Noise	Drilling operation Blasting with explosives Operation of process equipment (industrial complex) Traffic of light and heavy vehicles on roads and accesses Handling and operation of light / heavy equipment and vehicles	Noises caused mainly by the operation of engines and, secondarily, by friction of moving parts of the equipment and against the ground or rock. Atmospheric overpressure characterized by the propagation of an elastic wave through the air due to the abrupt expansion of explosive gases through fractures of the rock and the explosive column itself. Noises caused due to the operation of the processing facilities. These noises will be felt more in the vicinity of the equipment.	Drills: use of new equipment and maintenance of equipment of this nature. Equipment and Vehicles: Periodic maintenance of light and heavy equipment and vehicles. Blasting of rocks by explosives: implant a control and safety perimeter with a safety radius from the limit of the proposed pit; execute perfectly demarcated and perforated drilling grids; carry out a well-planned and executed fire plan; detonate only at pre-established times; avoid detonating on Sundays, holidays and in periods of silence; avoid detonating unconfined explosives; consider the weather conditions, avoiding detonating in the morning or after sunset, on clear and still air days; try not to direct the detonation front towards people; always start detonation with the fewest holes in standby; keep the load within the specified range; use of better technology material. Use of PPE (ear protectors) by operators.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Vibration	Blasting with explosives	Vibrations caused by the detonation of explosives to blast rock in the mine when a fraction of energy released by the explosive is not converted into useful work and is transmitted to the rock mass.	Vibrations can be reduced by using more advanced technology, adopting an efficient fire plan, adopting delays between rows or rows compatible with the frequency of vibration, in addition to blasting in favorable atmospheric conditions.
	Handling and operation of heavy vehicles and equipment	Vibrations caused due to the weight of vehicles and heavy equipment. These vibrations are generally restricted to the vicinity of the generating agent and cease immediately as soon as the movement ends.	Adoption of maintenance program for vehicles and heavy equipment focusing on alignment, balancing, replacement of defective parts, tightening of loose parts, etc.

2.9.9.5. Sediments

In addition to the rain drainage system that will cover the entire area of the project, the construction and operation of 4 solid containment dikes is planned to contain the fines eventually carried by rainwater from all the project's structures, as shown in no Map 2.1-1.

The dike massif will be built with rockfill (blocks of rock), with granulometric transitions in the upstream parameter (contact with sediments) and in contact with the foundation. The material deposited on the dikes should be removed periodically, by excavation, and transported for disposal in the waste dump area itself.

2.9.10. Operation Schedule

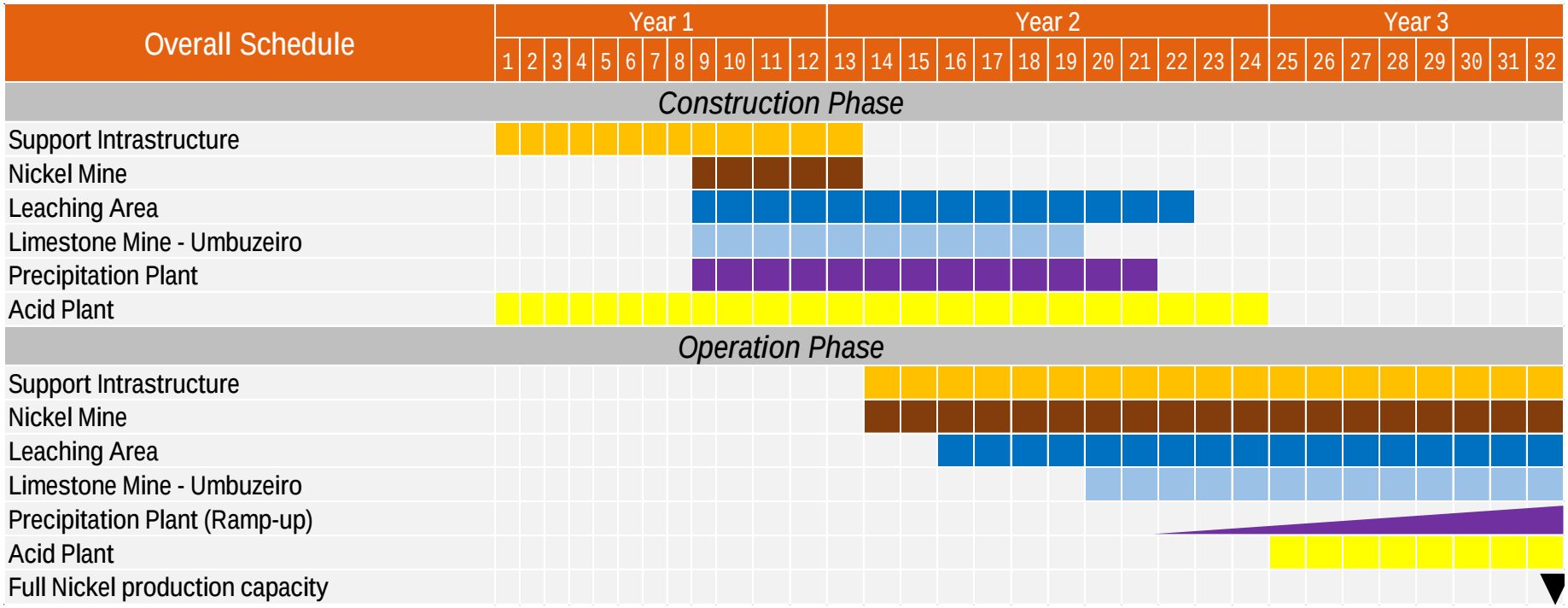
The beginning of the operation of the project structures will be gradual, as presented in the Table 2.9-11. The support infrastructures (access roads, water supply and 69kV LT), mining, crushing and assembly of nickel ore heaps will start operating at the beginning of the first month of the project's operation Phase. The leaching of the heaps with acidic solution will start shortly after the assembly of the heaps, around the third month.

Considering the long period of the construction and the heap leaching process to obtain the first concentrated nickel solution for processing, the processing plant will only start operating around the 10th month, with a staggered production until reaching the maximum production capacity, in the 19th month. The acid plant will be the last structure to start operating, in such a way that until the beginning of its operation, the sulfuric acid used will come from external suppliers.

It should be noted that the respective environmental control structures will be in place and operational at the beginning of the operation phase.

The useful life of the project is conditioned to the exhaustion of the nickel ore deposit, estimated for 17.6 years in the current knowledge of the deposit.

Table 2.9-11 – Operation Schedule (Months).



Source: PNM, 2017. Prepared by: Arcadis, 2017.

2.10. Closure Phase

Decommissioning (Closure Phase) is the last Phase of a mineral undertaking. It is the moment when, according to the defined future use, the area is prepared for its new function, whether environmental, industrial or social.

However, decommissioning must be done according to technical and environmental criteria, since a given project or infrastructure should not cause damage to the environment after its activities are closed. The measures to be implemented aiming at decommissioning depend, as mentioned, on the chosen future use that will be given to the area where the structure in question is located. What is expected is the full environmental balance of the area in terms of physical, chemical, biological and social aspects.

Therefore, in order to ensure the stability of the Piauí Nickel Project's component structures, such as the waste dumps, residue storage, pit slopes, with a view to decommissioning, together with the other infrastructure units of the project, measures should be implemented with the objective to provide physical and environmental stability after its useful life has expired. The suggested procedures aim at the security of the structures in order to allow their harmonious incorporation into the local environment, or even, the use of the area for another economic activity. The measures to be implemented are as follows:

- Critical interpretation of the geotechnical monitoring data performed during the operation phase of the waste and residues deposition system and observations collected during this period, regarding safety conditions and the occurrence of unstabilized displacements;
- Assessing the efficiency of surface drainage systems and the need to implement complementary actions;
- Implementation of vegetation cover according to the future use that will be planned for the area;
- Continuation of the geotechnical monitoring of the structures, as well as the evolution of the vegetation cover, with the objective of decommissioning it, together with the other areas that are part of the project.

In general, as pointed out by Sánchez et al (2013), the deactivation of a mining operation is considered to be the process of closing down its activities, starting just before the end of mineral production and concluding with the removal of all unnecessary installations and the implementation of measures that guarantee the security and stability of the area, including environmental recovery and social programs. This process involves an integrated analysis, taking into account technical, environmental, social and financial criteria, applied to the characteristics of each mining venture.

Mining is characterized by being an extremely dynamic activity, and the decision making for the deactivation of a mine depends on a series of factors, among which the level of knowledge of a mineral resource, the technological advance that allows the use of resources that until then had no economic value and the consumer market.

It is important to note that the phase of deactivation of the Piauí Nickel Project must be supported by a closure plan to be implemented with the execution instrument, the preparation of a closure plan. This plan will be discussed in the chapter on Mitigating, Compensatory Measures and Environmental Programs of this ESIA.

To ensure a successful closure of the mine, the following principles can be followed:

- Outline the mine with the closure in mind, in order to build and operate all the utilities to make the vision of the mine closure real;
- To become aware of the best available techniques and technologies for planning the closure of operations and preparing the mine closure plan;
- Manage and reduce the communities' dependence on the operation of the project, through the life cycle of the entire operation;
- Minimize post-closure liabilities and the need for major changes to the structure of the project close to closure through proactive planning and execution;
- Developing the closure vision over time, satisfying the requirements contained in the mine closure plan;
- Program post-mining water use plans;
- Remove, rehabilitate or render inert all materials liable to pollute and contaminate water resources.

2.10.1. Control Systems

2.10.1.1. Effluents

The main emissions of liquid effluents expected during the Closure Phase are summarized in rain drainage, oily and sanitary effluents.

Rainwater drainage is characterized by the incidence of rainfall over exposed areas and over those with exposed disaggregated material. Most of these areas will be characterized in the Closure Phase as those in the process of decommissioning.

The oily effluents foreseen for the project closure must be those from a vehicle and equipment maintenance workshop. This workshop can be set up specifically for decommissioning the structures or the project's own workshop can be used. Activities such as oil change, maintenance and washing of vehicles and equipment will take place there. The oily effluent will basically consist of water, oils, greases, sediments and various cleaning products.

It can also be considered an area for refueling these vehicles and equipment where there will be fuel tanks and storage of lubricants and, in the event of a leak, it may constitute a liquid effluent contaminating soil and water.

The sanitary effluents will come from the use by kitchen workers and sanitary facilities (bathrooms and changing rooms) both in existing areas and in construction sites that may be set up specifically for the decommissioning of structures and environmental recovery of degraded areas. Table 2.10-1 shows the main sources of emission of liquid effluents in the project's closure Phase.

Table 2.10-1 – Analysis of emissions of liquid effluents in the closure phase of the Piauí Nickel Project.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Rain water Drainage	Set aside areas for recovery Access Storage and parking yards Maneuvering areas Decommissioning site areas	Effluent basically characterized by water and sediments from the disintegration of soils where there is an impact of rain on unprotected surfaces such as roads, accesses, embankments and other areas without vegetation cover. Sediment transport via surface runoff to the bottom of valleys where the region's water collections are located.	Use of efficient drainage system. revegetation of exposed areas
Oily Effluents	Workshop / Washer / Decommissioning Site Lubrication Area Storage areas for oils and lubricants (risk of leakage / spillage)	Effluents characterized mainly by water, oils and greases, sediments and cleaning products in general from vehicles and equipment maintenance areas where there will be activities such as oil change, maintenance and washing. Effluents composed of fuels and lubricants in the supply areas subject to the risk of leaks and possible spills.	Use of containment boxes and impermeable floor around tanks and other fuel and lubricant storage devices. Waterproofing the floor of areas where maintenance and washing activities for equipment and parts will be carried out. Use of solids settling boxes and water-oil separators.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Sanitary Effluents	Decommissioning site Service areas distributed in specific points of the project	Effluents from the use of kitchens and sanitary facilities (fixed and mobile toilets, and changing rooms) by workers in decommissioning works.	Use of the environmental control systems used in the operation, leaving them to be demobilized last. After demobilization, use of compact and temporary systems until the end of decommissioning.

2.10.1.2. Solid Wastes

In the decommissioning Phase, several types of solid waste should be generated, mainly related to the dismantling and demolition activities of the structures.

In an overview, the main wastes foreseen in the project decommissioning Phase can be classified as:

- Medical (or health service) waste: from health areas such as wards and outpatient clinics. They consist of syringes, needles, bandages, medicine bottles, etc. that are subject to contamination by pathogenic agents;
- Household waste: originating from living areas, offices, bathrooms, accommodation and other structures that are similar to the daily activities of a household. They consist basically of food scraps, paper, glass, toilet paper, plastic, etc.;
- Commercial waste: also from the administrative areas of specific work sites for deactivation. They focus more on the generation of waste with a higher degree of recycling such as packaging, cardboard, paper, etc .;
- Rubble: typical construction waste and renovations. These should be generated mainly at the demolition sites of the project's physical structures such as hydrometallurgical plant, acid plant, administrative and operational areas, ordinance, explosive deposits, among others. They will be composed mainly of wood, steel, wire, glass, bricks, concrete, as well as surplus earthwork material.

Table 2.10-2 presents a general analysis of the main residues foreseen for the Closure Phase of the Piauí Nickel Project as a whole.

Table 2.10-2 – General analysis of the main residues foreseen for the Piauí Nickel Project Closure Phase.

Type of Waste	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Agrochemical packaging	Class I	Areas in environmental recovery. Waste consisting of packaging of fertilizers, pesticides and other agronomic products.	Temporary storage, as defined in standard NBR 12.235, to await the appropriate final destination as defined in the Mine Closure Plan.
Hazardous demolition wastes	Class I	Areas subject to dismantling, that is, those where there will be structures of the project. Wastes basically composed of contaminated materials, oil residues, greases, other chemicals, heavy metals, etc.	Temporary storage, as defined in standard NBR 12.235, to await the appropriate final destination as defined in the Mine Closure Plan.
Medical Waste	Class I	They will be generated in a unit planned for an outpatient / temporary ward or medical post before its closure. It should generate a small amount of waste classified as hazardous.	These residues must be properly separated and stored for final destination as provided for in the Mine Closure Plan.
Non-inert / hazardous waste in general	Class I	They will be generated in several areas to be decommissioned in the project. They may bring some environmental risk, for example, acid batteries, fluorescent lamps, batteries, packaging and residues of chemical reagents, among others.	This waste will be stored (as defined in NBR 12.235 and NBR 11.174) and disposed of properly according to the procedures established in the Mine Closure Plan to be prepared in the future.

Type of Waste	Classification NBR 10.004/2004	Probable points of generation	Proposed environmental control system
Sanitary and sweeping wastes	Class I & II	They will be generated in several areas where there is a circulation of personnel. They will consist of toilet paper, common sweeping garbage, vegetation pruning and septic tank sludge.	This waste will be disposed of in duly licensed in landfills in the region.
Demolition waste	Class IIA/IIB	Civil Construction Waste from demolition	This waste may be disposed of in licensed landfills and prepared to receive them in the project region. However, this will be better defined in the Mine Closure Plan.
Refectory and household waste	Class II	Cafeteria and other areas of the work site for closing. Waste basically consisting of organic waste, plastics, glass, wood and packaging in general.	For recyclable waste, a selective collection system will be implemented to reuse it during the decommissioning phase. Non-recyclable waste will be temporarily stored in an appropriate location, as defined in NBR 11.174, and will later be sent to a duly licensed landfill in the region. Organic waste consisting of food scraps and leftovers may be segregated for reuse through composting for later use in degraded areas or sent to a properly licensed landfill in the region.
Non-hazardous demolition wastes	Class IIA/IIB	Areas subject to demolition, that is, those where there will be structures of the project. Waste basically composed of rubber, wood, plastic, glass, cardboard, etc.	Temporary storage, as defined in standard NBR 11.174, to wait for the appropriate final destination as defined in the Mine Closure Plan.

2.10.1.3. Atmospheric Emissions

The main atmospheric emissions expected for the Piauí Nickel Project Closure Phase are limited to particulate emissions and gas emissions.

Particulate matter emissions are formed by dust, fumes, smoke and mists. These emissions are formed by particles of the most diverse sizes and can be in solid and / or liquid form.

The most likely particulate emissions for the closing activities would be in the form of dust and soot. The dust, originating from the mechanical disintegration of materials, should be generated mainly by the traffic of vehicles and equipment on unpaved roads, cargo transportation and by the opening of operations to recover areas. The soot will come from the exhaust of vehicles and equipment in operation.

Gaseous emissions will basically consist of gases such as carbon oxide (CO and CO_2), nitrogen oxides (NOx), sulfur oxides (SOx) and hydrocarbons. These emissions will come from the operation of light and heavy vehicles (automobiles, vans, pickup trucks, trucks, etc.), light and heavy fixed and mobile equipment (compressors, generator sets, tractors, loaders, etc.) that use as a driving force fossil fuel burning engines.

Table 2.10-1 presents an analysis of the atmospheric emissions forecast for this Phase.

Table 2.10-1 – Analysis of the atmospheric emissions forecast for this closure Phase.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Particulate Material	Refurbishment of areas for recovery	Particulate material in the form of dust due to the generation of material mechanically disaggregated by heavy equipment, transportation of disaggregated material and due to the movement of vehicles and equipment on roads and accesses. These particles are released into the atmosphere by the action of the wind and the movement of vehicles and equipment. Generation of smoke from the combustion engines of vehicles and equipment.	Use of judicious sprinkler via water truck in all exposed areas that are created.
	Opening of accesses, yards and maneuvering areas		Revegetation of exposed areas as soon as they are released.
	Wind action in exposed areas awaiting recovery		Adoption of a periodic maintenance program for equipment and vehicles.
	Truck loading operation		Use of new equipment and vehicles or in good condition, regulated according to the manufacturer's instructions.
	Transport of disaggregated material		During transportation, cargo should be protected by tarpaulin, when possible and appropriate.
	Handling of light and heavy vehicles		Reduce the speed of travel at points with the highest concentration of disaggregated material.
	Maintenance of rainwater drainage system		
	Compressor operation		Application of an efficient periodic equipment maintenance plan.

Type of Emission	Sources	Principle Characteristics	Proposed Environmental Control System
Gaseous	Compressor operation Operation of light and heavy vehicles Light and heavy equipment operation	Gaseous emissions characterized by gases such as carbon monoxide and dioxide, nitrous oxide, hydrocarbons, sulfur oxides, etc. generated from the burning of fossil fuels for the operation of equipment and vehicles.	Adoption of a periodic maintenance program for this equipment and vehicles. Use of new equipment or in good condition, regulated according to the manufacturer's instructions.

2.10.1.4. Noise & Vibration

The main sources of noise and vibration emissions foreseen for the closing Phase of the Piauí Nickel Project are:

- Handling and operation of light / heavy equipment and vehicles;
- Operation of fixed equipment;
- Mechanical maintenance activities;
- Demolition by explosives or hydraulic breaker.

The handling and operation of heavy equipment will be a major source of noise and vibration emissions on the ground during the decommissioning period. This is due to the traffic of loaded heavy trucks, road maintenance operations and environmental recovery in addition to the loading and unloading of material.

The operation of fixed equipment such as compressors and pumps, necessary for generating compressed air and pumping fluids for use in various decommissioning activities, will emit noises that cannot be completely eliminated; only attenuated. The same case applies to drills and hydraulic breakers to perform demolition of structures in general.

Mechanical maintenance activities are sources of noise generated mainly in the maintenance workshop of the closing site. These activities can be summarized in percussion, scraping, drilling, cutting, grinding, turning of motors, twisting, use of compressed air and other movements necessary for the exchange and / or adjustment of parts, general repairs and use of manual or electric tools.

Noises and sound pressure (or atmospheric pressure) from demolition of structures, if necessary, are those arising from the eventual detonation of explosives on very rigid concrete bases.

Table 2.10-2 shows an analysis of the sources of noise and vibrations expected for the closure phase of the Piauí Nickel Project.

Table 2.10-2 – Analysis of noise and vibration emissions - fixed and mobile sources - in the Project closure Phase.

Type of Emission	Sources	Principal Characteristics	Proposed Environmental Controls
Noise	Handling and operation of light and heavy vehicles Compressor operation Use of explosives Use of hydraulic breakers Demolitions in general	Noises caused mainly by the operation of engines, hydraulic breakers and friction between moving parts of the equipment and friction against the ground / rock. Noises generated from the dismantling and demolition of the decommissioning project's structures. They are characterized by the use of manual equipment, percussion, scraping, cutting and other inherent equipment.	There is no way to eliminate noise completely, but they can be mitigated by adopting an efficient program for maintaining vehicles and equipment and using them in good condition. For the use of explosives, adopt a fire plan compatible with the situation that requires this activity.
Vibration	Handling and operation of heavy vehicles and equipment	Vibrations caused due to the weight of vehicles and heavy equipment being displaced by roads and accesses. These vibrations are generally restricted to the vicinity of the generating agent and cease immediately as soon as the movement ends. Vibrations caused by the detonation of explosives, when necessary, at points that present material resistant to demolition, such as rigid concrete bases.	Vibrations can be attenuated by adopting a maintenance program for vehicles and heavy equipment focusing on alignment, balancing, replacement of defective parts, tightening of loose parts, etc. Adoption of an efficient fire plan. However, the ideal is to avoid the use of explosives as much as possible and adopt hydraulic breakers to demolish the structures.

3. Applicable Regulations

This chapter presents an examination of the relevant legislation applicable to the future implementation and operation of the Piauí Nickel Project, which is located in the State of Piauí, with an emphasis on issues related to environmental control and protection and the institutional aspects inherent to it.

To be viable, the nickel mining project will also require:

- a limestone mine in the municipality of Dom Inocêncio, in the Umbuzeiro location, to supply a demand of 476,000 tonnes / year, for the processing of nickel in the Brejo Seco Complex, in Capitão Gervásio Oliveira;
- the opening of new access routes including an exclusive connection route between the nickel industrial plant and the State road PI-465;
- a sulfuric acid plant;
- a pipeline, about 33.52 km long, buried, to capture 460 / m^3 / h of water in the Jenipapo dam, according to ANA Resolution 1,340 / 2014;
- the construction of a 69 Kv Transmission line 42.63 km in length, with an exit point at the CHESF substation in São João do Piauí, going towards Campo Alegre do Fidalgo parallel to the PI-465 road and diverging to the project, with approximately 103 towers.

Thus, we seek to compose a basic framework that contributes to the understanding, not only of the nature and objectives of this Environmental Impact Assessment, as a necessary planning tool for administrative licensing, but also of the possibilities and limitations of competence that the legal system - institutional framework imposes on the treatment of the various actions necessary for its consolidation.

To this end, the main legal instruments of the three levels of government were identified, with an emphasis on:

- the normative framework of the mining sector with reference to the DNPM - National Department of Mineral Production, one of those responsible, among other tasks, for the authorization of the project;
- national environmental legislation, its principles, objectives, instruments and forms of control;
- the environmental legislation of the State of Piauí;
- the main municipal rules and regulations.

Thus, and because it is a study aimed at incorporating other disciplines, as a support to the understanding and analysis of the legal and institutional factors that shape the existing and / or intended human activities in that region, it expresses a character of interaction and complementarity with the other studies that have been developed in this ESIA / RIMA.

In this sense and in view of its legal nature, this study, strategically, has a dual purpose, since it will support not only the environmental body responsible for licensing, but also the

entrepreneur himself in his decision-making processes regarding the improvement of the project, aiming, from the previous licensing, to consolidate its installation and operation.

However, in view of the large number of legal acts that must be observed, and to help the reading of the main standards relating to the project and its licensing, the legislation is presented in the form of tables, based on the hierarchy of laws and your chronology.

Therefore, a list of legal instruments taken from the current environmental legal framework will allow an understanding of the obligations required for the environmental management of federal roads

3.1. Preliminary Considerations

As a first step, in view of the need to ensure the understanding of some fundamental legal aspects that form the legal basis in the specific case, as well as to provide a swift and efficient process to the environmental licensing process, to set out some exceptional conditions for the intended project:

a) *The project subject to this study depends on express authorization by DNPM – i.e. the National Department of Mineral Production;*

b) *For this reason, although being a private enterprise, it is a strategic and essential undertaking for the public good, aimed at meeting the strategic needs of national development, and owned by the State because all ores and the subsoil are considered to be State assets, as explained in item IX, article 20, of the Federal Constitution;*

c) *In this way, although from the private sector, the enterprise is supported by public utility, so that, in due course, the entrepreneur may with authorization from the competent environmental agency, SEMAR / PI, if necessary, make use of all the exceptional environmental practices as to the use of natural resources and occupation of the intended area, enabling the project to be built and start operation, without prejudice to its obligation to adopt measures to mitigate and compensate for the environmental impacts that may arise, particularly the PRAD - Degraded Area Recovery Plan required at the time of closing the mine. It is worth remembering that the Forest Code recently reformulated by Law 12.651, of May 25, 2012, expressly characterizes mining activity as being of public utility, under article 8, item VIII, paragraph b.*

d) *The undertaking is also subject to express authorization from ANEEL for the production of energy in cogeneration from the sulfuric acid plant, either as an independent producer or as a self-producer, as well as for the implementation of the Transmission Line and;*

e) *Above all, you must be aware of the considerable risk of change to or even suspension of the water use rights granted by Res 1.340 of September 4, 2014, according to article 4, which expressly provides for this possibility due to adverse climatic conditions, negotiated allocations or meeting priority uses for human supply and animal feed, especially as the entire region covered by the project, including the municipalities of Capitão Gervásio Oliveira, Campo Alegre do Fidalgo, and Dom Inocêncio, are included*

in the state of emergency recognized by the federal government in mid-January 2017 due to the severe drought that has been getting worse, according to news published at www.portalgranderede.com.br/noticias/noticia/1432, accessed on 02/01/2017;

f) In addition, one should note:

- the broad character of the PNMA - National Environmental Policy, established by Law No. 6,938 of August 31, 1981, and accepted in its main points by the Federal Constitution of 1988, because it subordinates public and private policies in all other sectors to its instruments and forms of control, under articles 170 and 225 of the Federal Constitution, emphasizing: the protection of the environment as a public good; and the challenge of seeking a sustainable development model to conserve natural resources for current and future generations;
- compliance with federal legislation within the area and type of the proposed undertaking, as well as the legal and institutional framework for environmental protection in the State of Piauí, as carried out by SEMAR - State Secretariat for the Environment and Water Resources, under the guarantee CONSEMA - State Council for the Environment and Urban Development; and also with the Organic Law of the Municipality of Capitão Gervásio Oliveira, promulgated in 1997.
- the need to conduct the project during all its phases, of implementation, operation and closure, with the strictest environmental standards, both technical and regulatory, taking into account that the regulatory framework imposed is highly relevant to the intended activity, as well as others that make the validity of mining titles subject to environmental licensing.
- the possibility under article 12 of CONAMA Resolution 237/97, which allows the environmental authority to define specific procedures for environmental licenses, in light of each project's specifics and the compatibility of its implementation and operation Phases, whilst retaining the possibility in the specific case, at the discretion of SEMAR / PI, of a single LP to certify the environmental viability of the entire project, developing under different LI´s and LO`s as the works progress..

3.2. Competence in Environmental Matters

Issues relating to environmental policy fall within the group of laws over which states and municipalities have additional jurisdiction (the latter under the aegis of local interest, as per article 30, section I), or where the Federation only can dictate "general rules".

These parameters are to be found in art. 24 Sections VI and VII of the Federal Constitution, which expressly authorizes the states of the Federation to legislate concurrently with the Federation on forests, hunting, fishing, fauna, nature conservation, defense of the soil and natural resources, protection of the environment and pollution control; protection of historical, cultural, artistic, tourist and landscape heritage; and in article 30, Sections I and II, which authorizes municipalities to legislate in addition to federal / state legislation on matters of local interest.

In paragraph 1, it establishes the competence of the Federation to establish only general rules, it does not exclude the supplementary competence of States in its paragraph 2 and, in paragraph 3, it grants full legislative competence to States, to deal with their particular

circumstances, in case of non-Federal law; in case of contradiction, the general federal rules will prevail.

This means that states and municipalities are fully competent to legislate on environmental matters, as long as they do not contradict the principles established by federal laws, that is, as long as the events do not bring hidden disobedience to the general rules. In this way, state governments and municipal governments can make federal regulations more restrictive, but never less restrictive than those valid throughout the country.

On the other hand, it should be noted that, although legislative competence is concurrent, executive competence to “protect the environment and combat pollution in any of its forms”, as well as, “to preserve forests, fauna and flora ”, Is common, as determined by article 23 of the Federal Constitution, between the Federation, the States, the Federal District and the Municipalities, and any of these entities is responsible for promoting actions suitable for such purposes, under Complementary Law 140/11 .

These attributions were fully assumed by the Piauí State Constitution in its article 14, which deals with the competences of the state and by articles 237 to 246, which make up its chapter on the environment. These provisions are also addressed to the Municipalities of the State, and in Capitão Gervásio Oliveira, they were assumed by the Organic Law of the Municipality under article 141.

Thus, the preservation, conservation, defense, recovery and improvement of the natural, artificial and work environment are duties of the State and Municipalities, with the participation of the community, given the regional and local circumstances and in harmony with social and economic life.

This means that the bodies belonging to SISNAMA, within their sphere of competence, have a legal obligation to enforce the imperatives of the PNMA, its mechanisms and instruments, although there is no specific environmental norm at the state or municipal level.

3.3. Environmental Licensing for the Project

Environmental licensing is an administrative legal procedure characterized as one of the instruments of the National Environment Policy. It was introduced into our legal system, initially, by Law No. 6,803, of 7/2/80 and, later, validated by Law No. 6,938 / 81.

With the edition of the 1988 Magna Carta, the instrument, based on the assessment of environmental impacts, was received under the authority of article 225, section IV, which provided for the requirement “*in the form of the law, for the implementation of a potentially degrading work or activity for the environment, study environmental impact, which will be advertised*.”

Works related to the carrying on of mining activities, as well as the intended improvement, which characterizes the establishment of an industrial unit, are activities considered potentially degrading to the environment and subject to environmental licensing, as explained in CONAMA Resolution No. 001/86 (art. inc IX), and reiterated by CONAMA Resolution No. 237/97 Annex I.

It should be clarified that the environmental licence is irreplaceable and indispensable for the installation and operation of any real or potentially polluting activity, without prejudice to other legally required licences, issued by other federal, state or municipal bodies. This aspect is often overlooked, but it is intrinsic to the spirit of environmental licensing, assuming a two-way relationship between the State and the administration.

The issuance of the licence represents the formalization of a commitment signed between the entrepreneur and the Government.

On the one hand, the person in charge of the project commits to implement and operate its activity according to the conditions contained in the licence; on the other hand, the licensing agency guarantees that, during the term of the license, provided that the conditions expressed therein are complied with, no other environmental control requirements will be imposed on the licensee.

It should be noted, however, that there is no acquired right to pollute and if adjustments are necessary, the public authorities can and should make them to protect public health and the environment even if such measures prompt the entrepreneur into wishing to discuss possible indemnities.

Such procedure, as provided for in article 19 of Decree No. 99.274 of June 6, 1990, which regulated Federal Law No. 6.938 / 81, will provide for the entrepreneur to deliver environmental impact studies and for the public administration to grant administrative acts in the form of environmental licences, namely:

> I - Preliminary License (LP), in the preliminary phase of the activity planning, containing basic requirements to be met in the locational, installation and operational phases, observing the municipal, state or federal land use plans;
>
> II - Installation License (LI), authorizing the beginning of the construction, according to the specifications contained in the approved Executive Project, and
>
> III - Operation License (LO), authorizing, after the necessary checks, the beginning of the licensed activity and the operation of its pollution control equipment, in accordance with the provisions of the preliminary and installation licenses.

It is worth remembering that CONAMA Resolution No. 237/97, in article 10 Paragraph 1, requires that the opening of the licensing procedure must take place with a description of the project (engineering description), which must include:

- a City Hall certificate to the effect that the type of project or activity is in compliance with the municipal legislation for land use and occupation.

- Authorization[1] to remove vegetation by the competent environmental agency;
- permitting of the right to use water.

It should be noted, at this point, that these requirements can be amended by the environmental authority, depending on the type of project, and the licensing phases.

It is also worth noting that, under the terms of articles 16 and 17 of Law No. 7,805 of July 18, 1,989, no mining title is valid without the environmental licence as shown in the transcript:

> Art. 16. The mining concession depends on prior licensing by the competent environmental agency.
>
> Art. 17. The carrying out of research and mining works in conservation areas will depend on prior authorization from the environmental agency that manages them.

It is also worth remembering the incorporation of PRAD - Degraded Area Recovery Plan, as a fundamental part in the environmental licensing processes as determined by Decree nº 97.632, of April 10, 1989 and which should plan mine closure actions together with actions to rehabilitate the environment, allowing for a future use of the area. Such plan must be compatible with the PAE - Economic Use Plan for the deposit with DNPM.

It remains to be considered, in this section, that authority for the environmental licensing of the present project belongs to the State of Piauí, in view of the constitutionally deferred competence system, based on Complementary Law No. 140/11. It should be noted that the hypotheses of competence for the Federation described in article 7 are not present, nor those of the municipality, provided for in article 9.

As determined by article 7, sections XIII and XIV of the aforementioned LC 140/11, the Federation, through IBAMA, is responsible for licensing, and consequently inspecting, the undertakings (i) located and jointly developed in the neighboring country and country ; (ii) located and developed in the territorial sea and continental shelf; (iii) located and developed on indigenous lands; (iv) located and developed in two or more states; (v) located and developed in conservation units instituted by the Federation (except in APA); (vi) military in character; and (vii) involving radioactive materials and / or nuclear energy.

[1] The authorization for the removal of vegetation, permanently, awaits the processing of the ESIA / RIMA, and is normally only granted in the LI phase, through details of the executive project and compensation programs. Its requirement for the LP phase must be understood as a favorable statement by the competent body, in the case of SEMAR, that there is no insurmountable obstacle or legal impediment. This manifestation must be activated by the company.

In effect, by paragraph a, of inc. XIV, of article 9, of LC 140/11, the municipalities, and in the specific case, the prefecture of Capitão Gervásio Oliveira, if it has installed the COMDEMA - MUNICIPAL COUNCIL FOR ENVIRONMENTAL DEFENSE, if qualified to do so, and supported by an act specific to CONSEMA - STATE ENVIRONMENTAL COUNCIL, it could have the delegated authority to proceed with this licensing, because the criterion that emanates from LC 140/11 is the location of the project, and delegations between federated entities marked by future tripartite commissions, with the three levels of government.

As this did not happen, therefore, it is up to the State Secretariat for the Environment and Water Resources - SEMAR, to proceed with this licensing, with the backing of CONSEMA and CERH - State Water Resources Council, responsible for granting authorizations for funding. and use of water.

However, SEMAR must subject all licensing to the hearing and manifestation of the Capitão Gervásio Oliveira City Hall, (in compliance with the guidelines of the sole paragraph of article 4 of Res. CONAMA 237/97, for technical examination by the federated entities in the organs of the SISNAMA), which may propose additional, supplementary and specific requirements to guarantee the satisfaction of the environmental excellence indexes in its territory, as well as to amend the insertion of the project in the order of the occupation and use of the municipality's land, and to the control programs environmental problems that may already exist and are already underway in that location.

3.4. Acquisition of Areas – General Considerations

This section presents a summary of the main legal points that involve the acquisition of properties necessary for mining activities.

Obviously, as it is a summary of the main points, it does not exhaust the matter, and it does not enter into the legal controversies about doctrinal and procedural issues of the expropriation, indemnity, financial compensation (“royalties”) and servitude, which are the usual methods of releasing private land, for projects carried out by concessionaires or permit holders who qualify for the practice of public services or to explore Federal goods, as is the case with ores.

In addition, it is necessary to state that the survey and analysis of the forms of acquisition of properties and indemnification of owners and occupants, with their identification, preparation of maps of properties and evaluation of improvements, through proper registration, should be studied in depth and carried out between the LP and LI phases, which is why there is still no more specific detail that could better define the situation.

In fact, one of the worst problems faced by entrepreneurs in implementing their activities is the difficulty of accessing the exploitation areas when property owners refuse to enter into agreements or when formulating demands that are disconnected from reality.

Or even, when mining interests overlap with areas affected by specific laws that target them for environmental protection; for the settlement of rural workers; or for indigenous communities, because of their original right to the lands they occupy.

This is because the Federeal Constitution - CF, in its article 176, considered the deposits and mineral resources, a property distinct from that of the soil, belonging to the Federation, an edict that, due to its importance, for the case, follows below:

> Art. 176. “The deposits, in mining or not, and other mineral resources and the potential of hydraulic energy constitute a property distinct from that of the soil, for the purpose of exploration or exploitation, and belong to the Federation, the concessionaire being guaranteed the property of the product of mining.
>
> § 1 The research and mining of mineral resources and the use of the potential referred to at the head of this article can only be carried out with authorization or concession from the Federation, in the national interest, by Brazilians or a company constituted under Brazilian laws and that has its headquarters and administration in the country, in the form of the law, which will establish the specific conditions when these activities are carried out in a border strip or indigenous lands.
>
> § 2 - The owner of the soil is assured participation in the mining results, in the form and in the amount provided by law.

The problem is consolidated because mining is still backed by outdated diplomas and has not had its new regulatory framework approved, which, although it has been in progress for years, is still the subject of much discussion, with its most important references being the Bill 37 of 2011, and Bill 5,807 / 2013.

In this Bill, in addition to the transformation of the DNPM into an Agency, the bidding procedure is foreseen, instead of the right of first refusal to own the polygons of the deposits, and the possibility of the private - concessionaire to invoke the DUP - Declaration of Public Utility for the purposes of expropriation and bondage institution, for properties that are not obtained by amicable agreement.

Today, even though Decree 3,365 / 41 foresaw in its article 5, section “f”, mining activity as a case of public utility, its article 2, only provided legitimacy for its proposal to the federated entities or by service concessionaires public institutions and establishments of a public nature, or that exercise delegated functions of the public power, provided that it is contained in a specific law or in their concession or permission contracts.

In view of this obstacle, the current Mining Code places at the disposal of entrepreneurs the institute of *Servidão de Mina*, under the terms of article 59 of the Mining Code, whose objective is to make mining projects in the country viable, authorizing the holder of a mining right to use, exclusively and temporarily, the portion of the property affected for mineral research, or for the exploration and exploitation of the mineral deposit located there, with the specific purpose of meeting the extensive list of purposes provided for in the aforementioned article of Decree-Law 227 / 1967, aimed at making the implementation of the mining project feasible.

Note that in the specific case, each stage or subproject mentioned above must have different forms of acquisition / negotiation of properties, in view of the legal and institutional characteristics that make up each sector, being certain that for the road, the water pipeline and the Transmission Line - LT, the publication of a decree of public utility, by the corresponding granting authority, DNIT, ANA and ANEEL, should enable the institution of easement or the expropriation of private areas.

In the case of mining polygons under DNPM administration, the solution for the acquisition will depend on a specific agreement with the owner of the soil who will be able to sell his property or participate in the mining result as guaranteed by article 11 of Dec - Law 227/67 - Mining Code transcribed below:

> Art. 11. The following will be respected in the application of the Authorization, Licensing and Concession regimes:
>
> a) the priority right to obtain research authorization or license registration, attributed to the interested party whose application has as object an area considered free, for the intended purpose, at the date of filing the request with the National Department of Mineral Production (DNPM) , having met the other applicable requirements, established in this Code; and
>
> b) the right of the landowner to participate in the mining results. (Wording given by Law nº 8.901, of 1994)
>
> § 1 The participation referred to in paragraph b of the caput of this article shall be fifty percent of the total amount due to the States, Federal District, Municipalities and organs of the direct administration of the Union, as financial compensation for the exploitation of mineral resources, as provided for in the caput of art. 6 of Law No. 7,990, of 12/29/89 and in art. 2nd of Law nº 8,001, of 03/13/90. (Included by Law nº 8,901, of 1994).

Therefore, there is a need for the Installation License - LI application:

- to proceed to a register of occupations, able to record the property's limits and perimeters for descriptive plants and memories with GPS, as well as to register and evaluate improvements and also to constitute a profile of the owner and his family, registering the documents and deeds that you have on your property, (data necessary to bring legal actions if applicable);
- to develop a policy for the acquisition of areas capable of providing fair and quick compensation to the occupants, favoring friendly routes over judicial ones; and to foresee the indemnification conditions of vulnerable populations in sufficient amounts so that they can recreate their living conditions.

In the case of areas affected by rural workers' settlement projects, it is not enough to negotiate directly with the occupants, because INCRA - National Institute of Colonization and Agrarian Reform - has the domain of the land and its mandatory guarantee.

3.5. Main Legal Instruments

3.5.1. Federal Legal Acts

The main normative benchmark on the environment is the PNMA - National Environment Policy instituted by Law No. 6938 of August 31, 1981 which was, in its main points, received by the Federal Constitution of 1988.

Alongside this law, in an absolutely integrated and systemic manner, are Law No. 9433 of January 8, 1997 that instituted the PNRH - National Water Resources Policy and Law 9,605 of February 12, 1998 that typified environmental crimes and established respective penalties, giving in Article 70 a solid basis for the administrative activity of control and inspection.

Thus, it can be said that all other policies designed to guide the processes of land occupation and use of natural resources as well as the fight against pollution, such as the National Environmental Education Policy; the National Solid Waste Policy; the National System of Conservation Units; the National Policy on Climate Change and others, although signed as federal laws, have national scope and belong to a macro legal system with national scope that has SISNAMA - National Environment System as its backbone, and CONAMA - National Council of Environment, composed equally with civil society organizations.

Next to this structure, SNGRH - National Water Resources Management System; the SISNIMA - National Environmental Information System; the SNUC - National System of Conservation Units; and others.

This means that environmental legislation constitutes a macro legal system that makes flexible and articulates all other sectoral policies in pursuit of sustainable development as ordered by Article 170 of the Constitution.

This also means, as explained above, in sub-section 2.1 on competence in environmental matters, that all federal entities must observe federal commands as general guidelines for the formulation and application of state and municipal policies.

Regarding the regulation of the mining sector, the federal government recently published three Provisional Measures (MP) that change the sector a lot. However, these new laws do not yet have a definite practical effect since they have not yet been converted into Law and their consequences have not been regulated through Decrees and other legal instruments.

The aforementioned MP's are:

- MP 789: Amends Law No. 7,990, of December 28, 1989, and Law No. 8,001, of March 13, 1990, to provide for Financial Compensation for the Exploitation of Mineral Resources;
- MP 790: Amends Decree-Law No. 227, of February 28, 1967 - Mining Code, and Law No. 6,567, of September 24, 1978, which provides for a special regime for the exploitation and use of mineral substances that it specifies and makes other provisions;
- MP 791: Creates the National Mining Agency (ANM) and extinguishes the National Department of Mineral Production (DNPM).

According to information from the Agency for the Technological Development of the Brazilian Mineral Industry, on August 8, the statutory deadline for submitting parliamentary amendments to the three MPs edited by the Federal Government on July 25, within the Brazilian Mineral Industry Revitalization Program, ended. In those 15 days, 492 proposals were filed, including changes to the original text or the devices it changed and inclusion of new articles.

Thus, it is understood that the matter must still undergo several changes in relation to its original content, and the present project must conform to the sector's legislation insofar as the legal rules are defined.

The following are the other laws that relate to the implementation of the aforementioned project, now under licensing.

Federal Constitution	Menu / Main Commands
Art. 20.They are Federal benefits:	... IX - mineral resources, including those of the subsoil; X - the natural underground cavities and the archaeological and prehistoric sites; XI - lands traditionally occupied by Indians. Paragraph 1. Under the terms of the law, States, the Federal District and Municipalities, as well as organs of the direct administration of the Union, are guaranteed participation in the result of the exploitation of other mineral resources in the respective territory, continental shelf, territorial sea or zone exclusive economic or financial compensation for that exploitation.
Arts. 23 & 24	They establish the rules of functional division between the federated entities, imposing the common competence to act and competitor to legislate, in environmental matters
Art .30	Establishes the municipality's competence for matters of local interest
Art .170	The Greater Law, when dealing with the Economic and Financial Order, imposed as fundamentals the valorization of human work and free initiative, aiming at ensuring a dignified existence to all, according to the dictates of social justice, and established general principles for the development of economic activities. and financial, placing among these principles (sections III and VI) the “defense of the environment and“ the social function of property ”.
Art. 176	The deposits, in mining or not, and other mineral resources and the potentials of hydraulic energy constitute a property distinct from that of the soil, for the purpose of exploration or exploitation, and belong to the Federal Government, with the concessionaire ownership of the mining product. § 1 The research and mining of mineral resources and the use of the potentials referred to in the caput of this article can only be carried out with authorization or concession from the Union, in the national interest, by Brazilians or a company constituted under Brazilian laws and that has its headquarters and administration in the country, in the form of the law, which will establish the specific conditions when these activities are carried out in a border strip or indigenous lands. § 2 - The owner of the soil is assured participation in the mining results, in the form and in the amount provided by law.
Art 216	The Brazilian cultural heritage consists of goods of a material and immaterial nature, taken individually or together, bearing reference to the identity, the action, the memory of the different groups that form Brazilian society, which include: I - forms of expression; II - the ways of creating, making and living; III - scientific, artistic and technological creations; IV - works, objects, documents, buildings and other spaces intended for artistic and cultural manifestations; V - urban complexes and sites of historical, scenic, artistic,

Federal Constitution	Menu / Main Commands
	archaeological, paleontological, ecological and scientific value.
Art. 225, paragraph1º	Prays that everyone has the right to an ecologically balanced environment, a good for the common use of the people and essential to a healthy quality of life, imposing on the Public Power and the community the duty to defend and preserve it for present and future generations . To ensure the effectiveness of this right, it was incumbent upon the Public Power, in its § 1 IV - require, in accordance with the law, for the installation of a work or activity potentially causing significant degradation of the environment, prior study of environmental impact, which will be publicized. § 2 Those who exploit mineral resources are obliged to recover the degraded environment, according to the technical solution required by the competent public agency, in accordance with the law. § 3 Conduct and activities considered harmful to the environment will subject offenders, individuals or legal entities, to criminal and administrative sanctions, regardless of the obligation to repair the damage caused.

Federal Constitution	Menu / Main Commands
Decree-Law No. 25 of November 30, 1937.	It classifies as natural heritage assets, subject to special protection, natural monuments, sites and landscapes.
Decree-Law No. 3,365, of June 21, 1941.	Provides for expropriations for public utility
Law No. 3,924, of July 26, 1961	Provides for archaeological and prehistoric monuments.
Law No. 4,717, of July 26, 1965	Regulates Popular Action.
Law No. 5,197, of January 3, 1967	Provides for the protection of fauna and other measures (Hunting Code).
Decree-Law nº 227 of february 28, 1967	Instituted the Mining Code
Decree-Law nº 1,413 of August 14, 1975.	Environmental Pollution Control caused by industrial activities.
Law No. 6,938 of August 31, 1981.	It instituted the National Environment Policy, and created the SISNAMA National Environment System, aligning the three spheres of government for environmental management. It created CONAMA with parity between civil society and the government. It imposed strict liability on the degrader. Among its instruments, it chose, among others, the licensing and impact assessment of effective or potentially polluting activities.

Federal Constitution	Menu / Main Commands
Law No. 7,347 of July 24, 1985	Known as the law of diffuse and collective interests, it disciplines public civil action for liability for damages caused to the environment, to the consumer, to goods and rights of artistic, aesthetic, historical, touristic and landscape value and takes other measures.
Law No. 7,805, of July 18, 1989.	Amends Decree-Law No. 227, of February 28, 1967, creates the mining prospecting permit regime, extinguishes the registration regime, and takes other measures. Art. 16. The mining concession depends on prior licensing by the competent environmental agency. Art. 17. The performance of research and mining works in conservation areas will depend on prior authorization from the environmental agency that manages them. Art. 18. Research or mining works that cause damage to the environment are subject to temporary or permanent suspension, according to the opinion of the competent environmental agency. Art. 19. The holder of a research authorization, gold mining permit, mining concession, licensing or mine manifest is responsible for the damage caused to the environment.
Federal Law No. 7,990, of December 28, 1989	Institutes, for the States, Federal District and Municipalities, financial compensation for the result of the exploitation of oil or natural gas, water resources for the purpose of generating electricity, mineral resources in their respective territories, ...
Federal Law No. 8,001, of March 13, 1990	Defines the percentages of the distribution of the financial compensation referred to in Law No. 7,990, of December 28, 1989, and provides other measures.
Law No. 9,433, of January 8, 1997.	It institutes the National Water Resources Policy, defining principles and guidelines for action, such as the recognition of the hydrographic basin as a planning unit, and water as a good for the common use of the people, establishing a national system. Among its principles, the polluter (user) - payer stands out. One of the instruments provides for the onerous granting of rights to use water resources; All interventions in water resources, such as capturing or discharging domestic and industrial effluents, must be preceded by obtaining grants.
Law No. 9,605, of February 12, 1998.	Provides for criminal and administrative sanctions derived from conducts and activities harmful to the environment. Chapter V describes crimes against the environment. Article 70 allows the unfolding of this criminal law to the administrative level.
Law No. 9,636, of May 15, 1998	Provides for the regularization, administration, tenure and sale of real estate owned by the Federal Government, being important for the eventual regularization of the territorial base of the municipality of Capitão Gervásio Oliveira
Law No. 9,795 of April 27, 1999	Institutes the National Environmental Education Policy

Federal Constitution	Menu / Main Commands
Law No. 9,984 of July 17, 2000	Provides for the creation of the National Water Agency - ANA, an entity implementing the PNRH and coordinating the SNGRH, and takes other measures.
Law No. 9,985 of July 18, 2000.	It institutes the SNUC - National System of Conservation Units separating them into groups of integral protection and sustainable use. By the force of the CF, art. 225 § 1st inc. III, its alteration and removal will only be permitted by law, any use that compromises the integrity of the attributes that justify its protection is prohibited. The provision of article 36 for compensation in licensing with ballast in ESIA / RIMA was regulated by Federal Decree No. 6,848 of 05/14/2009 that inserted an equation and matrix for calculating the value limiting it to 0.5% of the value of the project .
Law No. 10,165, of December 27, 2000	Amends 6,938 / 81, institutes the Environmental Inspection Control Fee - TCFA.
Federal Law No. 10,257, of July 10, 2001	City Statute. Among other territorial control instruments, the Neighborhood Impact Study
Law No. 10,650, of April 16, 2003	Provides for public access to data and information existing in the bodies and entities that are part of SISNAMA.
Law No. 12,187, of December 29, 2009.	Institutes the National Policy on Climate Change - PNMC and takes other measures
Law No. 12,305, of August 2, 2010.	It institutes the National Solid Waste Policy, emphasizing the importance of public power, the business sector and the community in an adequate management of the waste generated. Holds generators and operators accountable. It provides the competent environmental agencies with the requirement for insurance. For the projects mentioned in article 20, the mandatory preparation of solid waste management plans imposes reverse logistics.
Law No. 12,527, of November 18, 2011	Regulates access to information provided for in section XXXIII of art. 5, in section II of § 3 of art. 37 and § 2 of art. 216 of the Federal Constitution;
LC - Complementary Law No. 140 of December 8, 2011	It establishes rules, under the terms of article 23 of the CF, for cooperation between federated entities in actions of common competence related to the protection of the environment and amends law 6.938, of August 31, 1981. It established new rules for the definition of competence environmental licensing and inspection priorities. It institutes tripartite commissions to define competence in complex cases and provides for delegation.
Law 12,651 of May 25, 2012	Instituted the new Forest Code. The way of calculating the Protection Areas of native vegetation on the banks of rivers, lakes and springs has changed, taking as a parameter the regular water level. Floodplains, mangroves, hillsides, hilltops

Federal Constitution	Menu / Main Commands
	and areas above 1800 meters can be used for certain economic activities; It allows the removal of vegetation in APPs and activities consolidated until 2008, provided that for public use, social interest or low environmental impact, including agroforestry activities, ecotourism and rural tourism. Other activities in APPs may be permitted by the states through Environmental Regularization Programs (PRA). Calculation of the legal reserve now allows overlapping with APPs. Establishes the concept of consolidated rural areas. Properties with up to four fiscal modules do not need to recompose native vegetation. It exempts rural landowners from fines and sanctions for irregular use of protected areas until July 22, 2008.

Federal Decrees	Menu / Main Commands
Decree No. 24,643, of 10 July 1934	Instituted the Water Code - Partially revoked by Law 9433/97 that instituted the SNGR - National Water Resources Management System defines the dominant regimes and brings essential concepts that are still valid today.
Decree 76.623 of November 17, 1975 (Legislative Decree 54/75 promulgated)	Ratifies the International Convention on Endangered Species (CITES).
Decree No. 96,044, of May 18, 1988.	Approves the Regulation for the Road Transport of Dangerous Products, and makes other provisions.
Decree No. 97,632 of April 10, 1989	The Plan for the Recovery of Degraded Areas is mandatory under the ESIA / RIMA for mining activities - it is advisable that this PRAD must comply with the PAE - Economic Development Plan submitted to DNPM as a requirement of the mining title.
Decree nº 99.274 of June 6, 1990	Regulates the provisions of the PNMA - Law 6938/81. It provides, among other points, about the necessary basis for the assessment of environmental impacts in the licensing process and separates the environmental license in advance, of installation and operation.
Decree No. 2,519, of March 16, 1998	Promulgates the Convention on Biological Diversity.
Decree No. 2,657, of July 3, 1998.	It promulgates ILO Convention No. 170 on Safety in the Use of Chemicals at Work, signed in Geneva on 25 June 1990. It applies to all branches of economic activity in which chemicals are used.
Decree nº 99.556, of October 1, 1990 (partially revoked by Decree nº 6.640 / 08)	Provides for the protection of natural underground cavities in the national territory, and makes other provisions.

Federal Decrees	Menu / Main Commands
Decree No. 3,551, of August 4, 2000	Institutes the Registry of Cultural Property of Intangible Nature that constitute Brazilian cultural heritage, creates the National Program of Intangible Heritage, and makes other arrangements.
Decree No. 3,607, of September 21, 2000.	Provides for the implementation of the Convention on International Trade in Endangered Species of Wild Flora and Fauna - CITES, and makes other provisions
Decree No. 4297, of July 10, 2002.	Regulates art. 9, section II, of Law 6,938, of August 31, 1981, establishing criteria for the Ecological-Economic Zoning of Brazil - ZEE, and other measures.
Decree No. 4,339, of August 22, 2002	Institutes principles and guidelines for the implementation of the National Biodiversity Policy.
Decree No. 4,613, of March 11, 2003	Regulates the National Water Resources Council, and makes other provisions.
Decree No. 4,340, of August 22, 2002	Regulates articles of Law No. 9,985, of July 18, 2000, which provides for the National System of Nature Conservation Units - SNUC, and makes other provisions.
Federal Decree No. 5,445, of May 12, 2005	Enacts the Kyoto Protocol to the United Nations Framework Convention on Climate Change, open for signature in the city of Kyoto, Japan, on December 11, 1997, on the occasion of the Third Conference of the Parties to the United Nations Framework Convention on Change of Climate.
Decree No. 6,514 of July 22, 2008 Regulates Law No. 9605/98	Provides for the specification of sanctions applicable to conducts and activities harmful to the environment, considered as environmental infractions,
Decree 6,848 of May 14, 2009	It regulated the application of article 36 of the SNUC by inserting an equation and matrix for calculating the amount of compensation required for licenses backed by ESIA / RIMA, limiting it to 0.5% of the project value.
Decree No. 7,390, of December 9, 2010.	Regulates arts. 6, 11 and 12 of Law No. 12,187, of December 29, 2009, which institutes the National Policy on Climate Change - PNMC, and provides other measures
Decree No. 7,830, of October 17, 2012	Provides for the Rural Environmental Registry System, the Rural Environmental Registry, establishes general rules for the Environmental Regularization Programs, dealt with in Law No. 12,651, of May 25, 2012, and provides other measures.
Decree No. 8,235, of May 5, 2014.	Establishes general norms complementary to the Environmental Regularization Programs of the States and the Federal District, which is dealt with in Decree No. 7,830, of October 17, 2012, institutes the Mais Ambiente Brasil Program, and takes other measures

Federal Resolutions	Menu / Main Commands
CONAMA Resolution No. 01, of January 23, 1986.	Establishes the definitions, responsibilities, basic criteria and general guidelines for the use and implementation of the Environmental Impact Assessment
CONAMA Resolution No. 001-A / 86	Provides for the transport of dangerous products in national territory.
CONAMA Resolution No. 6, of September 16, 1987	Provides for the environmental licensing of works in the electricity generation sector
CONAMA Resolution No. 9, of December 3, 1987.	Regulates the holding of public hearings.
CONAMA Resolution No. 01, of March 8, 1990	Provides for noise emission criteria and standards for industrial activities.
CONAMA Resolution nº 8 of December 6, 1990, complements Res CONAMA 03/90 and 05/89, and is complemented by 436/11	Defines the maximum limits for the emission of pollutants in the air.
CONAMA Resolution No. 237, of December 19, 1997.	It establishes the steps and procedures related to the environmental licensing process, as well as the competencies of the related agencies. Defines the types of licenses for each phase of the project (LP, LI and LO) and presents a list of the projects necessarily subject to licensing.
CONAMA Resolution No. 267, of September 14, 2000. (Repeals Resolutions No. 13, 1995, and No. 229, 1997. Amended by Resolution No. 340, 2003)	Provides for the prohibition, throughout the national territory, of the use of controlled substances specified in Annexes A and B of the Montreal Protocol on Substances that destroy the Ozone Layer.
CONAMA Resolution No. 281, of July 12, 2001	Provides for publication models for licensing requests.
CONAMA Resolution No. 302 of March 18, 2002.	Provides for the parameters, definitions and limits of Permanent Preservation Areas of artificial reservoirs and the use regime of the surroundings. Valid in what does not conflict with Law 12.651 / 12
CONAMA Resolution No. 303, of March 18, 2002.	Provides for parameters, definitions and limits of Permanent Preservation Areas. Valid in what does not conflict with Law 12.651 / 12
CONAMA Resolution No. 307, of July 5, 2002. Amended by Resolutions 348, of 2004, No. 431, of 2011, and No. 448/2012.	Establishes guidelines, criteria and procedures for the management of construction waste.
CONAMA Resolution No. 313, of October 29, 2002.	Provides for the National Inventory of Industrial Solid Waste.

Federal Resolutions	Menu / Main Commands
CONAMA Resolution No. 347, of September 10, 2004 Revokes Resolution No. 05, of 1987. Amended by Resolution No. 428, of 2010.	Provides for the protection of speleological heritage.
CONAMA Resolution nº 357, of March 17, 2005. (Amendment Res nº 370/06 nº 397/08, nº 410/09, and nº430 / 11. Complemented by Res nº 393/09)	Provides for the classification of water bodies and environmental guidelines for their classification, as well as establishing the conditions and standards for effluent discharge, and other measures
CONAMA Resolution No. 362, of June 23, 2005	Provides for the obligation to use the lubricating oil so as not to negatively affect the environment.
CONAMA Resolution No. 371, of April 5, 2006.	Establishes guidelines for environmental agencies for the calculation, collection, application, approval and control of resource expenditures arising from environmental compensation, according to Law No. 9,985, of July 18, 2000, which institutes the National System of Nature Conservation Units - SNUC and other measures.
CNRH Resolution 65, of December 7, 2006.	Establishes guidelines for the articulation of procedures for obtaining the right to use water resources with environmental licensing procedures.
CONAMA Resolution 382/2006 (complemented by Res CONAMA 436/11)	Establishes maximum emission limits for air pollutants for fixed sources
CONAMA Resolution No. 397, of April 3, 2008. Amended by Res CONAMA 410 of 05/04/2009)	Amends section II of § 4 and Table X of § 5, both of art. 34 of the Resolution of the National Environment Council - CONAMA 357/05, which provides for the classification of bodies of water and environmental guidelines for their classification, as well as establishing the conditions and standards for the discharge of effluents.
CONAMA Resolution No. 396, of April 3, 2008.	Provides for the classification and environmental guidelines for the classification of groundwater and provides other measures
ANEEL Normative Resolution No. 398/2010, (Wording given by REN ANEEL 616 of 1.07.2014)	Regulates the limits of human exposure to electric and magnetic fields originating from electric power generation, transmission and distribution facilities.
CONAMA Resolution No. 428 of December 17, 2010	Provides, within the scope of environmental licensing on the authorization of the body responsible for the administration of the Conservation Unit (UC)
CONAMA Resolution No. 430 of May 13, 2011	Provides for the conditions and standards for the discharge of effluents, complementing Res CONAMA 357/05.
ANA Resolution 833 of December 5, 2011	It establishes the general conditions for acts of preventive granting and the right to use water resources owned by the Union issued by the National Water Agency - ANA and takes other measures. In its article 22, it is stated that the grants have as their object changes in the flow regime or in the hydro energetic uses.

Federal Resolutions	Menu / Main Commands
ANEEL Resolution No. 669, of July 14, 2015	Regulates the Minimum Maintenance Requirements and the monitoring of the maintenance of Basic Grid transmission facilities.

Decisions	Menu / Main Commands
IBAMA Ordinance No. 113, of September 25, 1997	Provides for the mandatory registration in the Federal Technical Register of Potentially Polluting Activities or Users of Environmental Resources, individuals or legal entities engaged in potentially polluting activities and / or the extraction, production, transport and commercialization of products potentially dangerous to the environment , as well as minerals, products and by-products of fauna, flora and fisheries.
Ordinance of the Ministry of Transport No. 124, of August 20, 1980.	Prevention of pollution from land-based sources. It requires polluting industries and buildings or structures that store potentially polluting substances, to set up a minimum distance of 200 m from water bodies. And, that any deposit built above ground level, which receives potentially polluting liquids, is protected in order to prevent leaks from reaching water bodies. For this purpose, tanks, railings, underground silos or other containment devices that are necessary should be built.
IPHAN / MinC Ordinance no. 230, of December 17, 2002	Defines the scope of the archaeological studies to be developed in the different phases of environmental licensing;
IPHAN Ordinance No. 127, of 04/30/2009	Establishes protection for the Brazilian Cultural Landscape.
MMA Ordinance No. 9, of January 23, 2007.	It recognizes Priority Areas for Biodiversity, for the purpose of formulating and implementing public policies, programs, projects and activities under the responsibility of the Federal Government.
MMA Ordinance No. 443, of December 17, 2014.	It recognizes species of Brazilian flora threatened with extinction.
MMA Ordinance No. 444, of December 17, 2014.	Recognizes endangered Brazilian fauna species
MMA Ordinance No. 445, of December 17, 2014.	It recognizes species of fish and aquatic invertebrates of Brazilian fauna threatened with extinction.
Interministerial Ordinance MMA / MinC / MJ / MS No. 60, of March 24, 2015.	Establishes administrative procedures that regulate the performance of federal public administration bodies and entities in environmental licensing processes under the competence of the Brazilian Institute for the Environment and Renewable Natural Resources-IBAMA
Portaria DNPM nº 155 de 12 de maio de 2016	It approved the normative consolidation of the DNPM, bringing together all the administrative procedures they have on the regimes for the use of natural resources.

Other Federal Rules	Menu / Main Commands
IN MMA nº 03 of May 26, 2003	Recognizes the “Species of Brazilian Fauna Threatened with Extinction”.
IN MMA nº 05 of May 28, 2004 (amended by IN-MMA 52/2005)	Recognizes as endangered and overexploited or threatened species from overexploitation aquatic invertebrates and fish
IN MMA nº 06, of September 23, 2008	Recognizes as endangered species of Brazilian flora those listed in Annex I and those with data deficiencies listed in Annex II
Normative Instruction IBAMA No. 154, of March 1, 2007	Institutes the Biodiversity Authorization and Information System (SISBIO) and provides for licenses, collection and capture of fauna and flora species and access to genetic heritage.
Normative Instruction IBAMA nº 179 of June 25, 2008.	Defines the guidelines and procedures for the destination of animals of the native and exotic wild fauna seized, rescued or spontaneously handed over to the competent authorities
Normative instruction IBAMA No. 146, of January 11, 2007.	Provides for environmental licensing criteria to protect fauna.

3.6. State Legal Acts

State Laws	Menu / Commands
THE STATE CONSTITUTION	
Art. 14. The State is also responsible for:	I - concurrently with the Union, legislate on: f) forests, hunting, fishing, fauna, nature conservation, defense of soil and natural resources, protection of the environment and pollution control; g) protection of historical, cultural, artistic, tourist and landscape heritage; h) liability for damage to the environment, to the consumer, to goods and rights of artistic, aesthetic, historical, tourist and landscape value; h) liability for damage to the environment, the consumer, goods and rights of artistic, aesthetic, historical, touristic and landscape value; II - in common with the Union and the Municipalities: f) protect the environment and fight pollution in any of its forms; g) preserve forests, fauna and flora;
CHAPTER VII THE ENVIRONMENT Art. 237	Everyone has the right to an ecologically balanced environment, good for the common use of the people and essential to a healthy quality of life, imposing on the Public Power and the community the duty to defend and preserve it and to harmonize it, rationally, with the needs of socioeconomic development for present and future generations. § 1 To ensure the affectivity of this right, it is incumbent upon the Public Power: I - preserve and restore essential ecological processes and provide ecological management of species and ecosystems; II - preserve the diversity and integrity of the State's genetic heritage and supervise entities dedicated to the research and manipulation of genetic material; III - to define, supplementary to the Union, territorial spaces and their components to be specially protected, the alteration and removal being allowed only through law, any use that compromises the integrity of the attributes that justify their protection is prohibited; IV - require, in accordance with the law, for the installation of a work or activity potentially causing significant degradation of the environment, a previous study of environmental impact, which will be publicized;

State Laws	Menu / Commands
THE STATE CONSTITUTION	
	V - enforce the compensatory actions indicated in the environmental impact study referred to in the previous section, compatible with the restoration of ecological balance; VI - control the production, commercialization and use of techniques, methods and substances that pose a risk to life, quality of life and the environment; VII - promote environmental education at all levels of education and public awareness for the preservation of the environment; VIII - protect fauna and flora, prohibited, in accordance with the law, practices that put their ecological function at risk, cause the extinction of species or subject animals to cruelty. § 2 Those who exploit mineral resources are obliged to recover the degraded environment, according to the technical solution required by the competent public agency, in the form of law. § 3 Conducts and activities considered harmful to the environment will subject offenders, individuals or legal entities, to criminal and administrative sanctions, regardless of the obligation to repair the damage caused. (...) § 6 The promotion of integrated management of water resources, directly or through permission of use, based on the following principles: a) adoption of basin and sub-basin areas as a planning and execution unit for plans, programs and projects; b) unity in the administration of water quantity and quality; c) compatibility between the multiple, effective and potential uses of water resources; d) popular participation in the management and mandatory contribution to the recovery and maintenance of water quality according to the type and intensity of use; e) emphasis on the development and use of methods and criteria for assessing water quality. § 7 The following are areas of permanent preservation: I - mangroves; II - the springs of the rivers; III - the delta areas; IV - the maritime, river and lake islands 8º The Aroeiras, Faveiras, Paus d'arcos and Cedros tree species will have special protection from the Public Power and the use of these plant species or

State Laws	Menu / Commands
THE STATE CONSTITUTION	
	areas that make up the native vegetation cover of the State will depend on prior authorization from the competent public bodies, through mandatory replacement in percentages established in law. § 9 The installation of a work or activity potentially causing significant degradation of the environment must be preceded by a previous study of environmental impact, which will be widely publicized. Art. 238. The Public Power will establish a tax on the use of natural resources, corresponding to the costs of investments, the recovery and maintenance of environmental quality standards. Art. 239. They are areas of relevant ecological interest, the use of which will depend on prior authorization from the competent bodies, preserving their essential attributes: Art. Art. 239. They are areas of relevant ecological interest, the use of which will depend on prior authorization from the competent bodies, preserving their essential attributes: Art. I - the existing lagoons in the State; II - the coastal zone; III - the areas that contain rare specimens of fauna and flora, as well as those that serve as a place for landing or breeding migratory species; IV - the bands necessary for the protection of surface waters; V - slopes subject to erosion and landslides; VI - archaeological sites and interesting rock formations. Single paragraph. The State will promote a continued program for the reforestation of river springs, their banks and the lagoons existing in its territory.
Law No. 3,888, of September 26, 1983	It prohibits the felling of palm trees and trees, which it specifies, and makes other provisions.
Law No. 4,115, of June 22, 1987	Creates the State Secretariat for the Environment, Science and Technology and Urban Development and takes other measures.
Law No. 4,515, of November 9, 1992.	Provides for the protection of the Cultural Heritage of the State of Piauí and provides other measures.
Law No. 4,797, of October 24, 1995	Creates the Secretariat for the Environment and Water Resources of the State of Piauí.

State Laws	Menu / Commands
THE STATE CONSTITUTION	
Law No. 4,854, of July 10, 1996	Provides for the environmental policy of the State of Piauí and provides other measures
Law No. 5,165, of August 17, 2000	Provides for the Water Resources Policy, establishes the State Water Resources Management System and provides other measures
Law No. 5,178 of December 27, 2000	Provides for the forestry policy of the State of Piauí and provides other measures
Law No. 5,813, of March 3, 2008	Creates the ecological ICMS to benefit municipalities that excel in protecting the environment and takes other measures.
Law No. 5,959 of December 29, 2009	Institutes the Environmental Control and Inspection Fee of the State of Piauí - TCFA / PI
Law No. 6,140 of December 6, 2011	Institutes the State Policy on Climate Change and Combating Poverty - PEMCP and provides other measures
Law No. 6,158 of January 19, 2012	Amends Law 4,115, of June 22, 1987, which created the State Secretariat for the Environment, Science and Technology and Urban Development, which provides for the name, objectives, attributions, revenue and destination of the State Environment Fund, Science and Technology and Urban Development, created by the same Law.

State Decrees	Menu / Commands
DECREE No. 7,393, of August 22, 1988	Approves the Regulation of the State Fund for the Environment, Science and Technology and Urban Development, created by State Law No. 4,115, of June 22, 1987
DECREE No. 8,925, of June 4, 1993	Approves the regulations of the State Council for the Environment and Urban Development.
DECREE N ° 9,532, of July 4, 1996	Amends the Regulation of the State Fund for the Environment, Science and Technology and Urban Development, which is dealt with in Decree No. 7,393, of August 22, 1988 and provides other measures.
DECREE No. 9,533, of July 24, 1996	Amends Decree No. 8,925, of June 4, 1993 and provides other measures.
DECREE No. 10,880, of September 24, 2002	Approves the Regulation of the State Water Resources Council - CERH / PI.
DECREE No. 11,110, of August 25, 2003	Provides for the mandatory presentation of property title and the georeferencing of the property to grant the licensing of agricultural and agro-industrial activities for forestry and alternative use of the soil, and of natural resources in the State of Piauí.
DECREE No. 11,126, of September 11, 2003.	It regulates the use and occupation of the lands that shelter the cerrado biome in the State of Piauí, and provides other measures.
DECREE No. 11.341, of March 22, 2004	Regulates the preventive use grant and the right to use water resources in the State of Piauí, pursuant to Law No. 5,165, of August 17, 2000.
DECREE No. 12,184, of April 24, 2006	It establishes criteria and values to be charged for the operational costs inherent to the Issuing or Renewal of Water Resources Grants in the State of Piauí and takes other measures.
DECREE No. 12,212, of May 17, 2006 -	Regulates the State Water Resources Fund - FERH, which is dealt with by Law No. 5,265, of August 17, 2000, and provides related measures.
DECREE No. 13,835 of September 15, 2009	Amends the regulation of the State Council for the Environment and Urban Development -CONSEMA, approved by Decree No. 8,925, of June 4, 1993, and takes other measures.
DECREE No. 14,079, of March 9, 2010	Provides for public prices for Public Services provided by the State Secretariat for the Environment and Water Resources - SEMAR, and makes other provisions.
DECREE No. 14,104 of March 15, 2010	Approves the institutions that will compose the State Council for Environment and Urban Development - CONSEMA, as specified in art. 6 of its Regulation, for the 2010-2011 biennium.

State Decrees	Menu / Commands
DECREE No. 14,143, of March 22, 2010	Provides for the Framework of Water Bodies of State Domain. 99 DECREE No. 14,144, of March 22, 2010 - Provides for the Regulation of Charges for the use of Water Resources in the State of Piauí. 107 DECREE No. 14,145, of March 22, 2010 - Deals with Water Resources Plans.
DECREE No. 14,144, of March 22, 2010	Provides for the Regulation of Billing for the use of Water Resources in the State of Piauí.
DECREE No. 14,145, of March 22, 2010	Provides for Water Resources Plans.
DECREE No. 14,348 of December 13, 2010 (as amended by Decree 14.861 of 6/15/2012)	Deals with the guidelines for the concession of the Environmental Seal for the municipalities that meet the criteria established in Ordinary Law No. 5,813, of 03 of 2008 - ICMS Ecological Law, as they are developing actions to improve the quality of life, through the promotion of environmental management policies and actions.
DECREE No. 14,504 of June 20, 2011	Establishes the Interinstitutional Coordinating Commission for the Ecological-Economic Zoning of the State of Piauí - CICZEEPI, and takes other measures
DECREE No. 14,842, of June 4, 2012	Establishes procedures for the Simplified Environmental Licensing of emergency works necessary to face drought in the State of Piauí, and provides other measures.
DECREE No. 15,270, of July 16, 2013	Provides for the adhesion of the State of Piauí to the National Pact for Water Management.
DECREE No. 15,512 of January 27, 2014	It provides for the integration of the execution of land regularization policies for environmental licensing for the authorization of removal of vegetation and water resources and provides for other measures.
DECREE No. 15,513 of January 27, 2014	Regulates the use of fire in agricultural, pastoral and forestry practices and approves the State Plan for the Prevention and Fighting of Forest Fires and Burn Control and provides related measures
DECREE No. 16.142, of August 14, 2015	It institutes the campaign to register users of water resources in the State of Piauí on the platform of the National Water Resources User Registry - CNARH and takes other measures.

Resolutions	Menu / Commands
CONSEMA RESOLUTION No. 001 of June 5, 2003	Approves the Internal Regulations of the State Council for the Environment and Urban Development - CONSEMA
CONSEMA RESOLUTION No. 005, of September 8, 2004	Provides for the use, conservation and preservation of agricultural soil in the State of Piauí.
CONSEMA Resolution 002 of April 26, 2005	Establishes the Interinstitutional Reservoir Management Commission.
CERH Resolution 004/05, of April 26, 2005	Provides for Provisional Criteria and Procedures for Preventive Granting and Granting the Right to Use Water Resources.
CONSEMA RESOLUTION No. 007, of October 20, 2005	Institutes criteria for calculating the values of environmental compensation, charged in the licensing of agrosilvopastoral undertakings and / or activities, recognized as having a significant environmental impact.
CERH RESOLUTION Nº. 001/2006, of February 23, 2006 -	Establishes Criteria and Values of Fees to be Charged for Operating Costs Inherent to the Processes of Issuing or Renewing Water Resources Grants in the State of Piauí and other measures.
CONSEMA RESOLUTION No. 008, of June 5, 2007	Institutes criteria for calculating the values of environmental compensation.
CONSEMA RESOLUTION No. 009, of June 4, 2008	It defines the conditions under which the municipality may exercise its duty to license undertakings / activities that cause local environmental impact.
CONSEMA RESOLUTION No. 010 of November 25, 2009	It establishes criteria for the classification of projects and activities that modify the environment subject to a low impact declaration or environmental licensing at the state level and determines environmental procedures and studies compatible with the polluting potential and takes other measures.
CONSEMA RESOLUTION No. 012, of August 10, 2010	Adds paragraphs 5, 6, 7, 8 and 9 to Article 1 of CONSEMA Resolution No. 009, of June 4, 2008.
CONSEMA RESOLUTION No. 013, of October 7, 2010	Provides for technical procedures for the preparation, presentation, execution and technical evaluation of Sustainable Forest Management Plans - PMFS of the Caatinga vegetation and its successor formations, and other measures.

Decisions	Menu
SEMAR Ordinance No. 019/09	Provides for the judgment of the processes related to the Infraction Notices and their homologation.
SEMAR Ordinance No. 004/14	Provides for the establishment of the Environmental Performance Assessment Commission - CADAM, which is dealt with by State Decree No. 14,348, of February 13, 2010.
SEMAR / INTERPI JOINT ORDINANCE No. 01/14	Regulates the procedures for integrating the execution of land regularization, environmental licensing, authorization for removing vegetation and water resources.

3.7. Municipal Legal Acts

The survey and analysis of municipal legislation, in this case, has a preventive purpose since the Project occupies rural areas, and does not interact directly with the city.

Thus, research into municipal legislation focuses on rules that can, in theory, restrict the intended human uses, and optimize future environmental programs that will be designed to avoid, minimize and compensate for the impacts that the Project will cause.

With regard to the Project's compliance with the area, it should be noted that the municipal authorities have already pointed out that there is no obstacle to the continuity of the Piauí Nickel Project. In this perspective, Annex II (Volume IV) shows the Certificates of compliance with the land use and occupation legislation in the municipalities of São João do Piauí; Dom Inocêncio; Capitão Gervásio Oliveira and Campo Alegre do Fidalgo.

For these reasons, and considering that the survey of municipal level legislation involving the municipalities affected by this Project, cannot be done on the websites of the respective city halls; and that the contacted servants were unable to locate the main legal instruments; the survey will be carried out by means of letters already sent directly to the mayors in February 2017 (Annex III - Volume IV), which have not yet been answered and, with the approval of the environmental authority, should be postponed to the obtaining the LI and assist in the composition of the environmental programs and indication of possible partnerships.