HCVAfrica

HIGH CONSERVATION VALUE

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) FOR THE PROPOSED LONGONJO NdPr MINING PROJECT, HUAMBO, ANGOLA

February 2022

OZANGO MINERAIS S.A

PENSANA PLC

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PURPOSE OF THIS DOCUMENT

This Environmental and Social Impact Assessment (ESIA) document aims to assess the potential project induced environmental and social impacts of the proposed Longonjo NdPr mining project in Angola. The ESIA was performed in line with the requirements of the Angolan Ministry of Environment (MINAMB) (2019 – 2020), which was renamed as the Ministry of Culture, Tourism and Environment (MCTA) (2021), the World Bank Groups' Equator Principles and the International Finance Corporation's (IFC) Performance Standards and EHS Guidelines.

Pensana appointed HCV Africa as the independent consultant to conduct the ESIA.

The key objective of this report is to provide relevant project and procedural information to prospective Lenders/Financiers.

The first phase of the ESIA, the Scoping Phase, took place between April and June 2019. The Scoping phase identified potential issues/impacts relating to the proposed project, and the HCV Africa team defined the required Terms of Reference for specialist studies during the assessment phase. The Scoping Phase also defined the assessment methodology used during the assessment phase. The ESIA Phase took place from July 2019 to February 2020, followed by an update in 2021 due to design changes as per the IFS.

The ESIA consolidates the impact assessment results into a single document to enable stakeholders to review the results. They had opportunities to attend public meetings / focus group meetings and were invited to comment. The comments and responses report is attached in Appendix O.

This ESIA Report contains the following:

- Introduction;
- Objective and Rationale of Project Implementation;
- Project Description and Project Alternatives;
- Policy, Legal and Administrative Framework;
- Description of Current State of the Environment (Baseline Environment);
- Environmental and Social Scoping;
- Assessment and Evaluation of the Environmental and Social Impacts;
- ESMP (details of mitigation and management of environmental and social impacts);
- Environmental Monitoring Plan;
- Public Consultation and Disclosure;
- Cumulative Impacts; and
- Environmental and Social Management and Monitoring Plans

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LIST OF ACRONYMS

Acronym	Meaning
CR	Critically Endangered
DD	Data Deficient
EN	Endangered
ESIA	Environmental and Social Impact Assessment
GBIF	Global Biodiversity Information Facility
GPS	Global Positioning System
HL	Habitat Linkage
HR	Habitat Requirements
HS	Habitat Status
IUCN	International Union for the Conservation of Nature
LC	Least Concern
NE	Not Evaluated
NT	Near Threatened
POO	Probability of Occurrence
PROTA	Plant Resources of Tropical Africa
SCC	Species of Conservation Concern
VU	Vulnerable
WWF	World Wide Fund for Nature

1 INTRODUCTION

Ferrangol and Pensana Plc (Pensana) of the United Kingdom (UK) are partners, through their associated Angolan company Ozango Minerais S.A. (Ozango), in the Longonjo NdPr Project (the Project) located near the town of Longonjo in Huambo Province, Angola.

The proposal is to construct a shallow, long-life open pit mine including an on-site processing plant to produce a high-grade rare earth mineral concentrate to include NdPr (neodymium and praseodymium oxide) that will be transported via the Benguela Rail line from the siding at Longonjo to the port of Lobito for shipping to the international market. As an additional option, Pensana is investigating the economic feasibility of integrating downstream processing of flotation concentrate into a higher grade, NdPr-rich, mixed rare earth sulphate at the Longonjo Mine to provide feedstock to the Saltend Refinery[1], which will further upgrade this material to the final product.

Note: The Saltend Refinery is excluded from the scope of this ESIA.

The Project requires an environmental and social impact assessment (ESIA) to comply with Angolan legislation and regulations and conform to international standards. Pensana appointed HCV Africa to conduct the international (bankable) ESIA, while Ozango has appointed Grupo Simples to conduct the regulatory ESIA based on the outcomes of a competitive bid process.

1.1 Purpose of an ESIA

The primary goal of an ESIA is to identify environmental and social impacts as a direct or indirect consequence of project implementation and to devise mitigation measures to manage the impacts (positive and negative). However, there are cases where significant adverse impacts are regarded as showstoppers, and projects do not proceed.

Interaction between the design teams and the ESIA teams enable the best options and alternatives to be achieved (e.g., for water use, energy, site layout, and land use). In addition, the public consultation process that takes place separately but in parallel to the ESIA facilitates the involvement of diverse groups of stakeholders (e.g., local communities, regulatory authorities, non-governmental organisations (NGOs), and business entities).

An ESIA report with associated supporting documentation (e.g., specialist reports, data and consultation reports) provides:

- Stakeholders with information about a project and demonstrate that their comments, contributions, questions, and concerns have been addressed;
- The regulating authorities with information, so they can make an informed decision about whether to grant or not grant, authorisation (i.e. in the case of a Regulatory ESIA); and
- Prospective lenders/investors with information on the environmental and social aspects of a project, which assists with the decision-making process as part of their due diligence processes (i.e. in the case of this Bankable ESIA Report).

1.2 International finance requirements

HCV Africa conducted the Pensana NdPr Mining Project ESIA in conformance with International Finance Corporation (IFC) Social and Environmental Performance Standards (PS) (2012) and sector-specific EHS Guidelines of the World Bank.

The IFC categorises projects as either category A, B, or C:

[1] The Saltend Chemicals Park (SCP) is a cluster of world-class chemicals and renewable energy businesses strategically located on the Humber estuary, a gateway to Europe and the United Kingdom's (UK's) busiest ports complex.

- Category A: Projects that might have significant negative environmental/social impacts which are diverse, irreversible, or unprecedented;
- Category B: These projects differ from Category A mainly in terms of the scale of impacts. In general, these projects involve activities expected to have limited adverse environmental / social impacts. These impacts can generally be mitigated; or
- Category C: These projects have negligible impacts.

This Project is considered a Category A project as open cast mining projects typically may have significant negative environmental / social impacts that are diverse, irreversible, or unprecedented.

For this Category A project, HCV Africa undertook the following:

1. A scoping phase with a report including terms of reference for the full ESIA and results of desktop studies and initial site visit with high-level consultation;
2. Baseline studies;
3. Multi-phase consultation as per the SEP for the ESIA process;
4. Impact assessment including cumulative impacts; and
5. Environmental and social management plans.

The IFC also require that the ESIA consider and observe the relevant statutory requirements of the Republic of Angola. Therefore, a separate but parallel Regulatory ESIA was also conducted for the Project and submitted by Grupo Simples.

The Regulatory ESIA for the Project comprised the identification and evaluation of project induced environmental and social impacts in the context of the Project's area of influence. Risks and impacts were analysed for all stages of the Project, including construction, operation and closure. In addition, stakeholder consultation / public participation was undertaken with interested and affected parties (I&APs), and HCV Africa incorporated their comments and concerns in the ESIA process.

1.3 Objectives of the ESIA

The objectives of the ESIA include:

- Gaining an understanding of the socio-economic and biophysical environments through undertaking baseline data collection;
- Consulting with relevant stakeholders to understand their concerns about the proposed Project (if any) and answer questions;
- To independently assess the environmental and social impacts relating to the Project; and
- To propose monitoring and mitigation to manage impacts.

1.4 The proponent / developer

Ferrangol and Pensana Plc (Pensana), the United Kingdom (UK), are partners, through their associated Angolan company Ozango Minerais S.A. (Ozango), in the Longonjo NdPr Project (the Project) located near the town of Longonjo in Huambo Province, Angola.

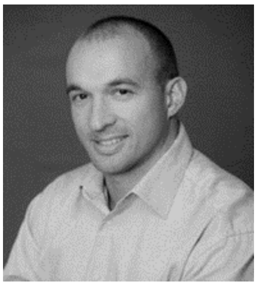
Pensana is a UK-based mineral exploration company with the sole focus to fast track the development of the Longonjo NdPr Project in Huambo Province, Angola, into production.

Pensana also owns 84% of Ozango, which in turn proposes to develop the Project. FERRANGOL (a state-owned corporation that manages iron ore production in Angola) holds the balance of the shares in Ozango.

1.5 The environmental assessment practitioner

1.5.1 Project leadership

Nelius Scheepers – ESIA Project Manager, Licensed HCS Assessor and Environmental Auditor



Nelius is an experienced Environmental Management professional with more than 20 years of experience in oil and gas, mining, major civil infrastructure projects, manufacturing and agri-business. Nelius is a registered Professional Natural Scientist (Reg No. 400138/03), an internationally registered Environmental Auditor (IEMA Reg No. 0051570) and a High Carbon Stock (HCS) registered assessor (certificate number 2018SanJose003).

One of his key speciality areas is as Project Manager for large-scale, complex EIA/ESIA/ESHIA projects. He successfully managed environmental assessment projects for multi-national clients in Africa, the Middle East and Asia. Environmental Assessments have been executed in compliance with in-country legislation and international standards (e.g. Equator Principles, IFC and Asian Development Bank) and other lender requirements.

Nelius has all-round experience in both environmental and social aspects of projects and, therefore, has the leadership and managerial skills to direct, manage large (20+) multi-disciplinary teams of specialists / subject matter experts located around the globe, as well as review specialist studies to ultimately compile ESIA reports. In addition, he has regularly consulted with communities during ESIAs and has a sound understanding of ecosystem services.

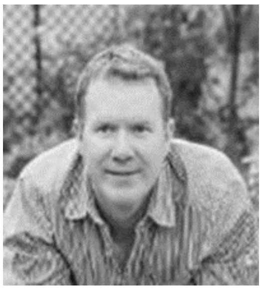
Nelius performed numerous environmental compliance audits, environmental management system audits, and IFC due diligence audits. Nelius is an internationally registered and experienced environmental auditor who can critically review projects, operations, ESIA, project documentation, environmental performance, EMS etc.

He has worked in South Africa, Swaziland, Botswana, Zambia, DRC, Tanzania, Uganda, Ethiopia, Namibia, Angola, Cameroon, Myanmar, Uzbekistan, Qatar and Saudi Arabia.

Nelius qualifications are as follows:

- M.Sc. Water Resource Management and Environmental Management, University of Pretoria, South Africa, 2000;
- B.Sc. (Hons) Wildlife Management, University of Pretoria, South Africa, 1999; and
- B.Sc. Ecology, University of Pretoria, South Africa, 1998.

Philip Patton – Licensed HCV and HCS Assessor, Environmental scientist and biodiversity specialist



Phil is a licensed High Conservation Value Assessor (ALS15041PP) and has conducted HCV assessments, biodiversity assessments, environmental impact assessments and audits in Europe, the Middle East, and Africa. Mr Patton is also an experienced ornithologist and a registered Professional Natural Scientist (400029/14). In addition, he has over 19 years of consulting experience in ecological assessments and environmental auditing within the mining, agriculture, and renewable energy sectors.

Phil's specific experience in Angola includes:

- Biodiversity team leader (including being the avifauna and mammal expert) for 4 International standard ESIAs for 4 integrated agricultural projects located in the provinces of Huambo, Kwanza Sul, Lunda Sul and Cabinda; and
- Biodiversity team leader (including being the avifauna and mammal expert) for an international standard ESIA, one new rare earth mine (NdPr) at Longonjo, Huambo province; and
- Phil holds a B.Sc. Hons (Environmental Science) from the University of Cape Town, and a B.Sc. (Geology and Botany) from the University of Port Elizabeth and has completed HCV assessments in the DRC,

Sierra Leone, Cameroon and is contracted by the Forestry Stewardship Council (FSC) to provide HCV training in Southern Africa.

1.5.2 Team member roles

Name	Expert subject matter topics
Nelius Scheepers	Project director and ESIA specialist, air quality, noise, soils, waste management
Phil Patton	Biodiversity Lead, mammals, avifauna
Steve Horak	Socio-economic lead and consultation lead
Ana Ramos	Socio-economics, consultation, liaison with MCTA, waste management
Russell Tate	Aquatic ecology
Llwelyn Coertzen	Botany
Chris Viljoen	Soil science and land rehabilitation
Ross Sephton	Hydrogeology
Airshed Planning Professionals (Renee Von Gruenewaldt)	Air Quality and GHG
Olo Cuango	Social and consultation
Luke Verburgt and Tyron Clark	Herpetology
Vitor Hugo Sousa	Noise monitoring
Barend Van Der Merwe	Noise modelling
Carlo Fourie	GIS and visual
Flip Krugel	Hydrology
Daniél Cillié	QA/QC

1.6 Structure of this report

This ESIA report is structured as follows:

INTRODUCTION AND CONTEXT
Section 1 is the introduction and provides an overview of the ESIA process, the proponent and the ESIA team.
Section 2 describes the Project and objective / rationale for the Project, and the alternatives considered.
LEGAL, POLICY AND ADMINISTRATIVE FRAMEWORK
Section 3 describes the legislative context in Angola as relevant to the ESIA. Project financing standards and requirements are also discussed.
CURRENT STATE OF THE ENVIRONMENT / BASELINE
Section 4 describes the Project area based on results collected during baseline studies. Essentially it provides a summary of the environmental and social aspects that the Project might potentially influence.
ASSESSMENT METHODOLOGY, IMPACTS AND MITIGATION PUBLIC PARTICIPATION
Section 5 describes the ESIA methodology and describes the impacts and presents the impact assessment.
Section 6 describes the public participation / stakeholder engagement process, how the consultation was conducted and how stakeholders were allowed to participate in the assessment process.
Section 7 described the cumulative impacts and complementary initiatives.
ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)
Section 8 and 9 detail the ESMP. This plan stipulates the management, mitigation and monitoring requirements that the proponent shall comply to.
Section 10 stipulates the Action Plan.
CONCLUSION
Section 11 and 12 present the conclusion and references.

2 PROJECT DESCRIPTION

2.1 Location and context

The Longonjo NdPr Project is located in the Longonjo Municipality, Huambo Province, Angola (Figure 2-1 and Figure 2-2). Huambo City is approximately 600km south-east of the national capital, Luanda. The municipality of Longonjo hosts a population of approximately 90,000 people and has four districts, including Longonjo (consisting of 60 villages), Catabola, Chilata and Lépi.

The national tared road, EN110, and Caminho de Ferro de Benguela (CFB) railway line (upgraded in 2014) both pass within approximately 5km of the Longonjo mining licence area. The location of the Project is in reasonable proximity to the upgraded Lobito Port on the Atlantic (port valued at USD 2 billion) connected by the Railway Line.

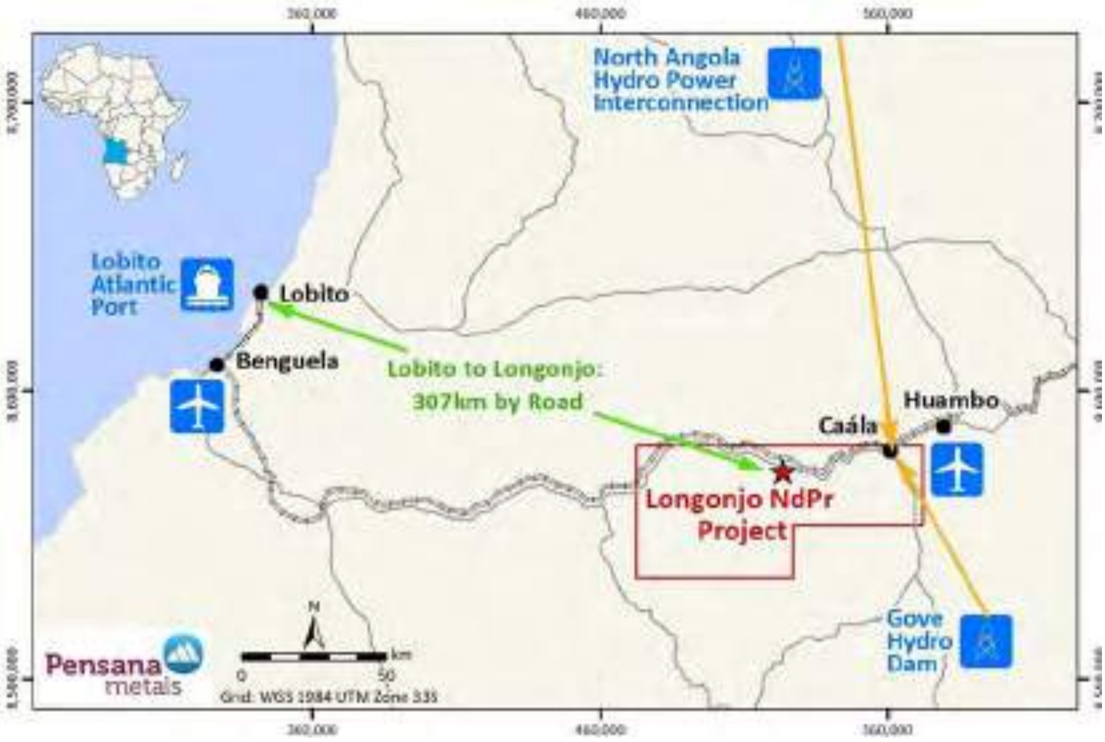


Figure 2-1: The Longonjo NdPr Project is located in Huambo province, and the Benguela rail line connecting the Project with the Atlantic Port of Lobito for product export

An area designated for future mining activities of the Project was defined and agreed upon within the Prospecting Area with the Department of Mineral Resources and formally demarcated as a reserve area of the Project; this area is protected from any new physical development for another purpose. The Title of Mining has been assigned, NO 298/05/01/T.E/ANG - MIREMPET/2020 (Figure 2-3 and Figure 2-4), which was granted Environmental Installation License No. 2893069200/2021.

Figure 2-2: Regional location map of the Project

2.2 Ownership and Mining Title Certificate

The state-owned entity Empresa Nacional de Ferro de Angola, EP (Ferrangol EP) holds a 10% interest in Ozango, and two Angolan partners hold 6% interest. In addition, Sable Minerals GmbH, a wholly-owned Germany domiciled subsidiary of Pensana, holds the remaining 84% interest and has funded all prospection costs to date.

The Longonjo NdPr Project lies within the granted Prospecting License (013/03/09T.P/ANG M.G.M/2015) that covers a land area of 3,670 km^2 (Figure 2 3).

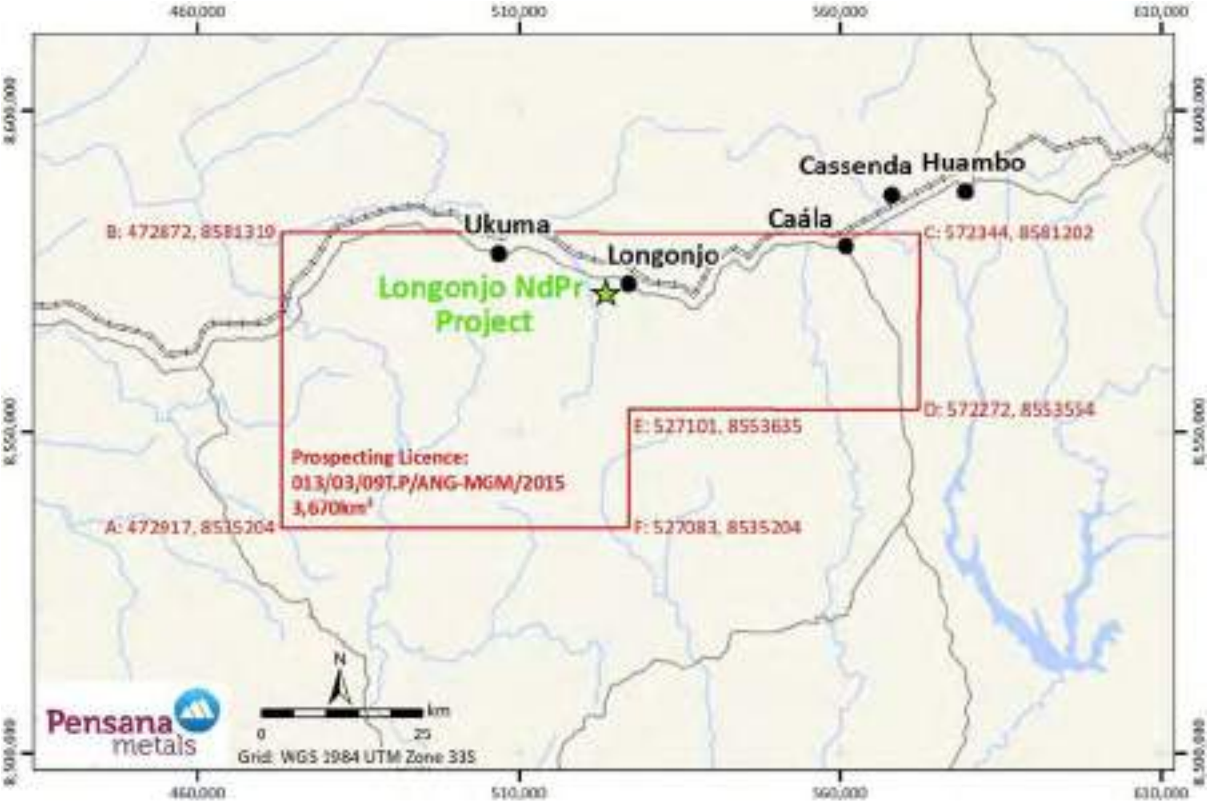


Figure 2-3: The Pensana Prospecting Licence area

The exclusive mining rights for rare earths (or rare-earth elements (REE))in the Longonjo mining licence area are held by Angolan registered company Ozango Minerais, S.A. (Ozango).

On 12 March 2021, a Mining Title Certificate No 298/05/01/T.E/ANG-MIREMPET/2020 was granted for an area of 31km^2 for an initial period of 15 years (renewable up to 35 years) which fully incorporates the Longonjo carbonatite deposit, the proposed open pit mine and its processing plant, Tailings Storage Facility (TSF) and all the associated infrastructure (Figure 2-4).

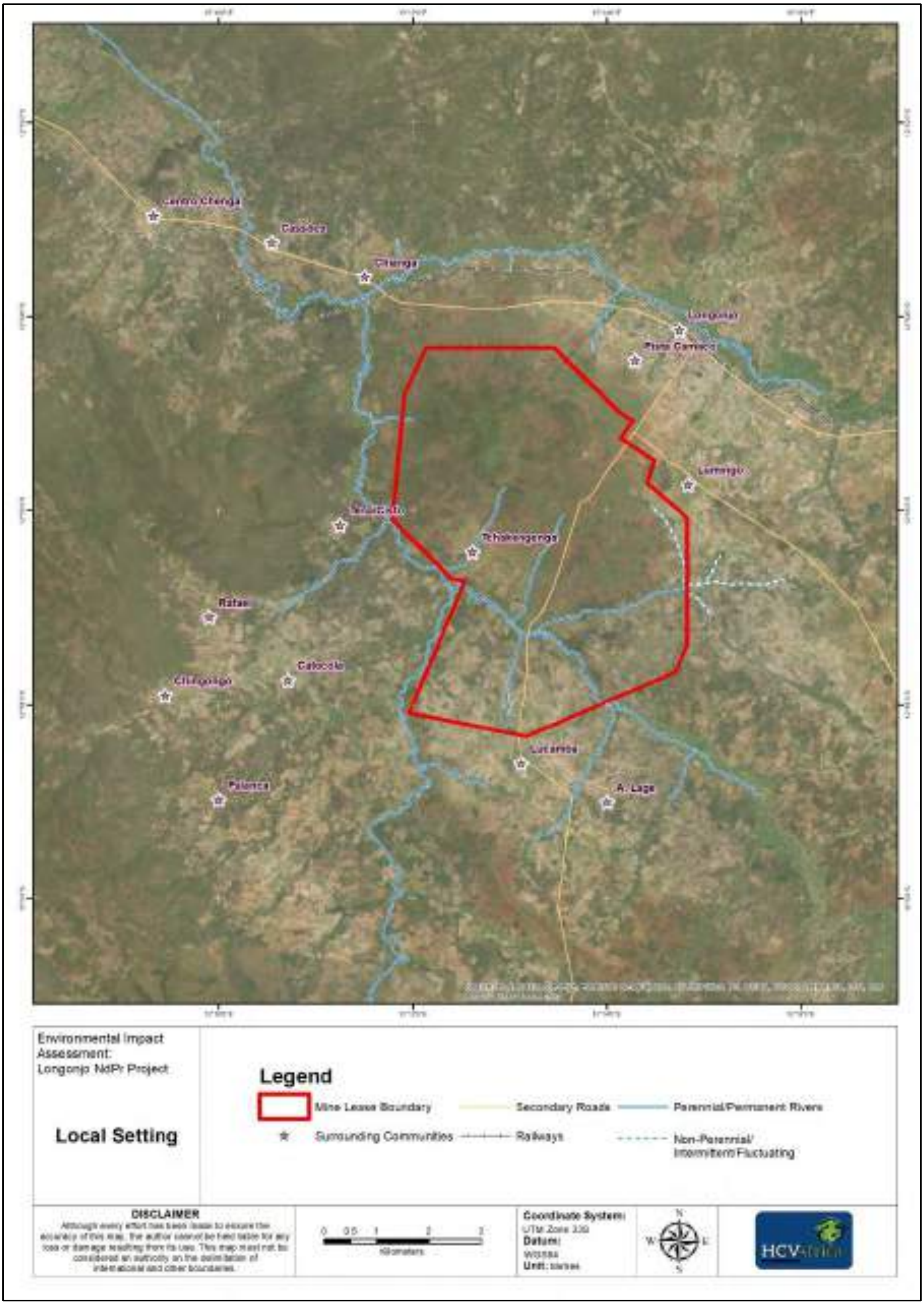


Figure 2-4: Project locality map indicating the new area as per Mining Title Certificate No 298/05/01/T.E/ANG-MIREMPET/2020

2.3 Project motivation

There is a significant international drive towards greener energy alternatives (electric vehicles and wind turbines) and other strategic industries. Consequently, the demand for rare earth metals is increasing exponentially. Rare earths display unique properties and benefits and neodymium (Nd)[2] and praseodymium (Pr)[2] are two rare earth elements of focus for this Project.

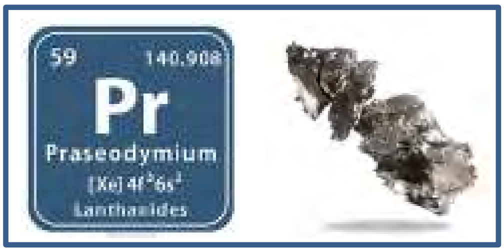
2.3.1 Products

Neodymium

Neodymium is a chemical element with symbol Nd and atomic number 60. It is a soft silvery metal that tarnishes in air. Neodymium was discovered in 1885 by the Austrian chemist Carl Auer von Welsbach.

Praseodymium

Praseodymium is a chemical element with symbol Pr and atomic number 59. Praseodymium is a soft, silvery, malleable and ductile metal, valued for its magnetic, electrical, chemical, and optical properties.



2.3.2 NdPr use

Neodymium and praseodymium are commonly referred to as 'NdPr' and are elements most widely used to create high strength permanent magnets.

NdPr materials drive the change that powers electric vehicles (EVs), wind turbines, other transport and military applications and domestic appliances.

2.3.3 Market demand

Commodity analysts forecasted that the NdPr oxide market would move into deficit in the next few years as demand takes off for magnets in EVs and other forms of transport, offshore wind turbines, military applications and a growing universe of green energy applications.

Adamas Intelligence[3] noted in its report Rare Earth Elements: Market Issues and Outlook Adamas Intelligence Q2 2019 that "*Demand for Neodymium oxide will substantially exceed global average production by 2030 leading to shortages of these critical magnet metals if additional sources of supply are not developed*".

The processing of REE is dominated by a small number of Chinese companies which control nearly 90% of the market. The market for sustainably sourced rare earth concentrates is expected to grow as producers come under pressure from the Chinese government. The magnet suppliers are pressurised by international

[2] Images adapted from https://en.wikipedia.org/wiki/neodymium and https://en.wikipedia.org/wiki/Praseodymium

[3] http://www.adamasintel.com/wp-content/uploads/2019/07/Adamas-Intelligence-Rare-Earths-Market-Issues-and-Outlook-Q2-2019.pdf

automotive customers of the current producers to diversify concentrate supply away from unsustainable local (Chinese) sources.

In addition, due to the strategic importance of REE in general, and neodymium in particular, several Governments and companies worldwide are looking to develop local processing capabilities. These are potential future customers for the Longonjo mine.

2.3.4 Proximity to infrastructure

As discussed in section 2.1, the Project is favourably located close to existing infrastructure that includes a sealed national highway and rail linking the Longonjo Project to the Lobito Port and the provincial capital of Huambo 60km to the east.

Figure 2-5: The Project located close to existing infrastructure

2.4 Development description and proposed project infrastructure

The development plan for the Project is to construct a shallow, long-life open pit mine including an on-site processing facility made up of a flotation concentration plant followed by a refinery to produce a high-grade mixed rare earth sulphate concentrate (in the Mixed Rare Earth Sulphate Refinery) for further separation at the Saltend Refinery (Figure 2-6). The Longonjo Mine is close to the recently upgraded Caminho de Ferro de Benguela railway line, which links it directly to the Atlantic port of Lobito and will use hydroelectric power from the Angolan National grid system.

Figure 2-6: Conceptual development plan schematic illustration

2.5 Project components

The project will comprise a shallow rare earth (Neodymium - Praseodymium) open pit mine, with a Concentrator Plant and MRES Refinery Plant for processing the ore, and the associated infrastructure for operating the mine is proposed. The Life of Mine is currently estimated at more than 18 years (~20) at a processing rate of 1.5 million dry tonnes of ore a year. A high-grade mineral product of up to 46,000tpa is to be produced on-site and transported to the Longonjo Rail Siding on the Benguela Railway, located 4 kilometres to the north of the project, either on existing roads or via a dedicated new road. The product will then be transported by rail to the port at Lobito for export to the Saltend Refinery based in Hull, UK.

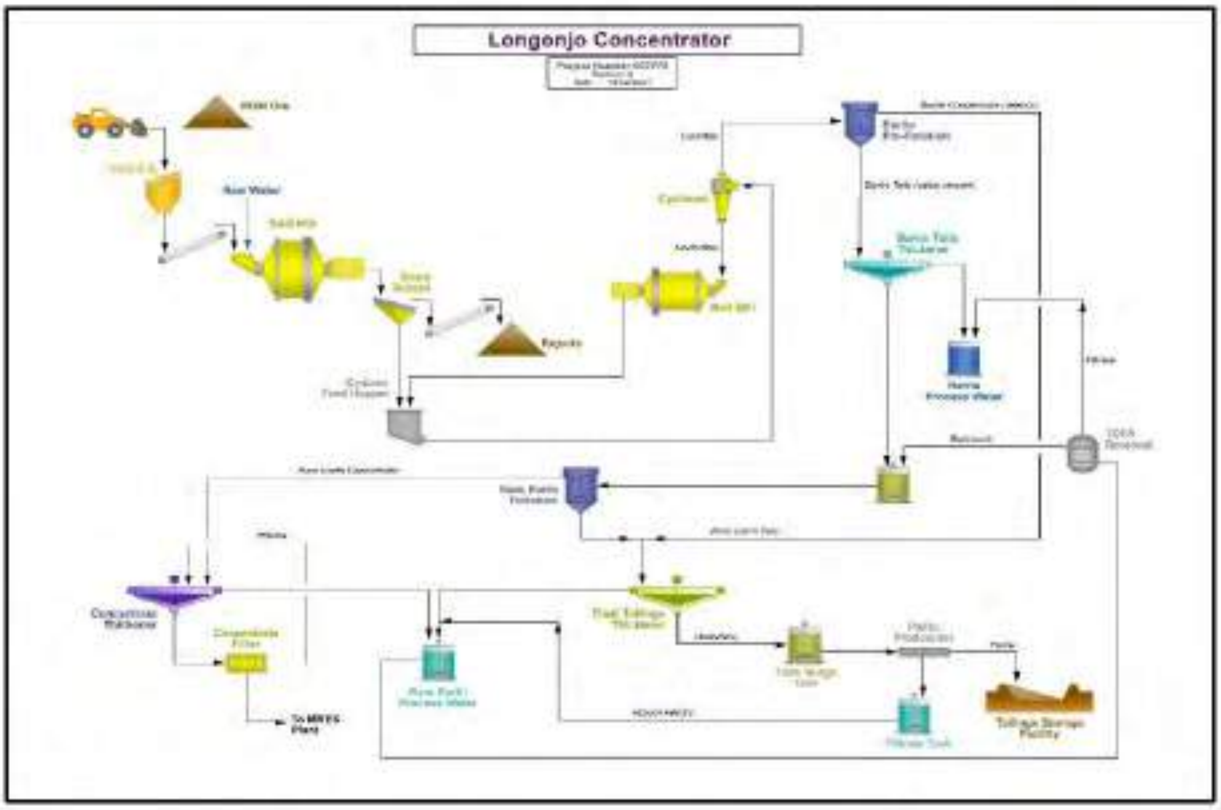
The major processes on-site will comprise of the following; open pit mine, unmineralised waste rock dump, ore and blending stockpiles, topsoil stockpile, Concentrator Plant (grinding and classification, flotation, filtration, steam generation, thickening), MRES Refinery Plant (acid baking, kiln off-gas scrubbing, acid leaching, elution, HCI production & Recovery/MRES precipitation, tailings, concentrate packaging, sulphuric acid plant), Infrastructure (electrical reticulation and distribution, diesel storage and distribution, potable water reticulation and distribution from existing and new boreholes, raw water reticulation and distribution which will be extracted from the Luluvile river, process tailings storage facility, personnel accommodation, sewage works, workshops, offices, internal road network.

The main Project components include:

- Open pit mine on average 25m deep;
- LG/MG/HG stockpiles;
- ROM pad;
- Unmineralised rock storage (waste dump);
- Crushing and milling circuit;
- Concentrator Plant -Processing facility with flotation process to produce a high-grade mineral concentrate;
- MRES Refinery Plant – to produce high-grade NdPr carbonate;
- Tailings facilities (TSF) for the waste from the processing plant and MRES plant;
- Accommodation village and offices;
- Boreholes field;
- River pump station and pipeline;
- Access road to road and rail (Longonjo Town Railway Siding) (*under investigation*);
- New Rail Siding from CFB Rail to the mine site (*under investigation*);
- Power supply; and
- Power line 220kV, 60MW from Dango substation to mine site (separate ESIA by a third party)

Figure 2-7 presents a simplified Project process flow chart. The site footprint and a preliminary site plan is shown in Figure 2-8.

It is possible that the layout (dimensions, quantities, and components) may change during the detailed design phase.



Longonjo MRES Plant

Project Number: 607770
Date: 19/08/2021

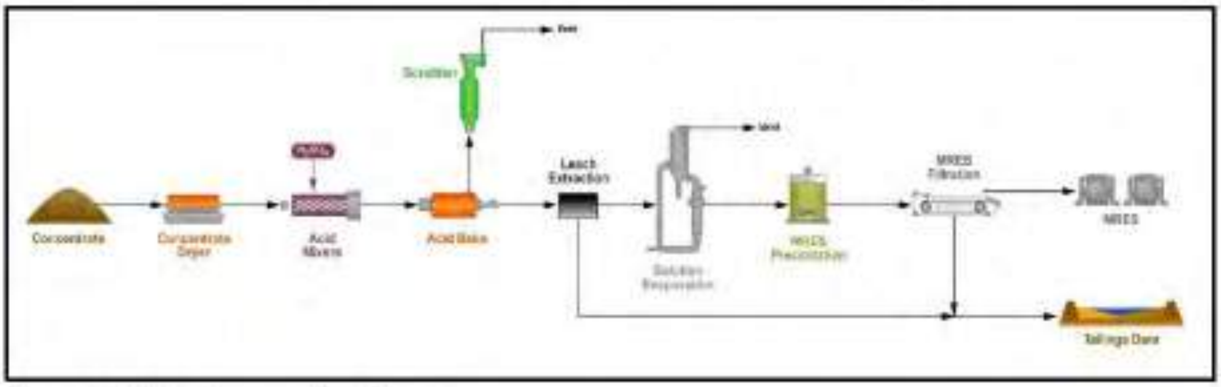


Figure 2-7: Project process flow diagram

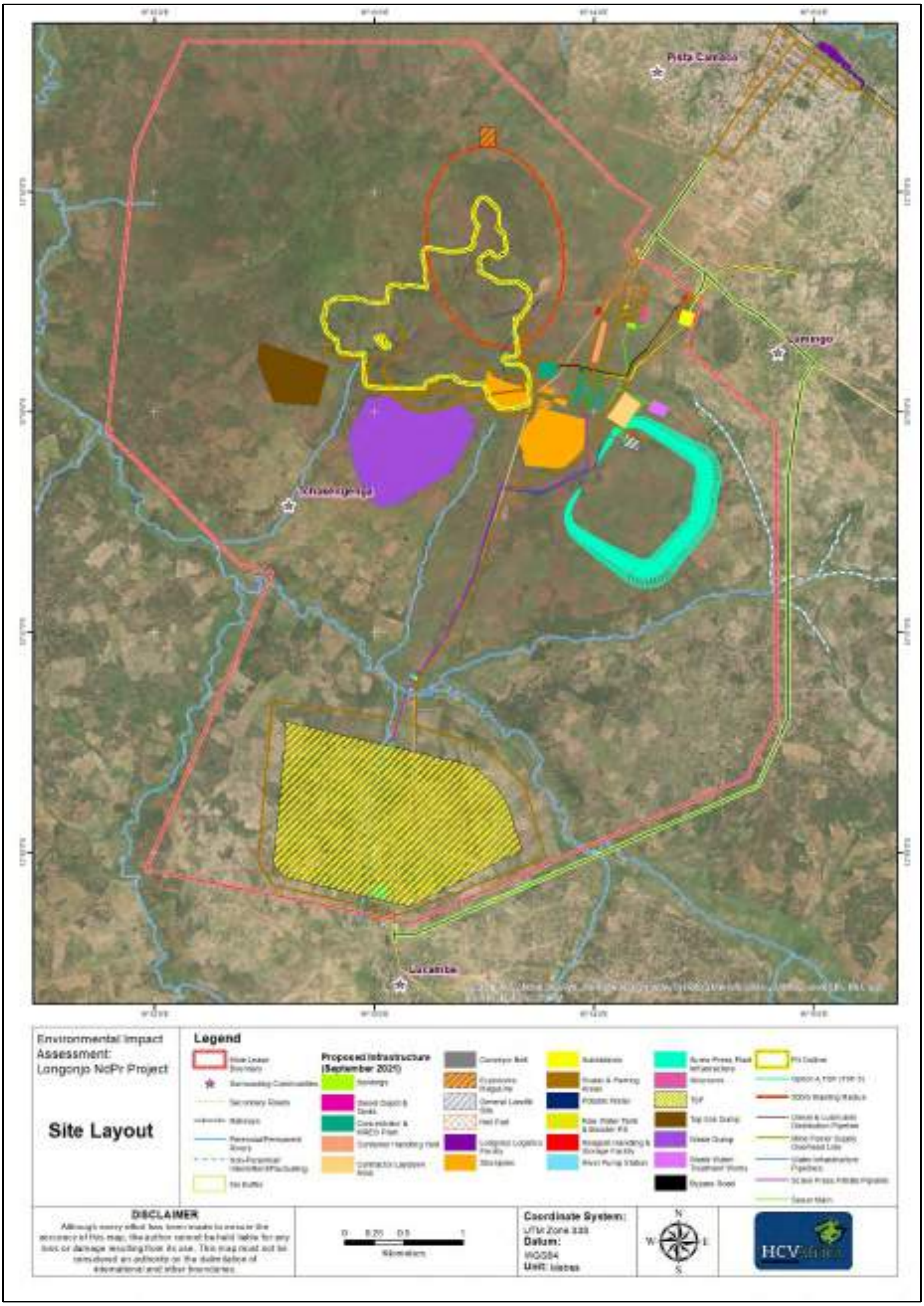


Figure 2-8: Project site layout map

2.6 Geology

NdPr rare earth mineralisation occurs in the partially eroded Longonjo Carbonatite. This structure is a sub - circular vertical diatreme (an explosive volcanic pipe) approximately 2.2 kilometres in diameter. A ring of hills surrounds the volcanic breccia pipe composed of more resistive alerted granitic country rock (fenite). Rare earth minerals within the weathered zone are predominantly monazite, with some bastnaesite occurring in peripheral areas.

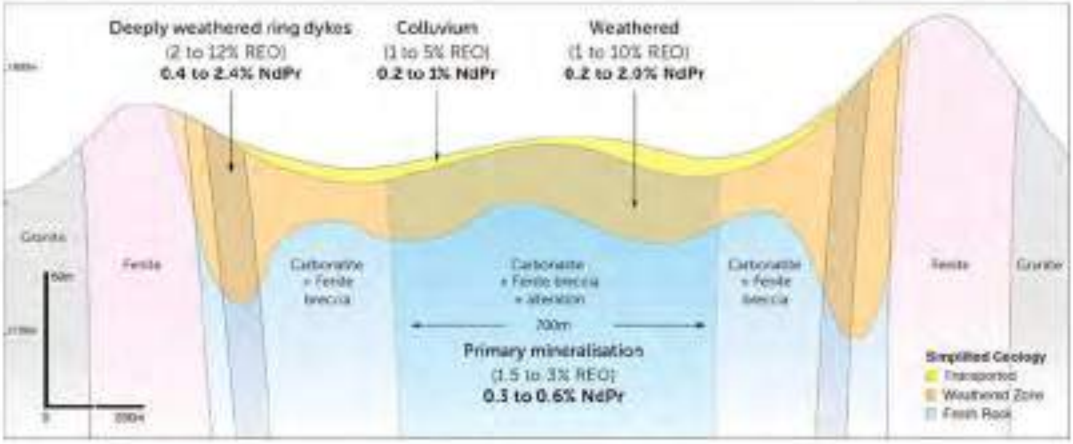


Figure 2-9: Schematic geological cross section across the Longonjo carbonatite. (Note vertically exaggerated scale).

For a more detailed discussion on-site geology, refer to section 4.5.1.

2.6.1 Drilling

Mineral Resource estimates were prepared using data from RC and DD drilling programmes completed by Pensana from 2017 to March 2020. In addition, the database compiled for resource estimation also contains data derived from a Rotary Air Blast (RAB) programme conducted in 2014. The RAB data were used to assist with the geological interpretation but not used for grade estimation.

Table 2-1: Resource estimation drill data summary

HOLE TYPE	DATES DRILLED	NUMBER OF HOLES	DRILLED METRES	TYPICAL DEPTH (m)
DD	2017	10	655	50
DD	Apr-2019 to May-2019	17	481	30
RC	Aug-2018 to Nov-2018	108	4,208	45
RC	Feb-2019 to Mar-2019	66	2,032	30
RC	Nov-2019 to Mar-2020	195	7,987	40
RAB	2014	22	657	30
Total	2014 – Mar-2020	418	16,020	38

A drilling programme was completed in March 2020 (see Figure 2-10), drilling of the 195 drill holes, totalling 7,987 metres. The drilling programme forms part of the IFS, and its objectives were to:

- Infill the area of planned first mining to 50m x 50m drill hole spacing to provide data to upgrade the Mineral Resource from the current Indicated to the highest Measured JORC category;
- Infill to 100m x 50m drill hole spacing to provide data to elevate the Mineral Resource from the current Inferred to the Indicated JORC category to allow inclusion into mine plan and extend mine life;
- Test a target area for fresh rock mineralisation to 80 metres vertical depth; and
- Test for extensions to the known mineralisation.

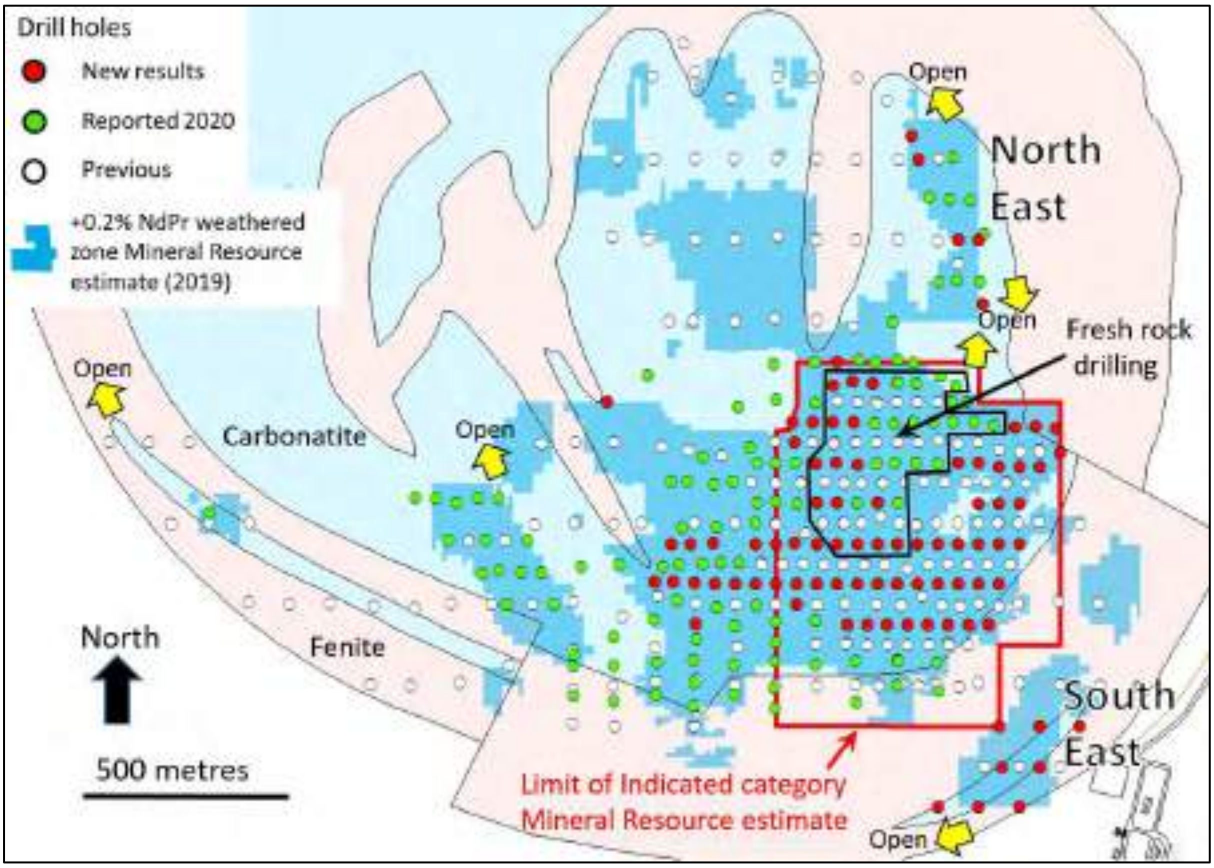


Figure 2-10: Plan view of the location of new assay results (red), over the +0.2% NdPr November 2019 Mineral Resource estimate block model for the weathered mineralisation. The extent of the Indicated category 2019 Mineral Resource estimate is highlighted

2.7 Resource estimate

Pensana appointed international mining industry consultants SRK Consulting (Australasia) Pty Ltd to complete an upgraded Mineral Resource estimate for Longonjo. The Mineral Resource estimate, reported under the JORC Code and Guidelines 2012, is:

313 million tonnes at 1.43% REO including 0.32% NdPr* for 4,470,000 tonnes of REO including 990,000 tonnes of NdPr**

**NdPr = neodymium + praseodymium oxide.*

***REO = total rare earth oxides. A 0.1% NdPr cut is applied. 14 September LSE and ASX announcement summarise the estimate at a range of cut off grades, material types, resource categories and individual rare earth oxide grades.*

- It contains more than **2.3 times** the previous estimate of the Measured and Indicated resources used in the Preliminary Feasibility Study[4] (announced ASX: 15 November 2019);
- It has increased the proportion of the resources reported in the Measured and Indicated categories from 31% to 68%[5]; and
- It increased the overall contained NdPr by 35%.

Table 2-2 below provides a summary of the Measured, Indicated and Inferred Mineral Resources at the 0.1% NdPr cut:

Table 2-2: Longonjo Mineral Resource estimate, Total, at 0.1% NdPr lower grade cut

Mineral Resource estimate category	Tonnes (million)	REO grade (%)	NdPr grade (%)	Contained REO (Tonnes)	Contained NdPr (Tonnes)
Measured	25.7	2.58	0.55	664,000	141,000
Indicated	165	1.51	0.33	2,490,000	536,000
Inferred	123	1.08	0.25	1,320,000	313,000
Total:	313	1.43	0.32	4,470,000	990,000

[4] Comparison of contained NdPr within the Weathered Zone Measured and Indicated categories at a 0.2% NdPr cut off, November 2019 and new Mineral Resource estimates.

[5] Comparison of contained NdPr within the November 2019 and new Total Longonjo Mineral Resource estimates at a 0.1% NdPr cut off (Measured+Indicated+Inferred categories).

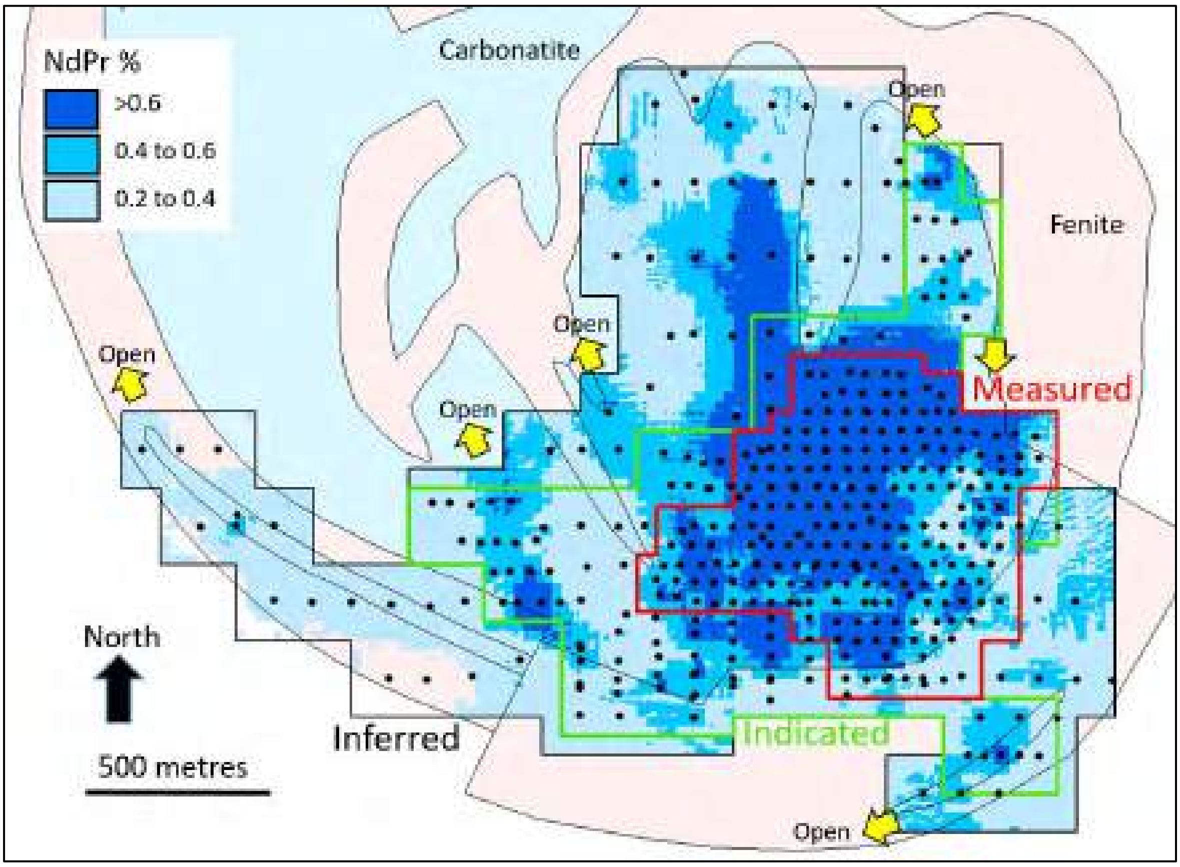


Figure 2-11: Plan view of the Mineral Resource block model for the weathered zone coloured by average NdPr grade over simplified geology of the Longonjo carbonatite. Resource categories highlighted

The initial IFS mine schedule is based on a subset of this resource – the Weathered Zone Measured and Indicated category mineralisation. This style of mineralisation is the most favourable for mining and processing due to its high grades from the surface and morphology of a thick blanket of soft material, typically ranging in thickness from 15 to 75 metres.

At a 0.2% NdPr lower grade cut, the Measured and Indicated category estimates for the Weathered Zone are:

- 39.9 million tonnes at 2.38% REO including 0.52% NdPr for 948,000 tonnes of REO including 208,000 tonnes of NdPr

A 0.2% NdPr cut is applied. Weathered Zone Measured and Indicated categories only, and is contained within and is a subset of the Total Mineral Resource estimate.

Table 2-3 summarises the Weathered Zone Measured, Indicated and Inferred Mineral Resources at a 0.2% NdPr cut.

Table 2-3: Longonjo NdPr– Weathered Zone Measured

Mineral Resource estimate category	Tonnes (million)	REO grade (%)	NdPr grade (%)	Contained REO (Tonnes)	Contained NdPr (Tonnes)
Measured	15.5	3.13	0.66	485,000	102,000
Indicated	24.4	1.90	0.44	463,000	106,000
Inferred	26.0	1.60	0.39	414,000	101,000
Total:	**65.9**	**2.07**	**0.47**	**1,360,000**	**310,000**

2.8 Geotechnical setting

No geotechnical logging or testing was done on exploration drill holes or trenches before 2019. However, during the drilling campaign of 2019, geotechnical logging and some limited testing were undertaken. The scope of the geotechnical logging was focused on the mining areas to be targeted during the initial years of the mining operation. The preliminary data was based on the geotechnical and structural logging of 16 vertical HQ3 diamond drillholes, total length 469.05 m, plus an initial geotechnical laboratory test programme.

The geotechnical setting is defined:

- The Residual material typically comprises a loose, medium to fine sandy material, with variable thickness from 0.0 m up to 2.0 to 3.0 m;
- The Saprolite horizon largely comprises a soft to firm, low to high plasticity, sandy silt, with occasional minor sections containing sandy, gravelly material. The base of this horizon varies from 6.46 m to 23.35 m depth below surface;
- The Saprock horizon comprises very weak to weak rock with thin intersections of soft, plastic silty/clayey material. It is interpreted as a series of moderately weathered core stones of moderate size separated by highly to completely weathered structural features (joints/minor faults). The base of this horizon varies from 16.3 m to 40.35 m depth below surface; and
- The primary carbonatite fresh rock horizon comprises a medium to strong rock material with moderate fracture frequency; along structures, some weaker infill material is present resulting from penetrative weathering.

Given the relatively shallow nature of the deposit and experience of the design engineering team (Wood), similar weathered rock materials, preliminary guidelines for mine design and optimisation studies have been assessed as follows:

- Inter-ramp slope angles (IRA):
    - In Saprolite, the recommended IRA is 30°
    - In Saprock, the maximum IRA can be increased to 45°
- For initial pit design and optimisation work, the recommended "average" maximum overall slope angle is 37.5°.
- The Saprolite and weaker sections of the Saprock horizon will be free-dig material, but less-weathered, more competent Saprock sections may require dozer ripping to improve mining production rates.
- Trafficability should not be an issue on Saprock benches, however, haul roads and ramps formed on wet Saprolite will need sheeting with competent sub-base material.

The geotechnical model and pit slope design recommendations are summarised in Table 2-4.

Table 2-4: Preliminary Pit Slope Design Recommendations

Horizon	Logged Strength	Estimated UCS	Resource Model Lith-code	Pit Slope Angle	Comment
Residual	Loose	Nil	20 (transported)	30°	Free-dig
Saprolite	Soft/Firm	50 – 100 kPa	30, 33, 36 (oxide)	30°	Free-dig
Saprock	Very Weak/ Weak	5 MPa	40 (fresh)	45°	Transition zone to fresh rock; dozer-ripping.
Fresh Rock	Moderate/ Strong	50 MPa	40 (fresh)	45°	Higher angle possible; currently dozer-ripping, will become drill and blast if modelled separately to saprock. More data required.

The typically fine-grained nature of the Saprolite and structural infill materials suggests that the Saprolite and Saprock horizons will have low permeability, and groundwater inflows will be relatively minor, although the materials may have high *in situ* moisture contents.

Since the completion of Phase 1, additional open pit mine design, metallurgical test work, and processing plant designs were completed. This led to the need to redesign the overall Longonjo Mine site plan, which, in turn, necessitates a new Phase 2 geotechnical investigation.

SRK undertook the task of compiling all the requirements for the Phase 2 programme, as provided by Wood, Snowden, and PPM, and generated a detailed scope of work. The tender for this workstream was issued in May 2021.

2.9 Mining method

The lithology controlled rare earth mineralisation occurs as a weathered horizontal blanket from the surface through the weathered regolith zone into the unweathered profile of the Longonjo carbonatite at the southern slope of Mount Chimbilundo. The mineralisation lends itself to open pit excavation with hydraulic excavators in backhoe configuration ("truck-and-shovel" mining) with predominantly "free-dig" excavation load and haul (Figure 2-12).

Figure 2-12: Mining cycle

Mining contractors will be used for mining operations, and as such, the equipment is representative, and the final fleet will be influenced by the equipment that the selected contractor has available.

2.9.1 Clearing and grubbing

Mining areas will be cleared of vegetation using tracked dozers. Vegetation will be stockpiled for spreading on rehabilitated slopes. Soil will be stripped from cleared areas (except soil stockpile areas), to a depth of 300mm (refer to Soil Stripping and stockpiling guidelines in the ESMP – Soil – section 8.15 of this ESIA report).

2.9.2 Drilling

2.9.2.1 Grade Control

Grade control drilling will be done using RC drill rigs, drilling 3" holes on a 10m by 10m pattern. Holes will be drilled vertically to full depth where practical (generally about 30m, although some areas are up to 70m). Samples will be taken every 2m to match the planned digging (bench) height.

2.9.2.2 Production

Production drilling, when necessary, will be undertaken on unweathered / fresh rock zones where ripping by bulldozer is not practical using track-mounted down-the-hole or top hammer drill rigs (~120mm diameter holes).

2.9.3 Excavation Guidance

Excavation guidance will involve the following steps:

- Grade control data collection
  - Collection of grade control samples
  - Sample assaying
- Ore/Waste determination
  - Grade control block modelling
  - Dig plan creation
  - Dig plan information provided to planning engineer
- Ore control
  - Mark out by surveyors
  - Assessment and adjustment of mark out by geologists, if required
  - Ore spotting, if required
- Reconciliation
  - Comparison of mined and processed with grade control and resource block models.

2.9.4 Blasting

Only the unweathered zones / fresh rock is planned to be blasted. Powder factors are anticipated to be around 0.5kg/m^3. This blasting is only anticipated in the latter stages of the LOM and in areas where there are fenite boulders or competent material which cannot be ripped by bulldozers or cast aside by excavation. Blasting is not planned to be undertaken in sensitive pit zones (**particularly 9 and 18** – refer to section 5 of this ESIA report), which are considered to abut environmentally sensitive areas. There is a risk that the saprock will also require blasting rather than ripping. As a result, the blasted quantity will increase by around 40%.

2.9.5 Loading

Most of the deposit will be free-dig, with the remainder requiring ripping, or in the case of fresh rock, blasting. Loading will be undertaken with small hydraulic excavators (backhoe ~70t) on 4m benches or as two 2m flitches. This is below the optimum digging height of 2.5m to 3.0m of the planned loading units and may result in slightly lower productivities and higher unit mining costs. These specifications should be revisited with the mining contractor, and potentially have the resource model updated to reflect an increment of 2.5m in the block model so that Mine planning is modelled on a 5m bench.

2.9.6 Hauling

Hauling is to be undertaken with articulated haul trucks (~45t capacity). This type of truck will be more suitable for the uneven ground likely to be encountered and reduce the risk associated with poor trafficability.

2.9.7 Tipping

2.9.7.1 Waste

It is not intended to backfill the open pit due to the potential processing of the underlying saprock and fresh rock. As such, the contractor will tip all waste onto external dumps (predominately mineralised waste). Some of the mine waste may be used to construct the mine haul roads (cut / fill and bunding) and the tailings dam walls; however, this has yet to be assessed by the mine planning / design team.

2.9.7.2 Ore

Lower-grade ore / ore required for later blending will be tipped on long-term strategic stockpiles to increase the project economics. The remaining ore will be tipped on the Run of Mine (ROM) into stockpiles for blending and rehandling when ore mining is not occurring.

2.9.8 Rehandling

Rehandling the ROM stockpiles to the crusher will be done using a Front End Loader (FEL). Long-term rehandling of stockpiles was assumed to be tipped on the ROM for further rehandling into the crusher.

2.9.9 Rehabilitation

Progressive rehabilitation (i.e., ongoing) will occur with dump batters pushed down to shallower angles and soil spread over them using track dozers. At Mine completion, the top of the waste rock dumps TSFs will be rehabilitated along with any other areas disturbed by mining. Topsoil on disturbed zones abutting environmentally sensitive areas (9 and 18) will be rehabilitated immediately, once profiled, to allow mining activities to proceed. Geofabric will be used to mitigate potential erosion during rehabilitation. Also, refer to the Closure and Rehabilitation Plan (Appendix Q).

2.9.10 Contracting

A contract mining operation was selected as the preferred approach. Main advantages of using mining contractors lies in the fact that they can supply immediate mining expertise, reduce operational risk and provide equipment flexibility required to enhance the success of the Project. This will also offer a competitive platform for local procurement.

2.10 Mining design and mining schedule

Based on the new mineral resource data, a further mining optimisation was carried out by Snowden, resulting in an extended LOM of 18 years (with potential for more as ore in fresh rock and the new areas remaining open for prospecting). At the end of the 18 years LOM, the processing plants will continue for a further two years while being fed by stockpiles. The mine plan envisages commencement in the areas of the laterally extensive deposit, based on the Weathered Zone Measured and Indicated category mineralisation.

Only Measured and Indicated resources were used in the base case pit optimisation. A scenario was run testing the inclusion of Inferred resources. Areas requiring special attention in terms of potential environmental and social impacts were identified in the 2019 baseline studies. The areas around the church ruins and bat caves were excluded from the pit optimization.

2.10.1 Pit Optimisation

Table 2-5 summarises the processing rates supplied by Wood used in the pit optimisation.

Table 2-5: Pit optimisation processing rates

WEATHERING TYPE	UNIT	RATE
Concentrator ore feed	kdtpa	1,500
MRES concentrate feed	kdtpa	107

Snowden used the supplied design criteria listed in Table 2-6 for the pit designs.

Table 2-6: Pit design parameters by weathering

PARAMETER	UNITS	TRANSPORTED/ SAPROLITE	SPAROCK/FRESH
Bench height	m	4	4
Berm width	m	4	2.5
Face angle	°	54	69
Overall angle	°	30	45

Ramp parameters were designed to be 13.5m wide. The minimum width for all stages was 20m with a minimum mining width of 13.5m.

Figure 2-13 shows the stage designs of the open pit. The stages were ordered based on:

- Early access to high grade ore;
- Delay the northern hill;
- Delay steeper areas;
- Minimise hauling trips ; and
- Minimise strip-ratio.

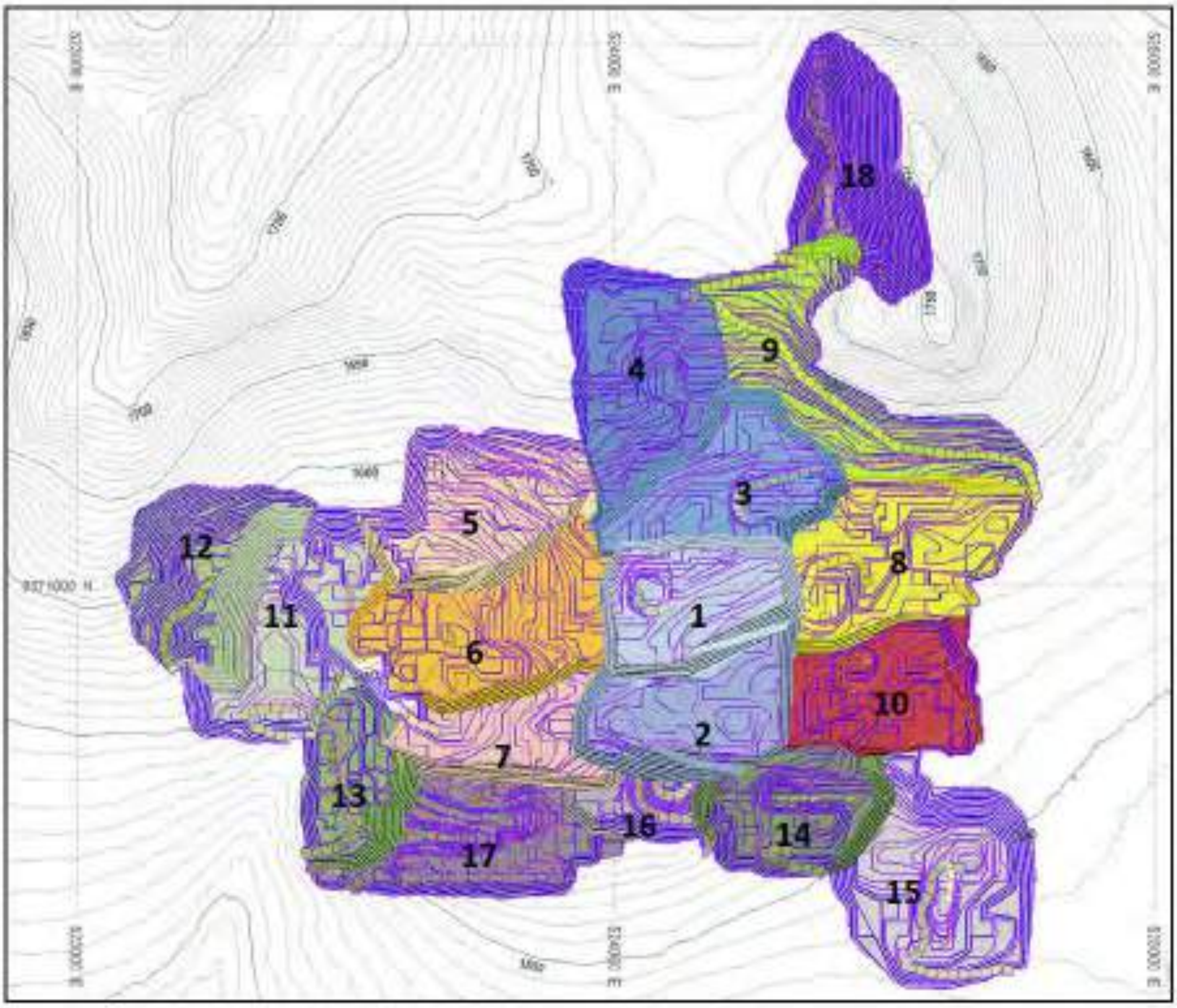


Figure 2-13: Pit schedule of 18 phases for LOM of approximately 18 years

Stage 9 was designed to avoid critical habitat (see section 4 and section 5 below – e.g., relating to the bat caves and Angola Cave Chat (*Xenocopsychus ansorgei*), and stage 18 avoids the ruins of a church of cultural value.

Table 2-7 Table 2-7 summarises the pit design inventory. Most of the mass is contained within the oxide (saprolite) lithology. Therefore, potential plant feed is restricted to the oxide and transported lithologies. On average, the grades are higher in the transported lithologies, accounting for 13% of the ore by dry mass. Almost 34% of the fresh material occurs in stage 16, with stages 1, 3, 5, 6, 8, 9, 10, 13, 14, 15, 17 and 18 containing less than 10% each.

Table 2-7: Pit design inventory

Item	Pit design
Total (Mwt)	53.2
Waste (Mwt)	11.7
Ore (Mwt)	41.6
Ore (Mdt)	30.0
NdPr (%)	0.57
TREO (%)	2.62

2.10.2 Waste Dumps

Table 2-8 summarises the dump design parameters. Dump ramps were designed at a 10% gradient with a width of 13.5m. A 20% swell factor was assumed like most of the material is oxidised and will be free-dig, so it should not swell significantly.

Table 2-8: Dump design parameters by weathering

PARAMETER	UNITS	AS-DUMPED	REHABILITATED
Bench height	m	10	10
Berm width	m	27.5	10
Face angle	°	37	18
Overall angle	°	13.8	13.8

Figure 2-14 shows the waste dump design located to the south of the pit, with a maximum height of 50m and a top level of 1,546mRL. The design avoids the drainage lines and has a capacity of 13Mlcm. This is 90% more than required, which will mitigate any risks associated with higher-than-expected swell factors and allow mineralised waste to be stored separately.

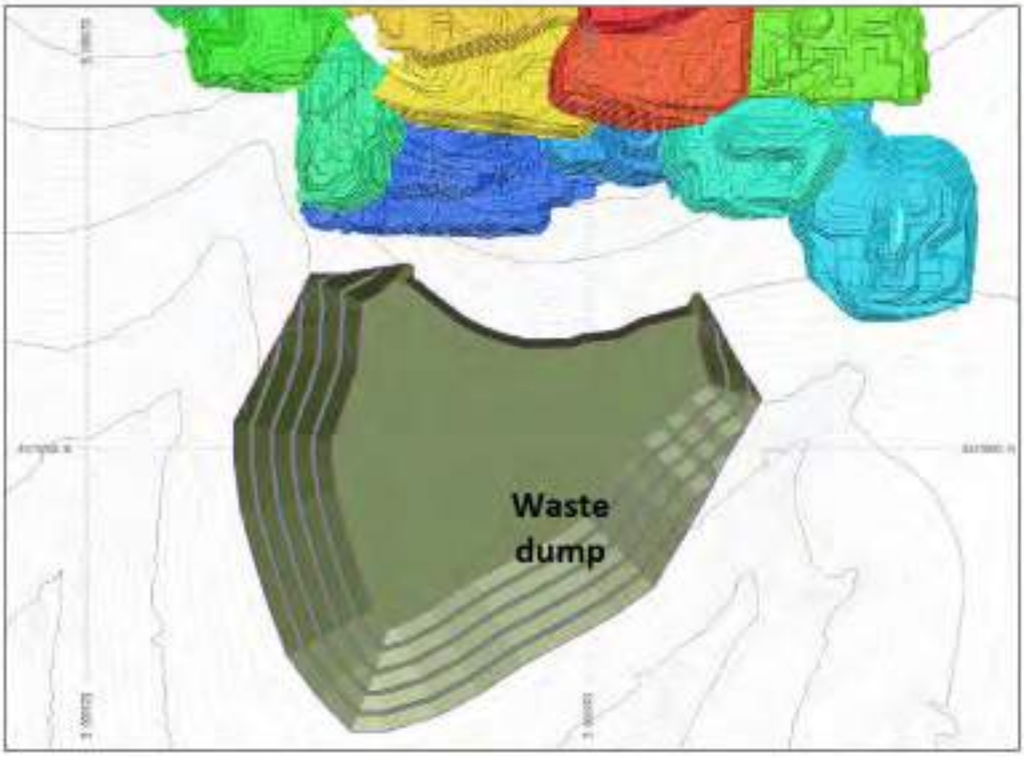


Figure 2-14: Dump design

2.10.3 Stockpiles

Figure 2-15 shows the long-term stockpile designs. The low-value stockpile (LVB) is located to the south of the ROM and uses the same design parameters as the waste dump. This allows rehandling to potentially occur on multiple lifts with easy access off the wide berms. In addition, should prices decrease, this stockpile can be more easily rehabilitated. The low-value stockpile has a capacity of 3.6Mlcm with a maximum height of 40m (1,560mRL).

The HVB/MVB (high/medium value bins) stockpile is located on top of stage 15 as it will be reclaimed before mining commences there. It has a capacity of 1.1Mlcm with a maximum height of 30m (1,564mRL).

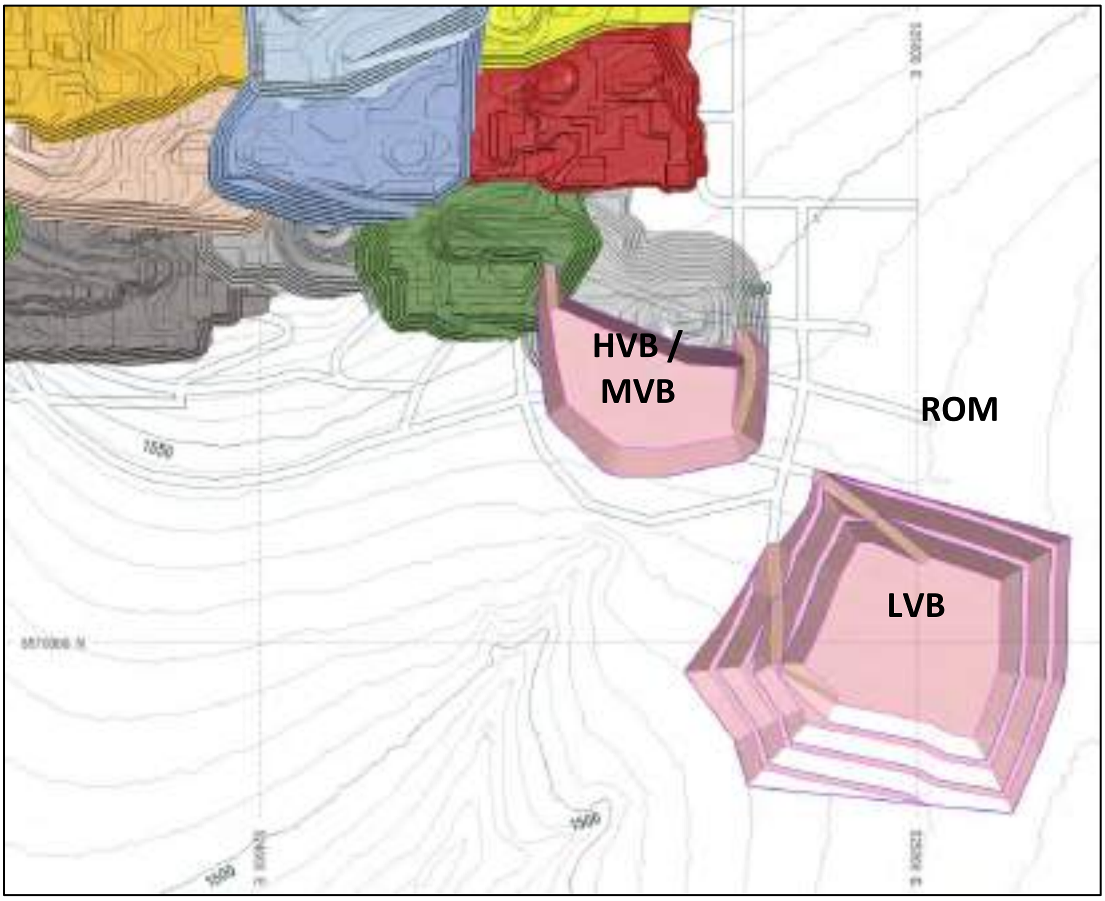


Figure 2-15: Long term stockpile designs

Depending on the final blending requirements, the number of ore types may increase. This would increase the area required for stockpiling as the stockpile height would need to be reduced to accommodate simultaneous access to more ore types.

Consideration should be given to constructing a ROM pad level with the crusher pad. This will eliminate the uphill / downhill haul component for the ROM rehandle FEL, which could be problematic during rain events.

2.10.4 Clearing

Figure 2-16 shows the mining areas cleared. Table 2-9 summarises the mining areas to be cleared and the topsoil to be recovered from those areas. Topsoil recovery was assumed at 300mm and stockpiled up to 5m in height.

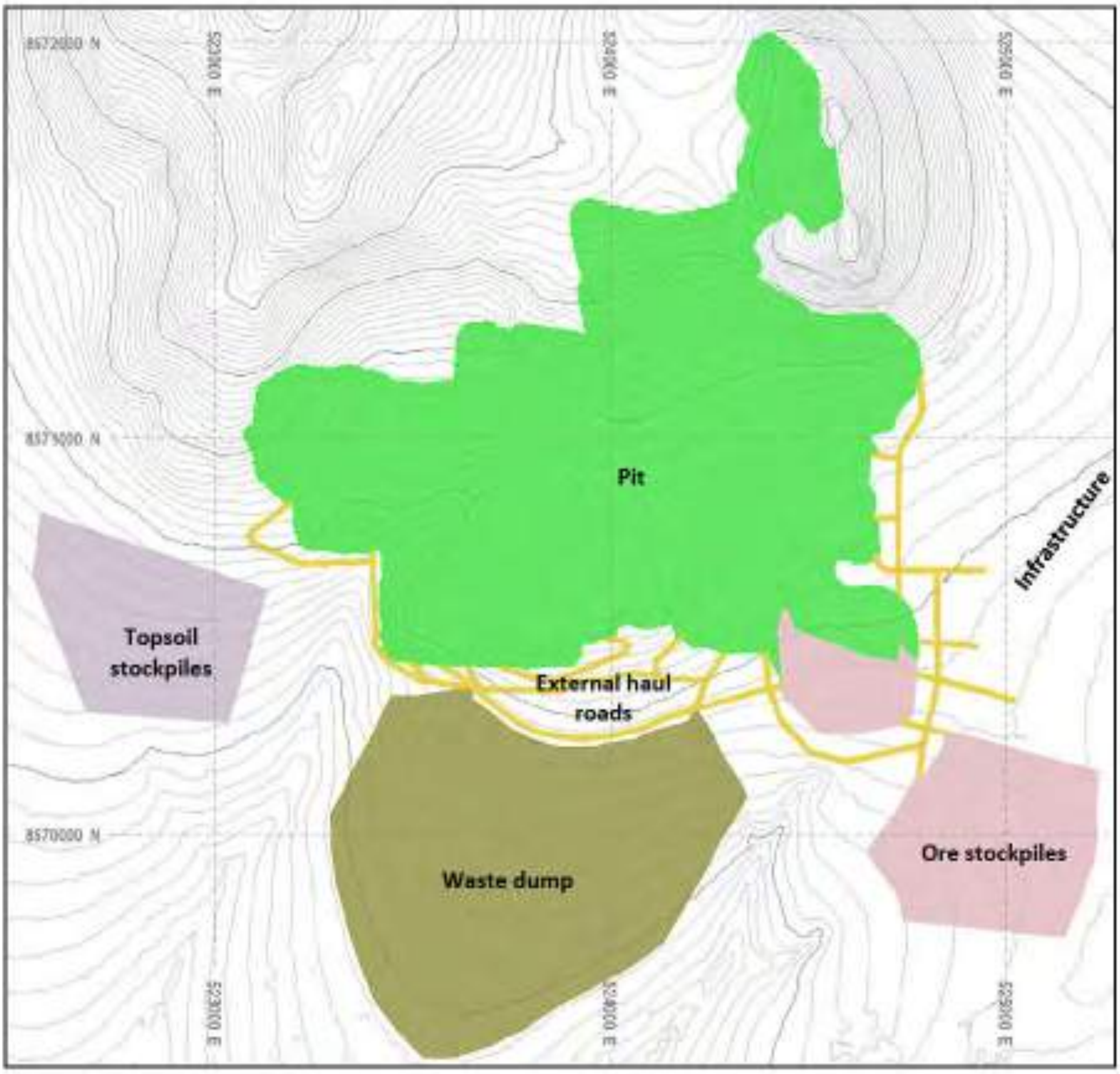


Figure 2-16: Clearing areas

Table 2-9: Clearing and topsoil

DESCRIPTION	AREA (ha)	TOPSOIL RECOVERED (kbcm)
Pit	141	423
Dump	69	208
Infrastructure	5	16
External haul roads	14	41
Ore stockpiles	35	105
Topsoil stockpiles	21	-
Total	285	792

2.10.5 Schedule

The schedule was completed in annual increments over the life of the Project except for the pre-production period (year -1), which is four months. Figure 2-17 shows the ex-pit movement by stage. Mining will peak at 3.4Mwtp/annum for four years at the start before reducing to about 3Mwtpa for most of the mine life.

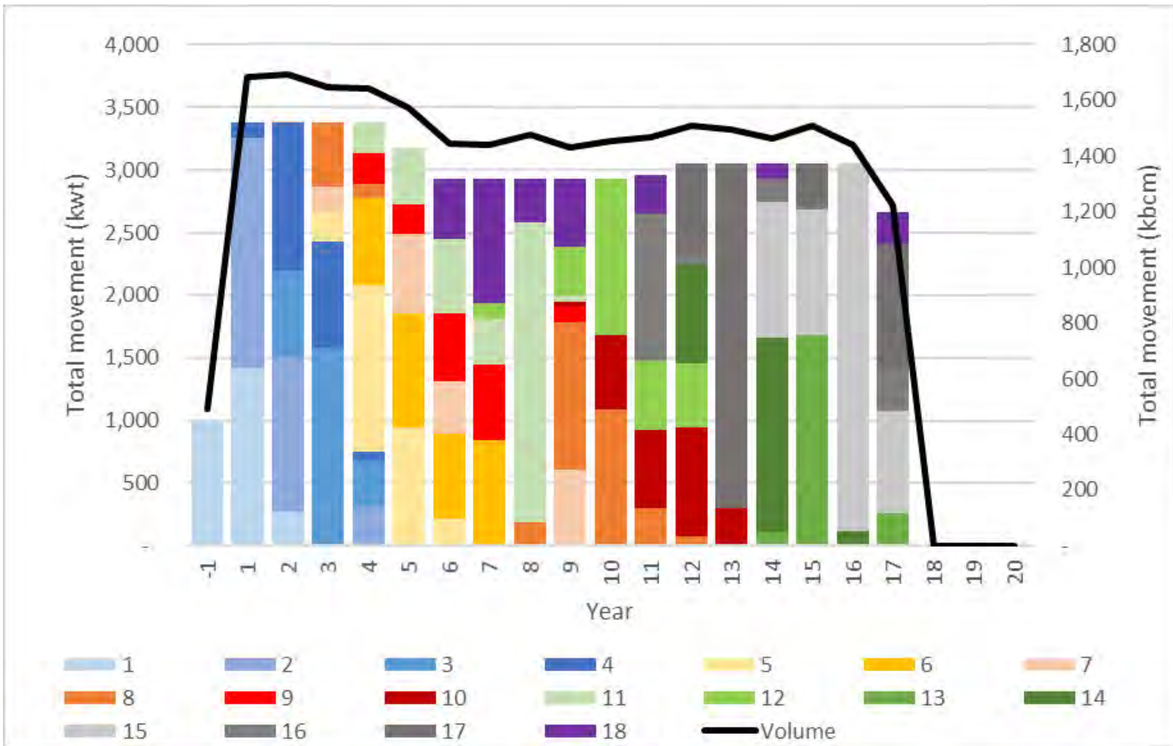


Figure 2-17: Total ex-pit movement by stage

Figure 2-18 shows the ore feed to the processing plant by resource category and the percentage of capacity that is used. The initial periods are sourced predominately from measured resources, which will reduce the resource risk. The plant is used to capacity over most of the schedule.

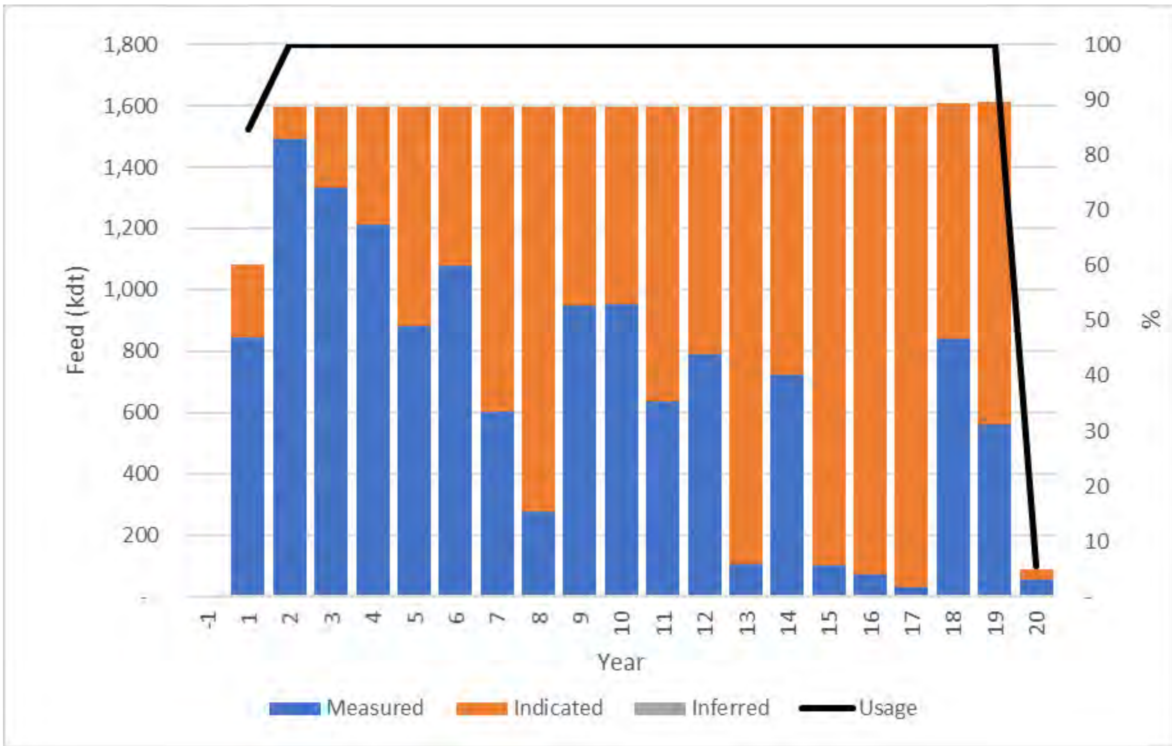


Figure 2-18: Plant feed by resource category

Figure 2-19 shows the stockpile size by ore type. The stockpile is at its 4.4Mdt capacity from year 7 to 11. Initially, higher value ore will be stockpiled, which indicates that it may be possible to lower the initial mining rates before increasing it mid-schedule as opposed to maintaining a relatively consistent rate between 3.2 and 3.5Mwtpa. This would also potentially reduce the amount of stockpiling, with a total of 12Mdt currently passing through the stockpile over the schedule.

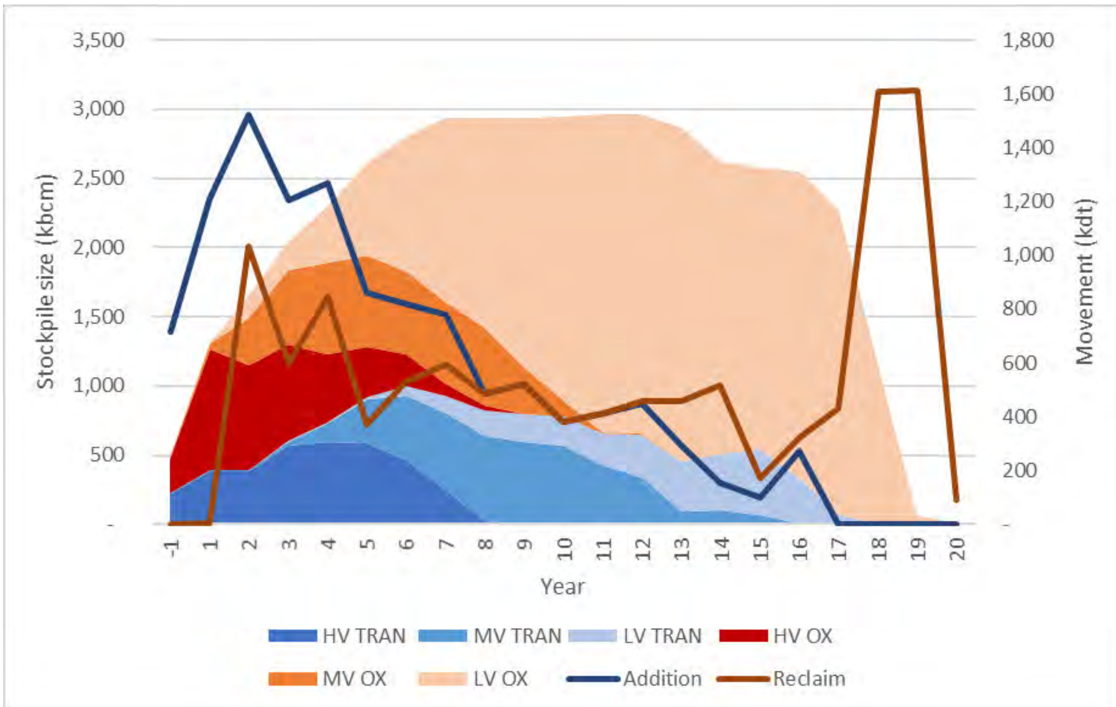


Figure 2-19: Stockpile size by ore type

2.11 Mining operations

2.11.1 Operating Philosophy

Contractors will be used for the mining operations. The appointed contractor is expected to be almost entirely self-sufficient, carrying out all mining operations, including:

- grade control drilling;
- drilling and blasting;
- loading, hauling and dumping; and
- rehandling of ores stockpiles to and on the ROM pad.

Pensana/Ozango will maintain control over the mining operation management through the supervision of the contractor operation, mine planning, grade control, geology and mining services and oversight over the operational health and safety management.

2.11.2 Mining Rosters

The mining operations will nominally operate a single 12-hour shift per day, seven days per week, all year round. This will allow mining to occur during daylight hours and reduce the noise impact on surrounding villages. Ore will be rehandled to blend the feedstock to the required plant specifications. Plant feed will be undertaken using an FEL on a continuous 24-hour operation.

2.11.3 Mining Equipment

Table 2-10 summarises the primary equipment required based on the contractor quotations. As contractors will be used, the equipment is representative, and the selected equipment will influence the final fleet. For example, the Contractor will operate water trucks to control dust generation from vehicle movement on all site roads, dumps and stockpiles and a grader to maintain haul roads.

Table 2-10: Equipment requirements

TYPE	SIZE	QUANTITY
Primary excavator	~70t operating weight	2 to 3
Backup excavator	~30t operating weight	1
Haul truck	45t capacity	8 to 12
Front end loader	30t operating weight	1 to 2
Motor grader	22t operating weight	1
Track dozer	40t operating weight	2
Roller compactor	17t operating weight	1
Water truck	35kℓ capacity	2
Service truck	20kℓ capacity	1
Drill	16t operating weight	0 to 1

2.11.4 Personnel

Table 2-11 summarises the labour requirements for the mining operation.

Table 2-11: Labour requirements

LABOUR TYPE	EXPATRIATE	LOCAL	TOTAL
Pensana/Ozango			
Management and supervision	2	-	2
Technical services	4	8	12
Administration	-	1	1
Sub-total	6	9	15
Contractor			
Administration	2 to 4	1 to 2	3 to 6
Technical	1	3	4
Supervision	2 to 6	1 to 3	3 to 9
Machine operators	2	43 to 48	45 to 50
Maintenance	-	19 to 24	19 to 24
Labour	-	12 to 35	12 to 35
Sub-total	7 to 13	78 to 122	85 to 129
TOTAL	**13 to 19**	**87 to 131**	**100 to 144**

2.12 Raw materials

Raw materials input to the mining operation and subsequent processing are summarised in Table 2-12. The raw materials storage is described in

Table 2-13.

Table 2-12: Planned raw materials input

NAME	UNIT	DAILY AVERAGE QUANTITY
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Table 2-13: Raw material storage

RAW MATERIAL	STORAGE OF RAW MATERIAL	CAPACITY	UNIT	SECURITY SYSTEM
[redacted]				

2.13 Mineral processing

It is proposed to construct a Concentrator Plant and MRES Refinery Plant for processing the ore, and the associated infrastructure for operating the proposed Longonjo mine, to have the ability to process at a rate of 1.5 million dry tonnes of ore a year. The ultimate design is to produce a high-grade mineral product of up to 46,000 tpa. The most significant processes on-site will comprise of the following; Concentrator Plant (grinding and classification, flotation, filtration, steam generation, thickening), MRES Refinery Plant (acid baking, kiln off-gas scrubbing, acid leaching, elution, HCI production & Recovery/MRES precipitation, tailings, concentrate packaging, sulphuric acid plant).

2.13.1 Metallurgical development

Pensana completed extensive metallurgical test work (in Australia) on a range of Project ore samples. A programme of evaluation and concentrator pilot test work on a range of mineralisation styles across the Longonjo deposit (from fresh rock to weathered) identified that the weathered zone mineralisation responds well to metallurgical treatment and should be initially targeted for development. This is due to:

- A high in-situ rare earth grade from the surface;
- Low content of carbonate and phosphate minerals gangue[6] minerals, which the natural weathering process has removed;
- Good liberation and grain size characteristics for physical separation; and
- Soft friable mineralisation requires reduced energy to crush and grind.

A simplified processing flowsheet is shown in Figure 2-20.

Pensana demonstrated the efficiency of a conventional concentrator beneficiation process for the Longonjo weathered mineralisation, consisting of:

- Comminution – the physical liberation of rare earth minerals from host gangue minerals by light crushing and grinding. The mineralisation is soft and naturally fine and has a relatively low work index, requiring only moderate crushing and grinding;
- An initial flotation stage to remove interfering gangue minerals; and
- Flotation targeting the recovery and concentration of rare earth minerals.

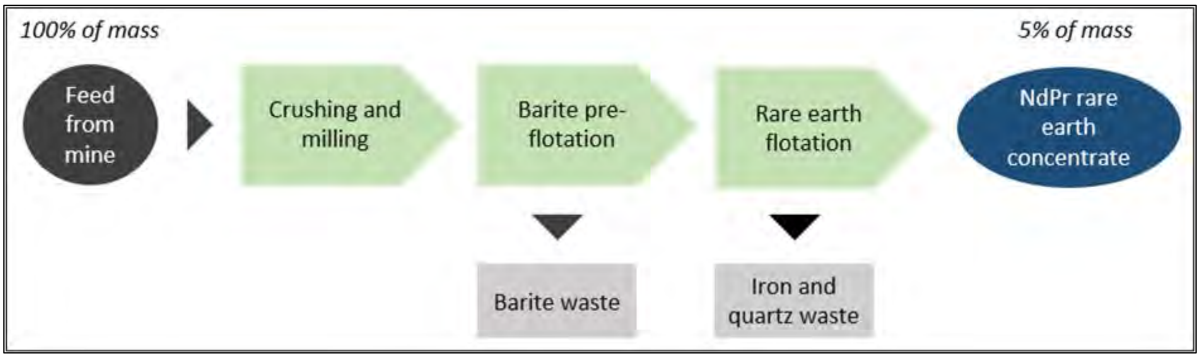


Figure 2-20: Simplified processing flowsheet for the Longonjo Project

The MRES Plant processes the mineral concentrate via:

- Acid bake,
- Leach extraction; and

[6] Commercially valueless material in which ore is found.

- MRES precipitation steps to produce a MRES salt.

A beneficiation pilot plant (in Perth, Western Australia) successfully treated 42 dry tonnes of material to produce NdPr concentrates up to 6.1% NdPr (within 25.8% REO). The operation of the pilot plant provided extensive operational and engineering design information and production cost data. The pilot plant also produced concentrate for use in the next stage carbonate process work (MRES), Figure 2-21.

Crushed and Blended ore from Longonjo

Pilot SAG and Ball mill to grind Longonjo ore for flotation

Flotation equipment for concentrating rare earth minerals

Flotation rare earth concentrate

Figure 2-21: Pilot plant

A large diameter drilling programme was concluded in early December 2020 (Figure 2-22) to provide bulk sample feed for optimisation and pilot plant programmes for the Company's expanded mining and processing operations strategy in Angola and a UK refinery.

Figure 2-22: Large diameter drilling programme bulk sample, December 2020

2.13.2 Processing plants[7]

2.13.2.1 Concentrator Plant

The Concentrator is designed to process a nominal 1.5 Mtpa (dry) of ore with a chemical makeup defined within an operating band to ensure downstream processing restrictions are not incurred. A simplified project flow chart is presented in Figure 2-7. NdPrO concentrate production will vary according to feed makeup. The feed rate's key factors are %NdPrO in feed and lithological differences that influence NdPrO recovery to concentrate (both positive and negative). The calcium content of the ore has a substantial effect on final concentrate grade and mass yield and must be controlled to limit dilution with acid consuming gangue. Coarse scalping has been allowed in the design to remove competent apatite particles ahead of ball milling to regulate the calcium grade presented to flotation.

NdPrO concentrate dewatering (thickening and filtration) is designed for a 14.4tph solids rate plus an operating margin. Filtered concentrate will be conveyed to a feed bin located in the refinery area awaiting acid bake treatment.

The Longonjo plant design does sophisticated control systems and will be simple to operate and maintain whilst accommodating variable feed mineralogy. The plant will engage in the following sequential activities:

- ROM feed handling – mineralised feed received and oversize rejection;
- Comminution – open circuit primary milling followed by closed circuit ball milling and size classification using hydrocyclones;

[7] No design details of the processing facilities were available relating to relevant information required for the Air Quality Dispersion Model. Once this becomes available, the Dispersion Model must be updated along with the relevant air quality impact ratings and mitigation measures.

- Pre-flotation – removal of barite and other minerals;
- Rare earth flotation – four stages of flotation to produce a rare earth concentrate;
- Product dewatering – thickening and filtration of rare earth concentrate to moisture content;
- Tailings dewatering – thickening of pre-float and rare earth tailings;
- Tails disposal – pumping of thickened tails to the tails storage facility (TSF);
- Decant water treatment – return of water decant from the TSF (the Project is planned to be a zero-discharge project) and filtration to remove rare earth flotation reagents before re-use in the pre-flotation circuit.

Plant reagents are added to the process in small amounts compared to throughput, as illustrated in Table 2-14

Table 2-14 : Reagent dosing summary

Reagent	Purpose	Dosing Strength, % w/w
[redacted]		

2.13.2.2 MRES Plant

The MRES Plant is designed to process a nominal 107ktpa of concentrate, and reasonable concentrate storage is expected to allow for varying concentrator production rates. As a result, the MRES Plant is expected to produce around 40ktpa of MRES salt, which will be shipped to the Saltend Refinery as feed. The Saltend Refinery will process this MRES salt through additional purification steps, and then employ solvent extraction to separate the rare earths into final products.

The MRES Plant will process the mineral concentrate via acid bake, leach extraction and MRES precipitation steps to produce an MRES salt shipped to the Saltend Refinery, where it will be processed by caustification, oxidative drying, re-leach and finally solvent extraction. This will produce four pure rare earth solid products.

A basic production flow chart of the MRES plant at Longonjo is shown in Figure 2-23, while a simplified project flow chart of the Saltend Refinery in the UK is presented in

Figure 2-24.

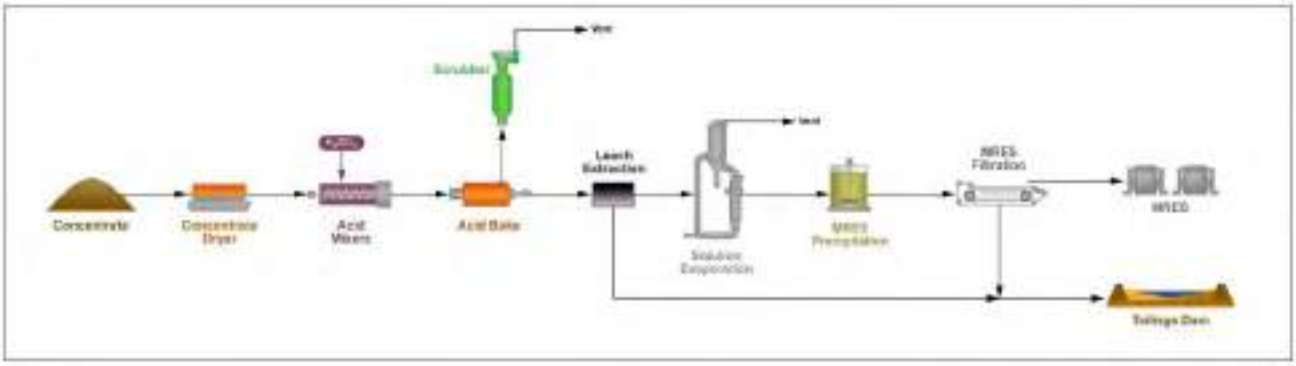


Figure 2-23: MRES plant simplified process flow chart of the Longonjo NdPr Project

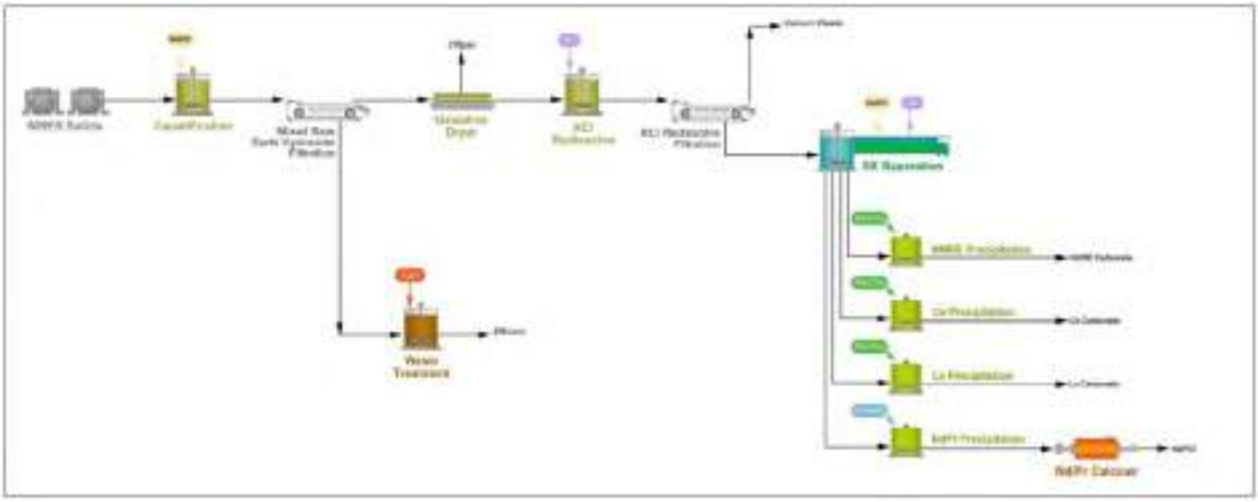


Figure 2-24: Simplified process flow chart of the the Saltend Refinery in the UK (not part of the scope of this ESIA)

In the Acid Bake, the moist mineral concentrate filter cake will be dried in a rotary dryer before mixing with concentrated sulphuric acid in a double shaft paddle mixer. The solids will be baked at 500°C for 30 minutes to an hour, ground to less than 300µm in a ball mill circuit, and recovered by mass flow screw feeders, each feeding an acid mixer. Next, the dried concentrate will be mixed with concentrated sulphuric acid, with the resulting solids recovered by dedicated discharge screw feeders and then fed by a screw feeder into the acid bake kiln.

The acid bake kiln will be an indirect fired rotary kiln. The bake conditions have been optimised to crack the mineral matrix to maximise rare earth extraction and gangue rejection in the subsequent water leach.

The leach solution will be treated with concentrated sulphuric acid and sodium bisulphate, which causes the rare earths to precipitate. The mixed rare earth sulphate and double sulphate salt cake (MRES cake) will be transferred by conveyor to a bagging station where it will be placed in 1t lined bags, sampled, and tagged. A set of 20 bags would be placed in a container for transport to the Saltend Refinery (not part of the scope of this ESIA).

Table 2-15 lists the reagents used in the MRES Plant.

Table 2-15: Reagent summary MRES Plant

REAGENT	PURPOSE	DISTRIBUTION STRENGTH, % W/W
[redacted]		

2.13.3 Materials handling and concentrate export

Containers will be used to export rare earth MRES concentrate from the mine via the Benguela railway to the Lobito Port to be shipped to the Saltend Refinery in the UK.

2.13.4 Tailings Storage Facility (TSF)

Two tailings streams will be produced:

- Concentrator flotation tailings, being approximately 93% of the overall volume; and
- MRES leach tailings comprise the remaining 7%.

A TSF options study was conducted by Wood, which informed the position, attributes and design of the preferred TSF option. In total, eight possibilities were considered, with a ninth option being a combination of two options. All options were based on safety, financial, environmental, operational and design requirements. More information on this process is available in the Alternatives Section (section 2.29).

The TSF will meet globally accepted tailings standards and guidelines, including the Australian National Committee on Large Dams (ANCOLD) (2019). Guidelines on Tailings Dams -Planning, Design, Construction, Operation and Closure. July 2019. GlobalTailingsReview.org (2020). Global Industry Standard on Tailings Management (GISTM). August 2020.

Geotechnical site investigations were undertaken to assess the proposed TSF foundation conditions for the main embankment, seepage potential of the TSF basin and availability of construction materials for TSF embankments. In addition, test pitting and laboratory testing were undertaken.

The final position of the TSF will be confirmed during detailed design. When writing the ESIA, the combined TSF option (named "Option 6 and 7 Merged") located to the south of the mining area was the preferred option.

The TSF will be constructed as a starter zoned embankment using local borrow material or selected open pit mine waste. The TSF facility will be lined with a synthetic liner (e.g. HDPE[8]) to prevent seepage of tailings leachate or from causing elevated pore water pressures on the embankment. The TSF facility will also incorporate an over-liner underdrainage system, including an upstream toe drain to drain tailings water by gravity to facilitate dewatering and consolidation of tailings.

At the time of writing this ESIA, additional geotechnical and hydrogeological investigations of the proposed TSF site were underway to determine basin and embankment foundation conditions, as well as groundwater levels and potential impact. Wood will assess the outcomes of these investigations and their impact on the TSF design.

Dam safety monitoring will include piezometers, monitoring bores and frequent survey monitoring.

[8] High-Density Poly Ethylene

A provisional closure concept will likely include a final land use as "pastural" or "farming". In addition, the closure concept will consist of some landform reshaping to fit with surrounding topography, visual impacts and long-term erosional stability.

2.13.4.1 Tailings Characteristics

A tailings sample was prepared as both a slurry and as a paste. After this initial test run, Wood concluded as follows:

- Paste performed better in several areas compared to the slurry. The maximum achievable air-drying density of paste is theoretically 1.12t/m^3 at its shrinkage limit (uncompacted). One of the main factors that govern the cost efficiency of tailings storage facility design is the achievable dry density. The paste outperformed the slurry sample by twofold.
- Slurry retained water showed higher plasticity than the paste and showed fewer fines after the pressing process. At the optimum moisture content of 31%, the paste can reach a maximum dry density of 1.4t/m^3. This indicates that an improvement from 1.1t/m^3 (achieved by uncompacted air-dried only) to 1.4t/m^3 (dried and compacted) is theoretically possible.
- Permeability of tailings is in a similar order of magnitude to natural clays found in this area.
- Shear strengths of both samples were higher than expected, but tests were done under idealised conditions. More testing will be undertaken to assign realistic strength characteristics.
- The tailings material is highly prone to dispersion.
- Therefore, the tailings materials are not suitable for conventional filtration methods.

Based on the findings above, the paste method of tailings preparation was selected as the most suitable design.

Air-drying is a critical aspect of the performance of most TSFs, and a surface area suited to provide air-drying was found within 20km of the process plant site. The go-forward site provided the flattest ground and best storage ratio in the area.

The following future activities will be undertaken:

- Wood will provisionally allow for a 10% reduction in the maximum design density, reducing the maximum density of paste from 1.1t/m^3 to 1.0t/m^3. Densities achieved in the field are generally lower than those obtained in the laboratory under idealised conditions;
- Wood will allow for a reduction in the maximum design shear strength parameters in accordance with the design standards factors of safety;
- Each year, with the annual audits, this dry-density and shear strengths must be reconciled with the achieved density, and the design parameters for the next raise adjusted accordingly; and
- The paste may improve its physical characteristics, by adding reagents or drying and compaction on the TSF. This will be investigated as part of the forward works.

Additional testing will be carried out on pilot plant tailings to characterise the mineralogy of the tailings product and the physical or chemical processes that can improve the densities. The full scope of testing will be determined upon receipt of all results from the current geochemistry testing and interpretation round. These results will impact the tailings placement management techniques.

2.13.4.2 Chemical and Mineralogical Composition of the TSF Solid Waste

Geochemical data for the tailings are limited. One tailings sample was tested (ANCOLD, 2019) as part of the PFS. Based on this data and project geological information, the ore is strongly oxidised material; therefore, there are no sulphides present, which can cause acid mine drainage (AMD) issues. In addition, the carbonatite host rock (comprising substantial carbonate minerals such as dolomite, calcite and ankerite) functions as a neutralising buffer to any acidic conditions. It is expected that the tailings will have similar properties. One short-term leaching test was conducted, and the test results were inconclusive; depending on the water quality criteria used for the Project, the tailings could be considered potentially metal leaching. In addition, residual parameters related to processing could also be leached from the materials. A tailings testing programme was proposed to address the limited information currently available.

Due to the expected characteristics of the tailings, the TSF design should include the use of a base liner to limit seepage out of the facility. An underdrain system will collect TSF seepage/contact water. For the PFS, it was assumed that water treatment would be required to manage contact water from the TSF. Water quality estimates for the TSF contact water will be developed once additional geochemical test results are available. Discharge criteria should be designed to support further evaluation of water quality management needs for the TSF.

2.13.4.2.1 Supplementary work

The following forward works recommendations are provided to assess the Metal Leaching and Acid Rock Drainage (ML/ARD) potential of project tailings in the forward works plan:

- Sample leachates were compared to International Finance Corporation (IFC) effluent guidelines to screen samples for their metal leaching potential. These guidelines include a limited list of parameters. Project-specific screening criteria will be identified and used for comparison purposes to assess metal leaching potential;
- Additional testing will be conducted on the available tailings sample, including kinetic testing (leach column) to assess further the sample's metal leaching potential, as well as mineralogical testing by Rietveld X-ray diffraction to confirm sample mineralogy;
- A geochemistry workplan will be developed to guide ongoing ML/ARD testing of project tailings generated from metallurgical test work. Process water generated during tailings production will also be tested. It is understood that a pilot plant will soon be commissioned to process a bulk sample at the project site. ML/ARD sampling from the pilot plant will be included in the geochemistry workplan; and
- Water quality estimates for the TSF for mine operations and closure will be developed once additional geochemical data are available.

2.13.4.3 Water balance

Figure 2-25 and Figure 2-26 show the outcomes of the monthly water balance. The graphs are scaled to compare with and without diversion drainage. Without diversion drains, the TSF will require around 12,000m^3 of decant per month to prevent the TSF from filling up. With no decant, the TSF will fill up over the years and will eventually require excess water removal. With a diversion drain in place, the TSF is likely to not fill up with water even with no decanting. The peak storage volume of less than 600,000m^3 is estimated. The design team requires significant forward work on TSF water balance to achieve more confidence on meteorological data and consequently design TSF components.

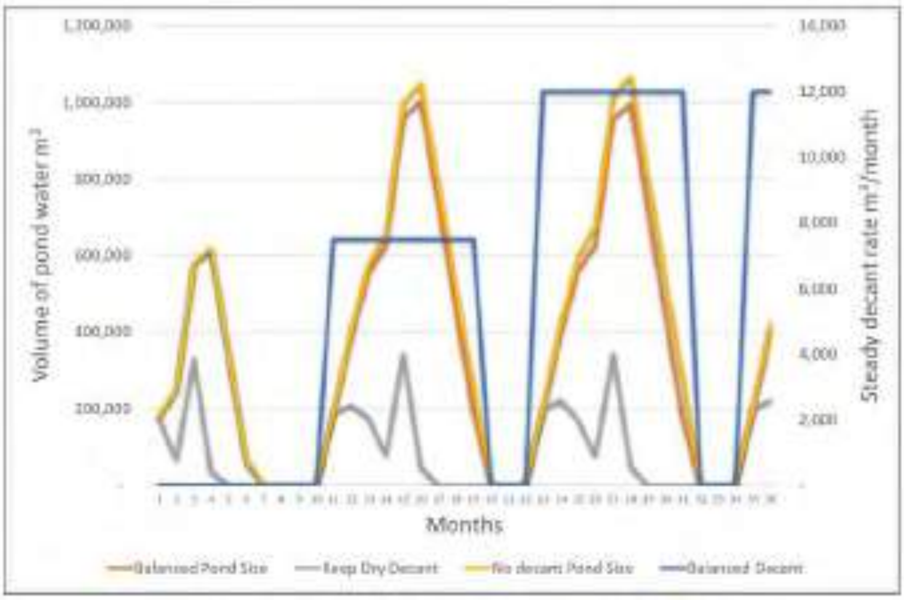


Figure 2-25: Water balance without diversion drains

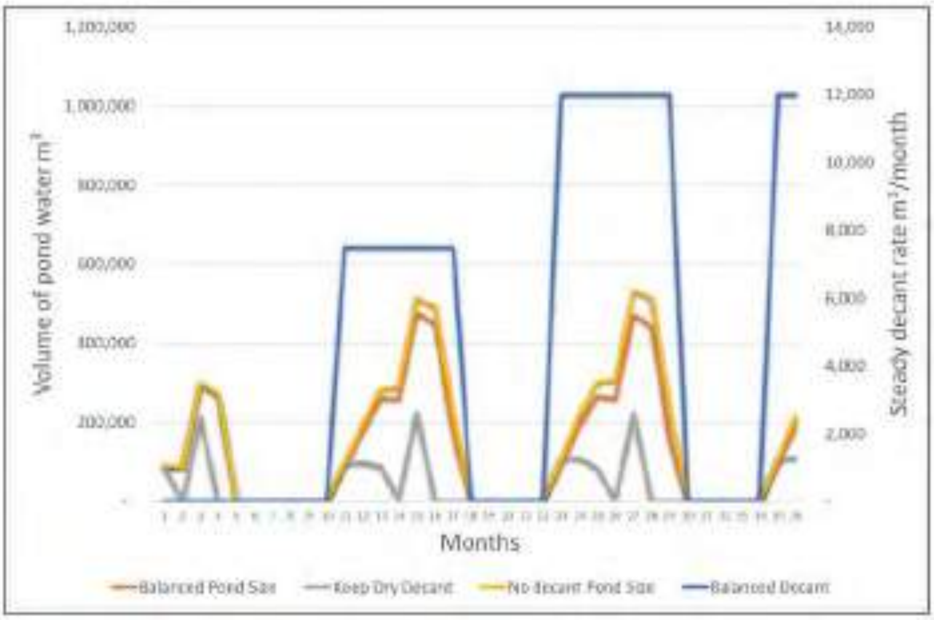


Figure 2-26: Water balance with diversion drains included

The main water management components to be considered in future design activities are:

- TSF specific: surface water reporting to the TSF, such as supernatant water, rainfall, and seepage return (if applicable);
- Surrounding or affecting the Mine and TSF design: such as diversion drains;
- Downstream off-lease receiving environment: in the case of diversion outlets and spillways; and
- Many of these items are addressed in the TSF water balance and site-wide water balance. This water balance determines how much water will report where and if there is an excess or shortage.

Wood will formulate a detailed daily water balance to model long-term rainfall events, storms, and statistical variability, taking climate change into account regarding the TSF.

2.13.4.4 TSF Design

Conceptual tailings deposition methods in future design activities include:

- Via chutes and dozers as a paste resulting in ponded water at or near the main embankment; or
- Sub-aerially via spigots as a slurry. Spigots are installed at regular spacing along the embankment crest, pushing the supernatant water (pond) away from the main embankment and towards the valley's centre.

Based on initial laboratory testing, the preferred tailings placement method will be as follows:

- Thickened slurry pumped from the plant to the TSF;
- Paste plant to be located at the highest location on the TSF footprint area;
- Paste to be placed by drop chutes and dozed in place down-stream; and
- Paste to be compacted by mud farming methods.

The paste plant will produce paste and overflow or excess water. The paste overflow water will be returned to the plant site for re-use. The current water balance indicates that almost no process decant water will be available from the TSF, and, therefore, only incidental and storm rainfall events are to be decanted. Water can be recovered in several ways, but it is recommended an extendable decant tower with submersible pump will be designed as the base case.

Excess water (wet season-post rainfall water) can be retained on the Concentrator TSF for short periods. Supernatant water and rainfall water will be removed from the Concentrator TSF and pumped to the leach cell of the TSF to keep the Concentrator TSF dry and keep the leach cell of the TSF saturated to prevent drying. The freeboard allowances on the TSF are designed to be enough to hold the design storm. Stormwater more than the design storm will exit the TSF via the spillway, which will be designed to convey a PMP storm event.

2.13.4.4.1 Storage capacity

The year 23 stage (Stage 12, Figure 2-27 and Figure 2-28) will have a conceptual total storage capacity of 33,100, 000m^3, and equates to 31,100,000t with a tailing's density of 1t/m^3. This embankment was modelled to provide 23 years of capacity. This capacity conceptually excludes stormwater storage and required freeboard allowances. These additional volumes are to be determined based on:

- Further tailings density tests;
- TSF footprint optimisation;
- Water balance calculations;
- Dam break assessment; and
- Consequence category of TSF.

Tailings densities will have a direct impact on the embankment sizes. The relevant calculations will be confirmed once the pilot testing is completed. The modelled 23-year capacity embankment plan arrangement is shown in Figure 2-27.

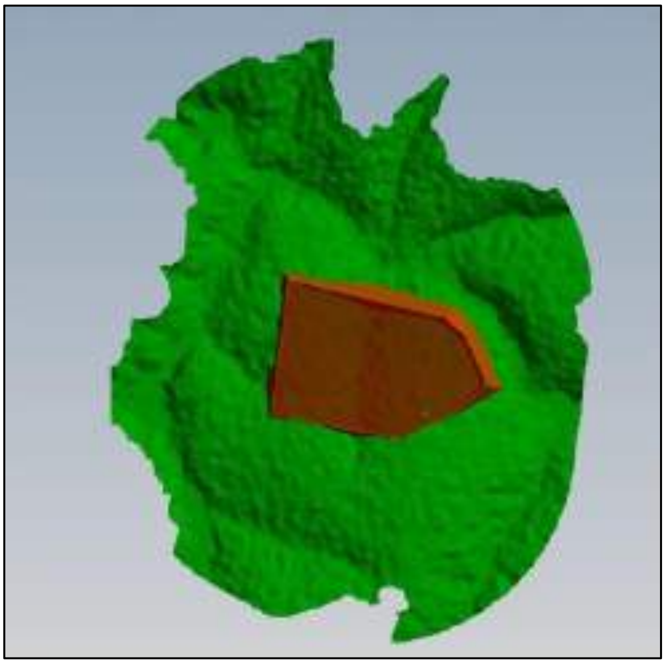


Figure 2-27: TSF illustration at year 23

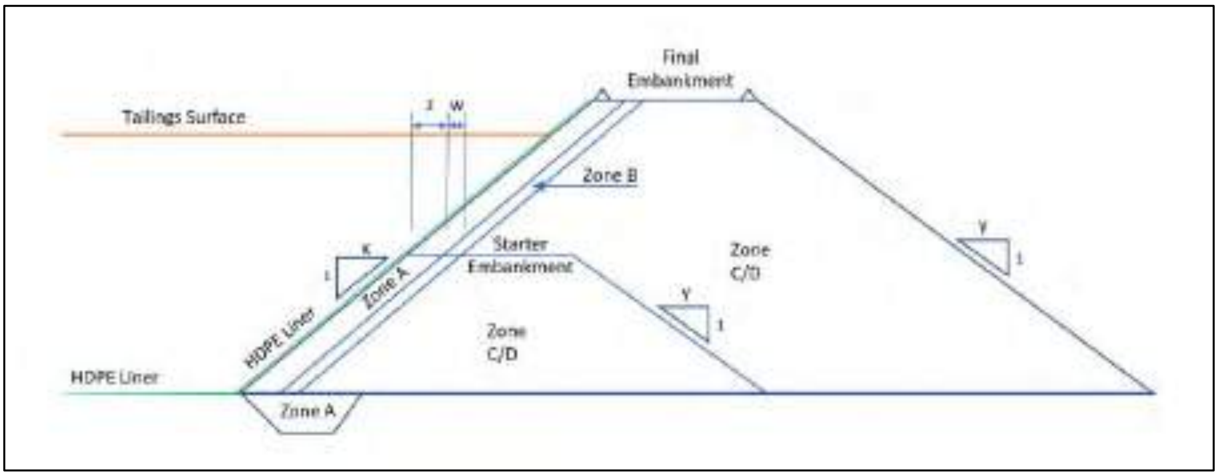
2.13.4.5 Construction

The proposed geometry of the TSF embankment Zones is based on typical cross-sections (Figure 2-28, not to scale). This TSF design is subject to:

- Construction material availability and properties thereof;
- Design requirements based on consequence category;
- Freeboard and spillway requirements; and
- Seepage and stability assessments.

The TSF zones comprise:

- HDPE liner (1.5mm nominal thickness);
- Zone A – Low permeability material (clay material) foundation for HDPE liner;
- Zone B – Filter zones (sandy material); and
- Zone C/D – General structural fill (clayey gravel or sand).



The following TSF general dimensions are used for the volume calculations:

- Upstream slope (x, n) = 2H: 1V;
- Downstream slope (y) =3H: 1V;
- Closure downstream Slope = 3.5H: 1V;
- Zone A crest length (z) = 2m; and
- Zone B crest length (w) = 1m.

In addition to the volumes for the embankment's zones, volumes for the cut of trench and basin liner are also included. The cut-off trench has a typical cross-section, i.e., trapezoidal shape, with a base 4m wide, 1H: 1V side slopes and a minimum height of 3m.

A low permeability liner will cover the TSF basin area with a nominal thickness of 0.3m. Next, the clay (or synthetic, if required) liner will be installed to be extended with subsequent raises, if needed. The breakdown of the volumes at different stages is shown in Table 2-16.

Table 2-16: TSF embankment volumes at mine stages

Stages	Starter (Year 1) (m^3)	Stage 5 (Year 9) (m^3)	Stage 11 (Year 23) (m^3)
Total Zone A	150,000	950,000	1,550,000
Embankment	*50,000*	*370,000*	*800,000*
Cut of trench	*11,000*	*40,000*	*50,000*
Basin Liner	*90,000*	*550,000*	*700,000*
Zone B	40,000	490,000	500,000
Zone C	230,000	2,700,000	10,000,000
Stage Total	420,000	3,800,000	7,900,000
Grand Total	420,000	4,150,000	12,000,000

The vertically exaggerated cross-section and longitudinal views of the TSF embankments at the starter (Orange), Stage 5 (Pink) and Stage 11 (Green) are shown in Figure 2-35 and Figure 2-30, respectively.

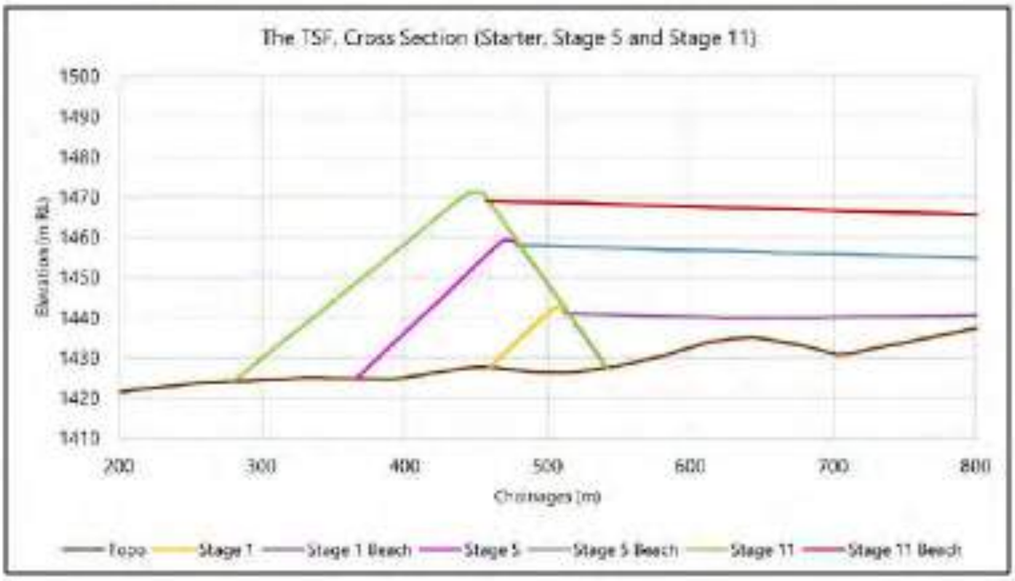


Figure 2-29: TSF cross section of embankment, illustrating Starter, Stage 5 and Stage 11

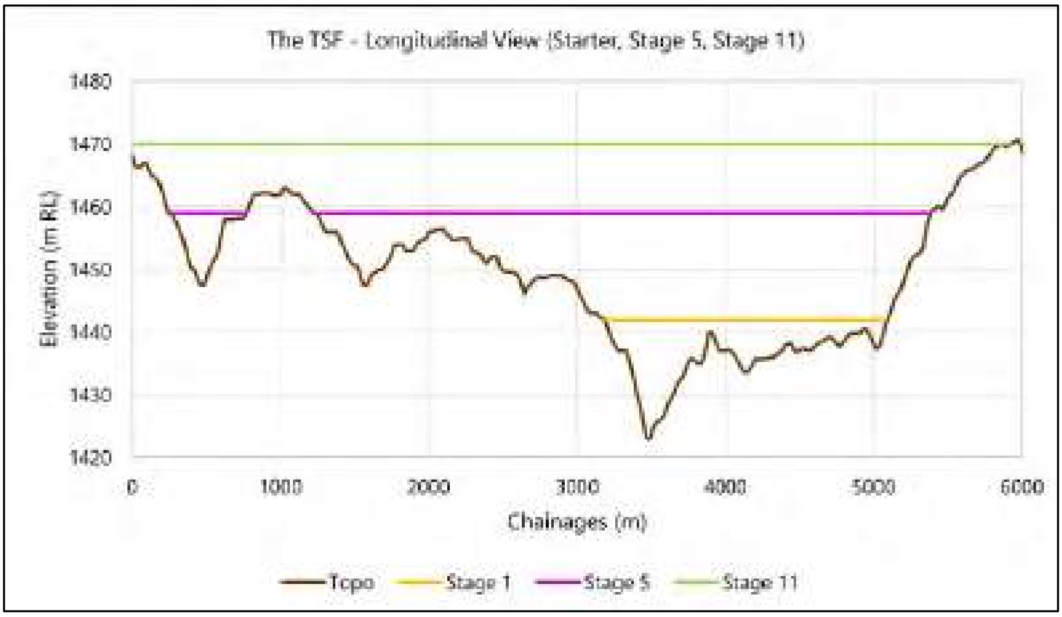


Figure 2-30: TSF longitudinal view

2.13.4.5.1 Construction timing

Stage 1 (Starter Embankment) construction must be completed before the first tailings are deposited at the commissioning of mining activities. The first raise (Stage 2) must be completed and ready to receive tailings without running out of freeboard about one month earlier. Conceptually, Stage 3 onwards is planned at 2-year intervals. However, if the construction methods and material sourcing prove difficult, the construction time frame can be longer than three months.

2.13.4.6 Operation

The tailings deposition strategy will still be formulated and will be managed throughout the operation to meet the design intent, which is summarised as being:

- Zero water return to the plant site;
- Effective utilisation of the net storage capacity;
- Reduce downtime through operational flexibility;
- Keep the TSF as dry as possible to promote air drying;
- Monitoring of the facility in the event of dust generation. Rotate deposition to spread wet tailings evenly. The use of excess paste or press overflow water for surface irrigation during drier times is possible;
- To reduce operating costs; and
- To facilitate implementation of the closure strategy.

A filter cake is considered "dry" at solids concentrations of greater than 70%. Depending on the slurry type, 40% to 70% may be regarded as a paste. The forward works will consider the possibility that the yield stress of the tailings filter cake behaves more like a paste which could allow pumping around the facility. This may be a more cost-effective placement strategy than dump and doze.

The base case design is based on a paste deposition by spigots, on the basis that solids concentration of 53% is likely to be pumpable.

2.13.4.6.1 Tailings Processing Considered

Based on future testing, two possibilities for the tailings plant were considered:

- The pressed tailings are dry enough to be placed and moved by track and dozer; or
- The pressed tailings behave like a paste and can be pumped by positive displacement (or other) pumps over short distances.

To accommodate the pressed tailings, a basin area as large as possible is needed to acquire enough drying time for the tailings to achieve their shear strength, which in turn will form part of the overall stability of the TSF.

2.13.4.6.2 Dry Cake

In the likely case that the filter cake can be placed and moved as a dry material, and for the purposes of this conceptual study, Wood recommends that a filter cake be:

- Placed by drop chute near the paste plant;
- Spread by truck-dumping (feasibility to be determined) or dozing;
- Farmed or turned to facilitate air drying using a screw propelled vehicle, also known as Amphiroll; and
- Compacted and shaped by swamp dozer to produce a dense product and uniform beach angle.

The deposition method will be carried out to keep surface water around the decant location.

2.13.4.6.3 Paste Slurry

If the tailings plant produces material that performs like a paste and can be pumped, the deposition of tailings to the storage facility would conceptually occur from multiple spigots inserted along a tailings distribution pipeline at locations to be determined based on the tailings rheology. Conceptually, the tailings deposition would be sub-aerial to promote a maximum amount of water bleeding and water removal from the facility by forming a large beach for drying. Deposition of the tailings is likely to be carried out on a cyclic basis, with the tailings being deposited over one area of the storage until the required layer thickness has been built up.

Tailings deposition will then move to the adjacent part of the storage to allow the newly deposited layer to dry and consolidate. The deposition could continue for a complete cycle, returning to the original area where it will have dried and consolidated.

2.13.4.6.4 Base Case

Paste tailings management forms the base case on the basis that:

- Dry cake movement by trucking and dozing at the rate required will be costly and difficult to manage;
- Rainy periods will produce difficult-to-manage periods with wet soft tailings;
- Bogging of vehicles is expected to be a problem; and
- Damage to the liner and underdrainage system is possible if not protected.

2.13.4.6.5 Delivery and preparation

The tailings delivery pipeline will be routed from the process plant high-rate thickener to the TSF paste plant, from where it will be pumped as a thickened slurry underflow at a solid's concentration of approximately 35%.The TSF paste plant will be located at a high elevation to the south of the Concentrator TSF footprint so that paste can be discharged downhill. The plant consists of a screw-press from which the underflow is produced as a paste, and the overflow is returned as process water.

2.13.4.6.6 Deposition method

Paste tailings delivery will be by single point discharge in a down-valley configuration from the paste plant. Delivery lines will initially be extended to the starter tailings footprint to prevent the need for a liner in future footprint areas. Then, paste delivery points will be systematically relocated (pulled back) as the raises prevent the pipe from being buried. After depositing in an area where beaching has stopped, and the tailings have completely settled down, further dewatering will occur through evaporation with some assistance through the drainage system. As the moisture content drops, the volume of the tailings will reduce to maintain a full saturation condition within the tailings. This process will continue until the interaction between tailings particles hinders volume reduction.

2.13.4.7 Monitoring

A monitoring programme for the TSF will be developed which will comprise:

- Deep and shallow monitoring bores for seepage monitoring located around the perimeter of the facilities;
- Frequent embankment and tailings surface survey monitoring for movement and settlement detection;
- TSF pond size and location monitoring for phreatic water levels correlation; and
- Piezometers will be installed in the embankments to monitor phreatic levels to enable stability monitoring.

General inspections will include the following:

Daily routine inspections:

- Tailings distribution pipelines;
- Leakages;
- Spigots and valves;
- Tailings deposition (flow, erosion, beach, and freeboard);
- Location and size of water pond;
- Decant structure and decant pump;
- Process water pond and water return pumps;
- Underdrainage sump and flow from underdrains;
- Seepage (if any) from retaining structure toe;
- Status of any secondary retaining systems;
- The integrity of the retaining structure wall, i.e., new cracks and or seepage;
- Changes to existing cracks and or seepage;
- Condition of windrows along the crest of retaining structure wall; and
- Assessment of flora and fauna that may be affected by tailings water consumption.

Monthly inspections:

- Retaining structures (cracking on crest or batter slope):
  - Seepage at the downstream toe
  - Possible water ponding encroaching embankment
  - Tailings freeboard.
- Tailings characteristics (material changes);
- Tailings deposition or placement;
- Decant system and operation;
- Tailings water return pipeline;
- Groundwater monitoring bores;
- Impact on flora and fauna;
- Record keeping of inspection and monitoring results; and
- Evidence of analysis and assessments, where required.

Compliance inspections and regular (usually annual) audits will be undertaken in accordance with applicable guidelines and laws. These inspections will also include dam safety audits.

2.14 Site infrastructure

2.14.1 Civil infrastructure

The following civil infrastructure is included in the design:

- Stormwater Infrastructure:
  - Cutoff drains for overland surface runoff – clean water drainage;
  - Localised terrace drains for terrace runoff – clean and dirty water drainage;
- Potable water supply and reticulation:
  - Early works – borehole #3, reservoir and gravity pipeline to entrance kiosk and existing camp;
  - Completion of site-wide gravity ring main;
- Raw water supply and reticulation:
  - River pump station, delivery pipeline, raw water dam and associated infrastructure;
- Sewage:
  - Site-wide sewage reticulation network;
  - Wastewater treatment works (package plant); and
- Buffer tank.

The following primary road networks are provided for:

- The Mine access road from Longonjo to Mine;
- Longonjo Town Loop Road to Longonjo rail siding and logistics facility;
- Link road to electrical consumer substation and the Mine Fuel and Lubricants Depot (MFLD);
- Contractor's access road; and
- Eastern bypass road[9] to raw water dam, pipeline and river pump station.

The following secondary roads and parking areas are included in the design:
Secondary access roads and parking areas

- Western boundary bypass road;
- Internal access roads (wastewater treatment plant, raw water dam, etc.); and
- Entrance gate, security kiosk, helipad and offices access and parking.

2.14.2 Building infrastructure

The following buildings and related infrastructure are included in the mine design:

- Mine entrance kiosk and security gate;
  - Containerised building foundations, paving and structural steel shade canopy;
  - Temporary toilet facilities;
- Existing camp;
  - Septic tank;
- Mine camp;
  - Change houses and associated laundry and boiler structures;
- Miscellaneous infrastructure;
  - Mine entrance gate, security kiosk fencing and parking area;

[9] The eastern bypass will not fall under the responsibility of Pensana/Ozango. It is discussed as Ancillary Infrastructure (section 2.28)

- Office parking area;
- Potable water reservoir foundations and fencing;
- Raw water

- Pump station and bowser filling station;
- Raw water dam inlet silt trap, overflow weir and bowser filling station and fencing;
  - Workshops and stores apron slabs, foundations and steel roofs;
  - Helipad;
  - Weighbridge structure and containerised control room;
  - Wastewater treatment works (package plant by a specialist); and

- Buffer tank.

The following infrastructure is included in the design package of the processing plant being completed by Wood. The mining contractor will provide the mining infrastructure, and an external contractor will provide the bulk power supply. the bulk power supply will be provided by an external contractor:

- Treatment plant infrastructure (concentrator, MRES Plant, ROM pad and plant blending stockpile);
- Plant raw water distribution pump station and pipeline;
- Pit haul roads and haul roads to ROM pad, stockpiles and waste dumps;
- Telecommunications and communications infrastructure;
- Main electrical consumer substation; and
- Mine electrical power lines.

2.14.3 Administration offices

The administration complex will comprise five air-conditioned prefabricated containerised buildings (12.215m by 6.055m) and one prefabricated containerised reception unit. The buildings rest on short plinths founded on a concrete ground slab. The total plan area of the office complex is 2,450m^2. A gravel surfaced parking facility to the north-east of the offices will provide parking in an area of 1,765m^2.

2.14.4 Radiation management room

The radiation management room is a resource for the Radiation Protection Officer to manage the overall Longonjo Mine RMP. The 3m by 3m structure is founded on a ground slab with concrete blockwork walls. The roof consists of a timber or steel trussed roof clad with galvanized steel sheeting.

2.14.5 Miscellaneous infrastructure

Other miscellaneous infrastructure provided for include:

- Helipad;
- Workshops, stores and garage;
- Diesel and lubricant storage;
- Diesel bowser area;
- Stores;
- Weighbridge and control room;
- Vehicle wash bay;
- Electrical infrastructure;

2.15 Electrical infrastructure

The Longonjo Mine is a Greenfields projects environment that is not currently serviced by any formal or informal power reticulation. Bulk power will be provided for the operational mine through the engagement and agreement with the Angolan Power Supply authorities, namely Rede Nacional De Transporte De Electricidade, Empresa Pública (RNT). The provision of the bulk power will be undertaken as a defined work stream during the development and delivery of the Project and will be facilitated and managed by the Pensana Owners Team, using various appointed consultants.

The power supply for the Project and ongoing operations have been categorised into three phases, namely:

- Phase 1: Early Works Programme (EWP)

  Power will be provided for the EWP by means of a diesel generator, with a total power requirement for Phase 1 being approximately 250kW.

- Phase 2: Project Implementation

  Power will be provided for the Implementation of the Project by means of diesel generators, with the power requirements for Phase 2 being approximately 1MW.

- Phase 3: Commissioning and Sustainable Operations

  Power will be provided for the commissioning and sustainable operations by means of bulk power sourced through the national Angolan electrical reticulation network, operated by RNT, with the power requirements not exceeding 60MW.

The local Longonjo hybrid substation (4 km from the Project) has a capacity of 5MW (3MVA diesel and 2MVA photovoltaic generation capacity). It will supply the approximately 1 MW required during the construction phase through a dedicated 30 kV line (current usage is approximately 560kVA only).

A preliminary electrical requirement summary is presented in Table 2-17.

Table 2-17: Longonjo Project electrical power requirement summary

Area			
Concentrator Process Plant	31,232	27,350	187,375
MRES (Refinery)	7,664	4,570	34,031
Infrastructure	2,231	2,008	15,232
Total	**41,127**	**33,928**	**236,638**

Electricity consumption will be updated and confirmed during the subsequent design phases.

2.15.1 Emergency power

The standby power requirement from the process plant is currently estimated at 370kW; however, this is subject to review as the processing plant design progresses.

- All services will be operational during a utility power failure;
- Provision is made for two 1,000kW generators; and
- The generators will synchronise and operate in parallel.

2.16 Water supply

2.16.1 Water sources and reticulation for domestic use

Six suitable water supply boreholes were identified in the Longonjo Mine licence area. Water will be pumped from Borehole 3 to a centralised 245m^3 potable water reservoir via a 90mm diameter HDPE pipeline. The reservoir will be a dual compartment Braithwaite-type steel panel tank founded on a reinforced concrete base and 1m-tall plinths. Compensation plates on top of the plinths will facilitate the correct levelling of the tank. The forecasted potable water demand is approximately 90,000ℓ/d. Based on this demand, the potable water reservoir will have more than a two-day storage capacity to provide 88m^3/day (groundwater).

Potable water from the reservoir will be distributed by gravity feed in a 140mm diameter HDPE pipeline configured as a ring feed. This pipeline will be bedded in earthen berms, which run on grade. At road crossings, the pipeline will be encased in 15MPa mass concrete to prevent damage. In addition, series of gate valves will be installed to isolate supply areas for maintenance and scour valve chambers positioned at strategic points, and drain pipelines when maintenance is required. This would provide a reliable supply of potable water to all consumers.

2.16.2 Raw water

Initially, raw water will be drawn from the Luluvile River at the raw water pump station (at a planned rate of 350m^3/hr) and pumped to the raw water dam. The raw water pump station is intended to be positioned close to the bridge that crosses the Luluvile River and consists of the following components:

- Intake Structure

A reinforced concrete intake structure will be positioned in the river linking a 250mm gravity feed pipeline to the pump sump. The river might be diverted for construction of the intake, or caisson construction may be used. Positioning of the intake structure is critical to make sure that raw water abstracted is not affected by excessive siltation.

- Intake sump

The pump intake sump is a reinforced concrete chamber fitted with grating to protect the pumps and for maintenance access.

- Pump station

The pump station comprises a reinforced concrete ground slab with two pump bases and perimeter bund walls. Screed to fall at a slope of 1:100 and drainage pipe to drain water into intake sump. Water bowser filling stations will be constructed adjacent to the pump station and the raw water dam for filling water trucks and firefighting. The raw water supply pipeline will be 2,640m long, with a diameter of 250mm, and rise 135m from the pump station to the raw water dam. This HDPE pipeline will be embedded in an earthen berm, which runs on grade. The pipeline will be encased in 15MPa mass concrete at road crossings to prevent damage due to mining vehicles. The current design is for a duty flow of 193m3/hr and a pumping head of 135m.

2.16.3 Raw water / Process water dam

The HDPE-lined raw water dam will have an adequate storage capacity of 4,795m^3 (total storage capacity of 5,344m^3) with a base footprint of 30m by 30m, a depth of 3.5m, and side slopes of 1V:2.5H. A reinforced concrete spillway and chute will be constructed into the dam wall to prevent overtopping due to mechanical failures or significant storm events. A 6m-wide road is built off the primary contractor’s access road with a loop route back to the treatment plant to access the raw water dam. Raw water will be pumped from the dam to the treatment plant from a pump station adjacent to the bowser filling station.

A 250mm-diameter suction pipe, surface mounted to the earth embankment dam and anchored to the base of the dam, will be used for the abstraction of water into the pump station, for where it will be delivered to a Reverse Osmosis (RO) plant at the treatment plant for processing the raw water before to use in the MRES plant. In addition, a reinforced concrete silt trap is installed at the raw water dam to prevent the loss of dam capacity.

2.17 Sewerage

Generally, 80% of potable water consumption is expected to be returned as sewage discharge. Based on the potable water demand of 88,613ℓ/d, approximately 71,000ℓ of effluent is produced per day.

All sewerage effluent will be collected to a containerised wastewater treatment works system. A technical proposal for a 70m^3/d Submerged Aerated Fixed Film (SAFF) Wastewater Treatment Works package was prepared for the Project by a Specialist Contractor. The plant satisfies South African Water Quality Standards (Section 39 of the Water Act (Act 36 of 1998) as amended), which are deemed appropriate for this facility in Angola in the absence of suitable similar standards/guidelines.

The 400PE unit requires a 36-hour buffer/retention tank and will cater for a maximum of 350 people, operating 24-hours per day. The plant is designed to be fed by a gravity delivery sewer pipeline.

A three-compartment structure 6.0m long by 2.5m wide and approximately 2.5m deep (internal dimensions) provides the required 36m^3 buffer capacity with a 500mm freeboard. This reinforced concrete tank, the walls, floor and roof structure are 250mm thick 35MPa concrete.

Details of pumping the effluent into the treatment plant are yet to be designed and access for maintenance and annual removal of sludge through pumping into tankers for disposal at a suitable hazardous waste site or drying bed facility.

2.18 Operating times

The design currently prescribes the mine to operate 24 hours a day for ~360 days per year. Downtime will include shutdowns for planned maintenance and an annual shut down for a week over the Christmas period. The anticipated plant operation time would be approximately 86-85% of the total hours available in 1 year based on similar mining operations.

2.19 Shift configuration

The planned shift structure will be as follows:

- The mining contractor will work a single 12-hour day shift, 7 days per week;
- The process plant will operate on two 12-hour shifts, 7 days per week;
- The mine-based management team, administration team and other day workers will work a single 8-hour shift per day; and
- Expatriate and Angolan national workers accommodated in the camp will work on a six week on and two weeks off roster system.

2.20 Project staffing

The mine is planned as a contract mining operation. The mining contractor will provide infrastructure as stipulated. Pensana will maintain control over the management of the mining operation through the supervision of the contractor operation, mine planning, grade control, geology and mining services, including oversight over the operational health and safety management and environmental management. It is anticipated that Pensana's staff compliment will be as per Table 2-18.

Table 2-18: Project staffing summary

POSITION	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15
Management	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2
Finance & Admin	2	7	9	9	9	9	9	9	9	9	9	9	9	9	9
Human Resources	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5
IT	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mining	0	3	9	9	9	9	9	9	9	9	9	9	9	9	9
Treatment Plant	0	56	217	218	218	218	218	218	218	218	218	218	218	218	218
Engineering	0	12	20	20	20	20	20	20	20	20	20	20	20	20	20
Supply Chain	6	15	37	37	37	37	37	37	37	37	37	37	37	37	37
HESC	4	7	8	8	8	8	8	8	8	8	8	8	8	8	8
Community/Government Liaison	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1
Security	8	15	46	46	46	46	46	46	46	46	46	46	46	46	46
Camp Management	4	29	29	29	29	29	29	29	29	29	29	29	29	29	29
Mining Contractor	0	0	151	151	151	151	151	150	150	148	148	147	147	147	147
Total /Year	27	152	538	537	537	537	537	536	536	534	534	533	533	533	533

2.21 Traffic and Roads

The Project is located approximately 4 to 5 hours' drive from the port city of Benguela or a 1-hour drive from the regional centre of Huambo City. Existing roads for the Project are all-weather roads. These include the link road that connects the Project to public highway EN110, a distance of 5.0 km. It is estimated that during operation, the Project would require approximately 20 trucks per day on the assumption of high-grade mineral product of up to 46,000tpa is to be produced on-site and transported to the Longonjo Rail Siding, plus one supply truck per day.

Additional project roads are discussed in section 2.14.

Figure 2-31: Longonjo carbonatite vent as viewed from the National Highway to Lobito Port

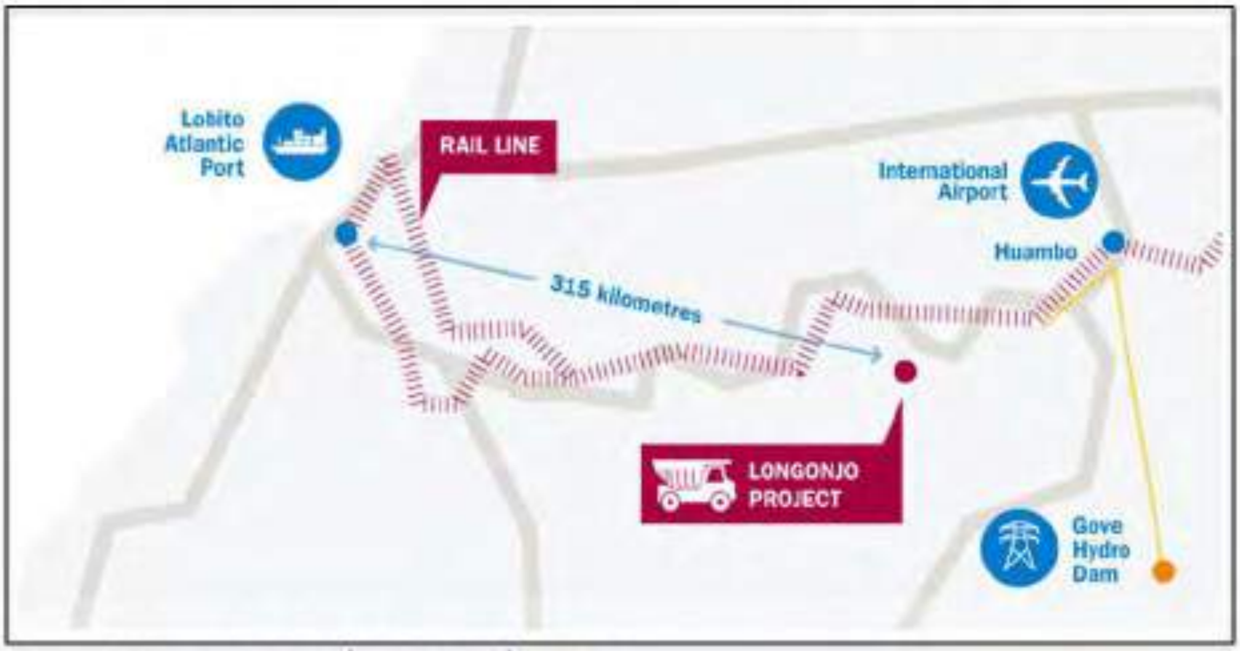


Figure 2-32: Longonjo Project logistics considerations

2.21.1 Mining Fleet

See section 2.11.3

2.21.2 Ancillary Equipment

The support fleet is presented in Table 2-19.

Table 2-19: Support fleet vehicles

LOGISTICS AND SUPPORT			
#	Description	Size	Operation
15	Double Cab 4x4 LDV		24 hours
19	Double Cab 4x2 LDV		24 Hours
19	Single Cab 4x4 LDV		24 Hours
19	Single Cab 4x2 LDV		24 Hours
2	Kombi		24 Hours
3	Forklift		24 Hours
3	Truck and Crane		24 Hours
1	Trailer Mounted Mobile Generator		24 Hours
1	All Terrain Mobile Crane	15t	12 Hours
1	All Terrain Mobile Crane	50t	12 Hours
1	Telescopic Boom Elevated Work Platform		12 Hours
1	Scissor Lift Elevated Work Platform		12 Hours
2	CAT 422F2 Plant TLB		12 Hours
1	Padfoot Roller	10t	12 Hours
1	CAT 950L Front End Loader		12 Hours
1	CAT 140H Grader		12 Hours
1	CAT 320 Tracked Excavator	20t	12 Hours
1	CAT ADT 730 Tipper Truck	28t	12 Hours
1	Fuel Bowser Trailer	10 000L	12 Hours
1	4x4 Ambulance		24 Hours
2	Personnel Bus	60 Seater	24 Hours
2	12m Boom Telehandler	5t	12 Hours
1	Potable Water Bowser	10 000L	24 Hours
1	Fire Water Bowser	10 000L	24 Hours
1	2 Wheel Drive Tractor (250Nm)	60kW	12 Hours
2	12m Tractor Drawn Trailer	20t	12 Hours
4	Container Trucks and Trailers		24 Hours
4	4 m reach Grab Type Mobile Container Handlers	30t	24 Hours

2.22 Accommodation

The majority of the construction labour will be skilled personnel from Angola and other suitable countries. During construction, it is assumed that local personnel will be employed as casual labour, or non-local personnel will find accommodation in the comunas of Longonjo. Professional personnel will be provided with camp-style site accommodation and catering.

During the early phases, the existing camp will be expanded to house 45 personnel. All accommodation, kitchen and ablution units will be connected to the electricity supply system by the diesel generator.. The kitchen and ablution block will be connected to the existing borehole on-site, and effluent discharges will report to the septic tank system. Oils, fat, and grease will be trapped, and grey water bypasses the septic tank.

Before full-scale construction activities and operations, a new mine camp will be constructed. The mining camp will house 402 people in prefabricated housing units grouped into management classes of B-Band, C-Band, D-Band and E-Band, respectively. In addition, all A-Band workers will reside off-site.

Additional buildings and facilities required at the camp include:

- Change houses and associated boiler room and laundry facility;
- Kitchen, dining hall and recreation hall;
- Swimming pool, braai and outdoor furniture and bar;
- Sports field with soccer, basketball and tennis courts; and
- Mine administration offices with parking areas.

2.23 General landfill site

The provisional plan for a general landfill site makes provision for a total area of 14,500m^2 (145m by 100m). The earthworks terrace will be shaped into a dish structure underlain by a geomembrane liner with an under-drain layer barrier protection complying with Class C landfill criteria (subject to confirmation of hazardous waste classification), as shown in Figure 2-33. The underdrain layer barrier will comprise 300mm thick finger drains of geotextile covered aggregate over a 100mm silty sand protection layer for a 1.5mm HDPE geomembrane. The barrier system overlies two 150mm thick compacted clay layers bedded on a 150mm compacted in situ base preparation layer. The leachate collected in the finger drains will flow to a dirty water evaporation pond. An overflow pipe connected to a sewerage line returning to the treatment plant will be integrated into the pond to manage excessive runoff.

The facility will comply with the South African Department of Water Affairs and Forestry Minimum Requirements for *Waste Disposal by Landfill and Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*[10]. Clean water cut off drains upstream of the landfill site will divert overland stormwater runoff flow away from the terrace to prevent contamination. Dirty-water drains will divert contaminated surface runoff to the evaporation pond. The following waste types will be separated and allocated to dedicated areas at a salvage yard for recycling and disposal off-site or incineration[11] on-site:

- Recyclable Waste
  - Cardboard, paper, plastic, wires, tyres
  - Mechanical parts and scrap metal

- Composting Waste
  - Food and vegetation

- Hazardous Waste
  - Oil and fuels
  - Laboratory waste
  - Medical waste
  - Radiation waste

[10] *MINIMUM REQUIREMENTS FOR WASTE DISPOSAL BY LANDFILL*. Department of Water Affairs and Forestry. Second Edition. 1998. South Africa.

[11] Incineration will be subject to approval from the MIREMPET. During the ESIA , no information was available to include sufficient details in the Air Quality Dispersion Model to simulate emissions from ad hoc incineration. Once available in future, it is recommended that the Dispersion Model, and subsequent implications on the ESMP, be updated.

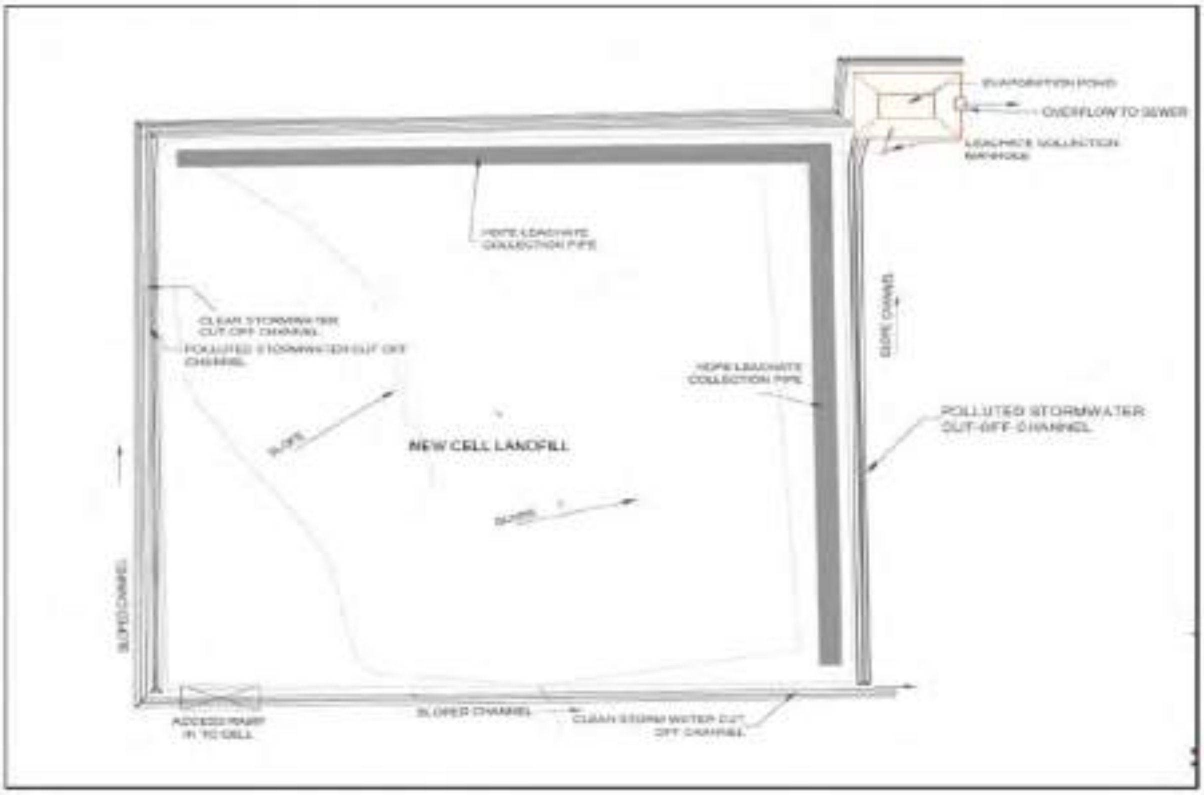


Figure 2-33: General layout of the proposed landfill site

2.24 Contractor laydown area

The contractor's laydown area terrace is planned to have a total area of 40,000m^2 (160m by 250m). The mining contractor's infrastructure terrace will have a plan area of 20,000m^2 (100m by 200m). For both, terraces are gravel surfaced and designed for heavy vehicle traffic.

2.25 Local Emergencies

The Mine will be designed to respond to medical emergencies and have a risk-based Medical Emergency Response Plan (ERP), which is communicated to everyone as a part of induction and is placed on notice boards..

Every worker on the site will be familiarised with the ERP and trained to make the appropriate emergency call. The ERP will be in place before any activities start on-site. Medical ERP is a part of the comprehensive Pensana Emergency Response Plan covering all potential hazards on-site. This plan is formulated on the first response being the First Aid Station on the Mine with more severe cases being transferred either to the hospital in Longonjo or Huambo, depending on the severity of the case, or by using airborne evacuation, if required. The First Aid Station will include, among other things, the following equipment:

- Oxygen;
- Surgical suction unit;
- Pulse oximeter;
- Defibrillator;
- Spine immobilisation equipment;
- Stretcher;
- ALS Jump Bag; and
- Snake anti-venom.

The Mine will train sufficient first aiders, and the Mine's health and safety personnel will have trauma experience and be on-site or on-call 24 hours per day, seven days a week. Continuous training of first aiders will be undertaken based on the Mine's ongoing risk assessments.

An ambulance will be on-site to transport accident victims to the First Aid Station and / or the hospital in Longonjo or Huambo as required.

In a trauma incident, the nurse will provide life-supporting treatment, stabilise the patient and organise ambulance transfer to the most suitable medical facility.

An arrangement with a reputable medical evacuation organisation will ensure immediate medical response and evacuation to the most suitable facility in severe accidents or illnesses. There will be a designated helicopter landing site at the Mine for these emergencies.

The Mine will employ a qualified paramedic and two nurses to man the First Aid Station. The d First Aid Station's design and function are based on user's identified health risks and needs and comply with the government requirements.

Some municipal services are available at Longonjo municipality, although limited. The Project will therefore be fully resourced for most emergencies.

Municipal and other facilities that may be utilised in Longonjo is the local municipal hospital with 24 beds. The unit offers paediatric medical services, X-rays, clinical tests, nutrition, minor surgery, first aid and a pharmacy.

More extensive and more sophisticated medical facilities are available in Huambo. In the event where hospitalisation is required, patients will be stabilised and transferred to Huambo by ambulance.

The Project will have dedicated fire sprinkler systems in the solvent extraction area of the plant, area-wide fire hydrants and a dedicated fire engine. In addition, suitable personnel will be identified and trained in emergency preparedness and response.

2.26 Project Schedule

The project execution schedule is based on a 12-month construction and 2-month commissioning period followed by an 18 year LOM, while the Concentrator and MRES plant will continue to run for an additional two years using stockpiled material.

2.27 Mine closure, rehabilitation and costing provisions

A preliminary closure plan and cost provision was produced for the development (Appendix Q). This document will be reviewed and updated annually by a suitably qualified person.

2.28 Ancillary Infrastructure

2.28.1 Railway and Port Storage

Section 2.3.4 presented the proximity of the Project to suitable infrastructure. The railway and port storage infrastructure is already pre-existing infrastructure requiring no changes to accommodate the Project.

Figure 2-34: The Benguela rail line connects directly into the Lobito container (above) and dry (below) ports, which have sufficient of spare capacity for additional freight

2.28.2 Port Storage

The Angolan Government invested approximately US$2 billion for the rehabilitation of the Lobito port and associated infrastructure, from where it handles approximately 2,000,000 tons of cargo and 370 ships on an annual basis. The container terminal is 414 metres long, the ore terminal has a 310-metre jetty, and the dry dock has an area of 90,000 square meters. No amendments to the port are required to accommodate the Project.

Figure 2-35: Above and following: modern, underutilised infrastructure at the Lobito port

2.28.3 Power Supply

The power supply is discussed in section 2.15.

Huambo City has been connected to the national electrical grid since 2019 and is supplied by a high tension (HT) inter-connection to the Laúca (2,070MW), Cambambe (700MW) and Capanda (500MW) hydro-electric power schemes in northern Angola. A substation and transmission lines inter-connecting to this grid are located approximately 45km to the east of Longonjo at Belem near Huambo, and reliable power availability to the region is available. Therefore, it is proposed that the power line from Huambo will be extended to Huambo – this process is ongoing and subject to its own ESIA process conducted by a Third Party.

As a further option, the new Laúca hydropower plant (2,070 MW) is in the north of Angola in the central part of the Kwanza River. Renewable hydropower thus extends to within 40 kilometres of the Longonjo Project. As a result, the Project electricity demand falls well within the Laúca production capacity with no additional power production requirements.

Figure 2-36: Final construction stages of the Laúca hydro power plant

2.28.4 Housing

See section 2.22

2.29 Project Alternatives

2.29.1 Location Alternatives

The Longonjo NdPr Project lies within the granted Prospecting License (013/03/09T.P/ANG M.G.M/2015). On 12 March 2021, a Mining Title Certificate No 298/05/01/T.E/ANG-MIREMPET/2020 was granted for an area of 31km2 for an initial period of 15 years (renewable up to 35 years) which fully incorporates the Longonjo carbonatite deposit, the proposed open pit mine and its processing plant, Tailings Storage Facility (TSF) and all the associated infrastructure. The mining activity is restricted to a Measured and Indicated resource of NdPr that meets the quality and production targets to make this a feasible venture. Due to the Mining Title Certificate and the location of the NdPr resource, there were no other alternatives available in terms of the project location.

2.29.2 Design Alternatives

Numerous processing and design alternatives were entrenched in the design philosophy of Wood (the design engineering firm) for the Longonjo Project. During the design processes, decisions were made to favour aspects of the Project which ultimately shaped the Project to its current IFS-stage design:

- Feasibility;
- Design of the processing plant, layout thereof, process optimisation, resource utilisation;
- Supply of inputs to the process – i.e. electricity (short term and long term), water, consumables, chemicals;
- Logistical considerations – i.e. inbound supplies, outbound product distribution;
- The layout of the Project to the current footprint – i.e. pit design and phasing, ROM location, TSF location, MRES plant, internal road layout, waste rock dump location, support services location (location of garage, workshops, fuel storage and refuelling area), office and accommodation location; Waste management and utilities.

During the various design stages, up to the detailed design stage (future activity), the Project description in this ESIA may be updated. The concept of the Project will, however, not change. Should the design changes need to be reflected at a future date, the ESIA will be updated accordingly.

2.29.3 Product refining and processing

During the early stages of planning and design, Pensana's model assumed that a high-grade rare earth mineral concentrate ore would be produced and transported via the Benguela Rail line from the siding at Longonjo to the port of Lobito for shipping to the international market. However, the latest design has fundamentally changed this approach and, Pensana has designed downstream processing to include the following: a Concentrator Plant (grinding and classification, flotation, filtration, steam generation, thickening), MRES Refinery Plant (acid baking, kiln off-gas scrubbing, acid leaching, elution, HCI production & Recovery/MRES precipitation, tailings, concentrate packaging, sulphuric acid plant). In this manner, the Mine will provide feedstock to the Saltend Refinery (UK), further upgrading this material to the final product.

2.29.4 Location of Infrastructure in Relation to the Aquatic 200m Buffer Zone[12]

The current Project infrastructure layout is based on the IFS stage design. The following design stage (Detailed Design) will involve a refinement of the current IFS stage design. The current design shows that some infrastructure falls into the 200m aquatic buffer zone as contemplated by Presidential Decree No. 82/14, Article 110[12].

As shown in Figure 2-37, the buffer zone overlaps with some of the Project infrastructures. Ozango/Pensana confirmed that during detailed design, the infrastructure would be shifted / moved outside the 200m buffer zone where possible to comply with the provisions of Article 110. However, there are situations where this would not possible and therefore mitigation and management measures will be implemented in order to mitigate the impacts arising from this situation (e.g. TSF 9/10) .

[12] Presidential Decree No. 82/14, approves the Regulation on the General Use of Water Resources: Article 110 which stipulates those proponents shall consider a 200m buffer zone as follows: “areas of protection of water resources, the water course beds, river banks and water courses adjacent zones of up to a distance of 200 metres”. See Section **Error! Reference source not found.** for detailed information regarding the statutory provisions.

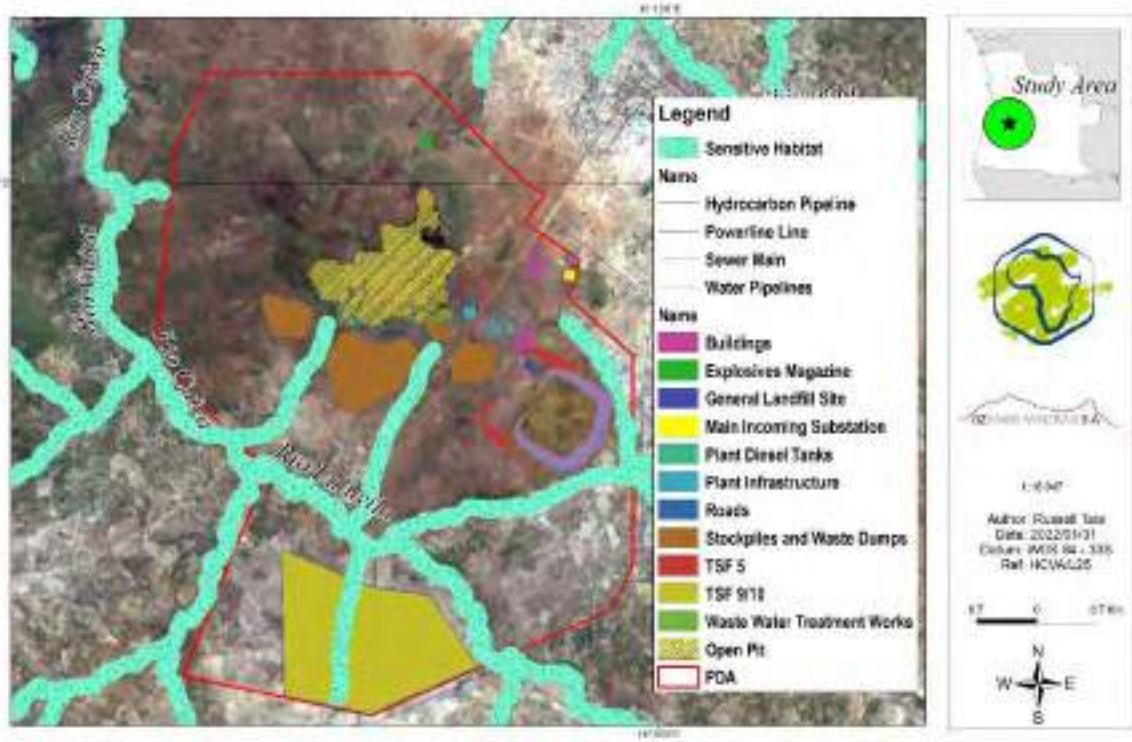


Figure 2-37: PFS stage infrastructure layout in the context of the 200m aquatic buffer zone

2.29.5 TSF Location

The alternatives for the TSF locations included three valley storage locations based on safety, financial, environmental, operational and design requirements. Initially, three valleys were identified as potential initial TSF options and are indicated in Figure 2-38:

- Option 1 – Valley storage located south-west of Longonjo Project Site;
- Option 2 – Valley storage between Option 1 and Option 3; and
- Option 3 – Broad valley storage located south-east of Longonjo Project Site.

Option 3 was discounted for potential impacts on the biophysical environment and surrounding community in the first round of consideration.

Figure 2-38: Location of the initial three TSF Options.

An additional two options were then considered (Figure 2-39) on the basis that valley options may not be suitable due to similar concerns. As a result, two other options were added while Option 3 was omitted/discounted:

- Option 4 – Side hill storage located northwest of Option 1.
- Option 5 – Non-drainage line option located southwest of Longonjo Project Site and west of Option 3.

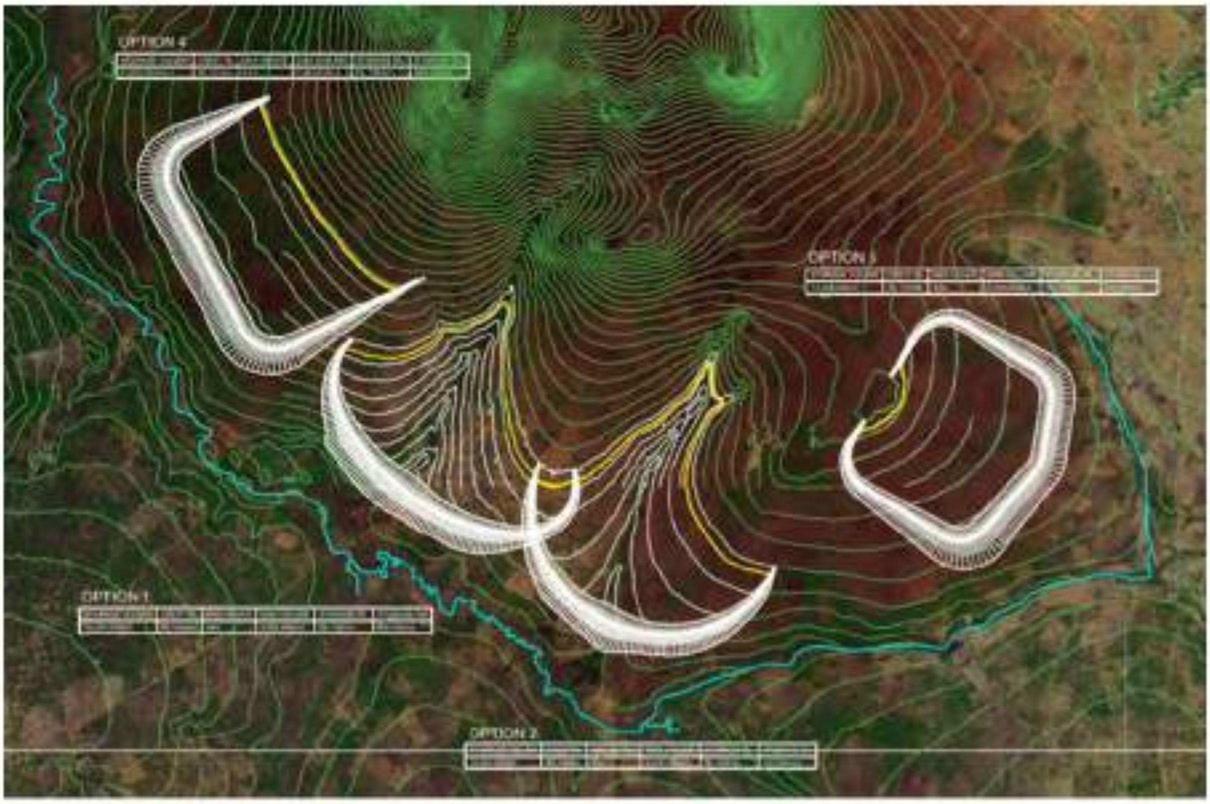


Figure 2-39: TSF Initial Four Remaining Options

For the subsequent options assessment, the selection basis was set out as below:

1. Community impact;
2. Financial aspects;
3. Maximum storage capacity;
4. Storage ratio – volume of airspace gained for m3 of embankment constructed;
5. Proximity to processing plant;
6. Impact on operation and ease of access;
7. Disturbed footprint area;
8. Scalability – can this option be readily scaled up;
9. Water management (balance and handling) and seepage;
10. Foundation conditions – construction safety and ease;
11. Ease of operation;
12. Approval necessary;
13. Environmental and impacts; and
14. Closure liability.

Two options were selected based on a qualitative and semi-quantitative assessment of these criteria: Option 2 and Option 5. Option 2 and Option 5 were thus updated in the Project layout and renamed as Option A (previously Option 5) and Option B (previously Option 2) (Figure 2-40).

Figure 2-40: TSF location options – Option A and Option B

In the Pre-Feasibility Study, each of the options considered above could be utilised if required at a future date.

During the latest design stage (IFS), all TSF options were reviewed and compared in terms of advantages and disadvantages. A summary of the TSF options considered over time and their respective constraints and advantages are summarised in Table 2-20 and illustrated.

Table 2-20: Comparative assessment of all TSF options

TSF OPTION	ADVANTAGES	DISADVANTAGES	OPTION STUDY OUTCOME
Option 1	1. Good storage ratio 2. Close to plant site	1. Potential environmental and surrounding community impacts	Discounted
Option 2	1. Good storage ratio 2. Close to plant site	1. Artesian wells and perennial water flows at basin area 2. Very high wall 3. Potential collapsible soil	Discounted
Option 3	1. Good storage ratio 2. Closest to plant site 3. Best pumping head for slurry and water 4. Lowest height embankment 5. Larger surface area for evaporation	1. Potential environmental and surrounding community impacts 2. Larger surface area – largest environmental disturbance	Discounted
Option 4	1. Smaller basin area 2. Bigger room for expansion	1. Low storage ratio 2. Further away from plant site and main mining areas 3. Harsh terrain area for infrastructure and construction works	Discounted
Option 5	1. Closest to plant site 2. Pumping head and slurry for water return is favourable	1. Poor storage ratio 2. High CAPEX and OPEX 3. Little to no room for expansion	Favour 3
Option 6	1. Good storage ratio 2. Smaller basin area	1. Longer pipeline length 2. River crossing 3. Additional pump cost 4. Unknown social, environmental and heritage impacts	Favour 2
Option 7	1. Provide additional storage when Option 6 reaches capacity	1. Poorer storage ratio 2. Longer pipeline length 3. River crossing 4. Additional pump cost 5. Less room for expansion 6. Unknown social, environmental and heritage impacts	Discounted
Option 8	1. Not assessed	1. No topographic survey information available 2. Potentially low storage ratio 3. Unknown social, environmental and heritage impacts	Discounted
Option 6 and 7 Merged	1. Good opportunity to extend the life of storage for the TSF 2. Very good storage ratio 3. Low CAPEX and OPEX 4. Small basin area at starter; lower cost of liners and underdrainage	1. The need to remove the current public road, consequential community impacts 2. Unknown social, environmental and heritage impacts 3. Longer pipeline length 4. River crossing 5. Additional pump cost	Favour 1

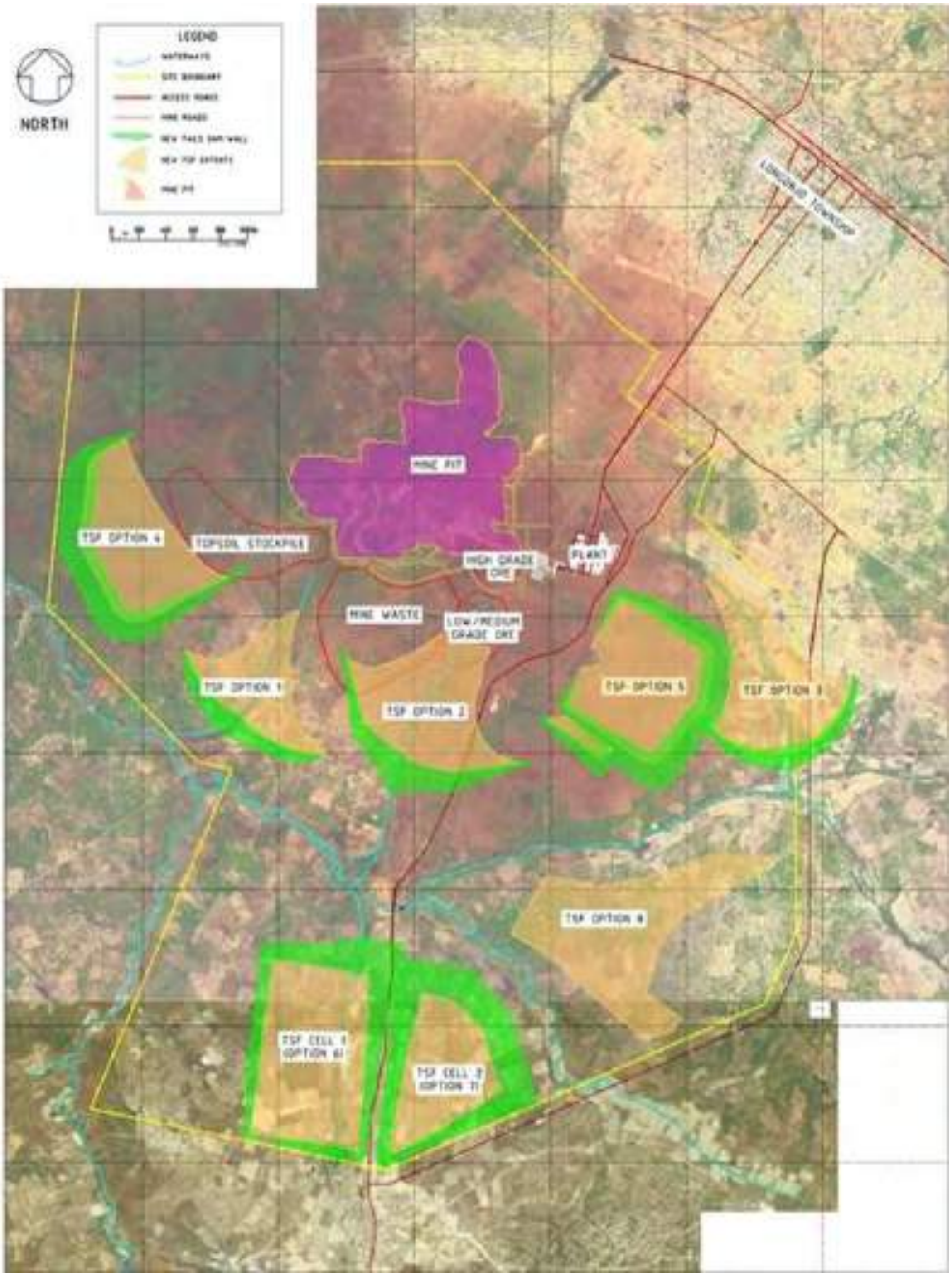


Figure 2-41: TSF options considered during the design process

This ESIA evaluated both Option 6 and 7 merged ("Favour 1") (which includes Option 6 ("Favour 2")) and Option 5 in the impact assessment section of this report. The final location of the TSF will be confirmed during Detailed Design. Geotechnical investigations were undertaken in 2020/2021 to determine the suitability of either option in terms of stability and other safety parameters. Geophysical and hydrogeological drilling was conducted in August 2021 for Option 6, and 7 merged and Option 5.

2.29.6 No-Go Project Alternative

Should the Project not proceed, positive aspects will not be realised (Section 2.3, Project motivation).

The IFC[13] states that: "…*Africa has over 30 percent of the world's global mineral reserves. The continent produces over 60 different metals and minerals and has huge potential for exploration and production. There is a considerable history of mining across Africa with artisanal and small scale mining of gold tracing back to the 15th Century. Africa's enormous mining potential, along with improvements in political systems, and changes in fiscal and regulatory environments has led to a rise in investments over the years…….For countries in Africa, mining has the potential to contribute significantly to economic growth and to help lift millions of people out of poverty.* …".

Without this Project, Angola will contribute less to the world demand for NdPr. Furthermore, without the proposed Project, the anticipated boost to the local economy through direct and indirect employment opportunities will not be realised. Therefore, the Project intends to employ people from the local region to the extent skills are available.

Without the Project, there would be a lack of new investment in the mining sector in the Longonjo area and the Huambo province.

[13] https://www.ifc.org/wps/wcm/connect/14d1fb8c-8d63-47c9-acb7-35b20a488ff2/Sustainable+Mining+in+Africa.pdf?MOD=AJPERES&CVID=knWL6Rr

3 LEGAL, POLICY AND OTHER REQUIREMENTS

3.1 Introduction: Angolan legal overview

The National Assembly of Angola approved the new Constitution of the Republic of Angola on 5 February 2010 to replace the 1992 Constitution. The Constitution provides the basis for the Environmental Framework Law through Article 39. Article 39 (Environmental Rights) provides that:

1. *Everyone has the right to live in a healthy and unpolluted environment and the duty to defend and preserve it;*
2. *The State shall adopt measures to protect the environment and species of flora and fauna throughout the national territory, maintain the ecological balance, ensure the correct location of economic activities and the rational development and use of all natural resources, within the context of sustainable development, respect for the rights of future generations and the preservation of species; and*
3. *Acts that endanger or damage conservation of the environment shall be punishable by law.*

Angolan legislation is issued at the national level through:

- Laws, which the National Assembly issues;
- Presidential Decrees, which the President´s office issues; and

A ministry or ministries typically issue regulations (executive decrees), joint executive decrees, and resolutions. This ESIA[14] was developed with due consideration to the Angolan national laws and regulations. Several national legal instruments refer to environmental pollution, environmental impact assessment and environmental protection in a general sense. Regulations tend to be broadly defined but generally do not define detailed standards (e.g., air quality, noise levels, etc.) to measure compliance. In the absence of these, international standards (e.g., World Bank) and sometimes regional standards (e.g., South Africa) are used. Below is a summary of the relevant legislative and administrative framework in Angola.

Note that there may be other administrative and regulatory requirements that may relate to the proposed Project. However, the identification and interpretation are beyond the summary of this study. Therefore, the outline below is not intended to be definitive and / or exhaustive, serving only to highlight the main pieces of legislation and concomitant obligations.

3.2 Institutional Framework

3.2.1 Ministry of Culture, Tourism and Environment (MCTA)

The Ministry of Culture, Tourism and Environment (MCTA), is the Ministerial Department responsible to formulate, conduct, supervise, evaluate, and execute the Executive's policy in the field of protection, preservation and conservation of environmental quality, pollution control, areas of conservation and enhancement of natural heritage, as well as the preservation and rational use of mineral resources.

MCTA comprises a set of agencies and services, in particular, the National Directorate for the Prevention and Assessment of Environmental Impacts (*Direcção Nacional de Prevenção e Avaliação de Impactes Ambientais* (DNPAIA)), which is the service responsible for the conception and implementation of policies and strategies to prevent the incidences of environmental impacts.

According to Article 2 of the Organic Statute of the MCTA (Presidential Decree 162/20 of 8 June 2020) the objectives of the Decree are:

[14] According to Decree No. 51/04, an Environmental Impact Study is the document prepared by the proponent under the Environmental Impact Assessment (EIA) procedure [Where the legal section refers to EIA as defined in the Angolan statutes, it would imply “ESIA” which will be developed for the Project], which contains a brief description of the Project, the identification and assessment of the positive and negative impacts to the environment that may be caused by the implementation of the project. The same decree defines that an EIA is a preventive environmental management procedure, which consist in the prior identification, qualitative and quantitative analysis of the benefits and harmful environmental effects of a proposed activity.

a. To define the policy for the development of culture, tourism and the environment with a view to contributing to the economic, social and sustainable development of the Country;
b. To ensure compliance with legislation for the proper functioning and development of culture, tourism and the environment;
c. To ensure compliance with the international conventions and agreements to which Angola is a party
d. To promote investigation, research, training and teaching in the areas of culture, tourism and the environment;
e. To propose programs and projects and adopt legislative measures to implement financing systems for culture, tourism and the environment;
f. To promote responsible tourism, based on the principles of environmental, socio-cultural, economic and political-institutional sustainability, and to develop tourism regionalisation strategies;
g. To study and propose to the Executive the creation of areas for the use and/or development of tourism and the protection of natural resources with a socio-economic and/or cultural impact, in agreement with the bodies involved;
h. To promote environmental training and education, dialogue and participation of citizens for a better understanding of the phenomena of environmental balance;
i. To promote the public dissemination of information on the state of the environment in the country;
j. Promote and coordinate actions to reinforce and recover conservation areas, especially those of the coastline, soils susceptible to contamination and other ecologically sensitive habitats;
k. To coordinate national actions in response to global environmental problems, by applying the recommendations of international conventions and agreements;
l. To ensure the protection and preservation of environmental components and the maintenance and improvement of ecosystems of ecological and socio-economic value;
m. To carry out environmental audits and environmental licensing of activities likely to cause significant environmental and social impacts, and to create environmental monitoring systems;
n. To ensure that the natural, historical and cultural heritage is the object of permanent valorisation, defence and preservation measures, through the adequate involvement of the communities, in particular environmental protection associations;
o. To prepare and ensure the implementation of strategies aimed at the preservation of biodiversity and the maintenance of natural ecosystems; and
p. Promote management programs for conservation areas, including national parks, nature reserves, biosphere reserves and landscape protection and preservation.

3.2.2 Ministry of Mineral Resources and Oil (MIREMPET)

The Ministry of Mineral Resources and Oil (*Ministério dos Recursos Minerais e Petróleos,* MIREMPET) is the Ministerial Department of the President and Holder of the Executive Power, responsible to create, conduct, execute and control the Executive's policy related to geological and mineral activities of oil, gas and biofuels, such as prospecting, research, development and production of minerals, crude oil and gas, in refining, petrochemicals, storage, distribution and marketing of mineral and oil-bearing, as well as in the production and marketing of biofuels, which establishes the nature, duties and regulates its organization in general.

According to Article 2 of the MIREMPET Organic Status (Presidential Decree No. 159/20 of 4 June 2020), it has among others the following duties:

a) Formulate and propose the general basis of the national policy on mineral, oil-bearing and biofuels resources;
b) Elaborate and propose the program of mineral, petroleum and biofuels resources development, according to the National Plan and ensure the control and supervision of its execution;
c) Promote inventory studies on the potentialities of the country's mineral, oil-bearing and biofuel resources;
d) Study and propose legislation that regulate the activities of the Sector;
g) Encourage the innovation on technological development through appropriate selection, acquisition and dissemination of technologies related to the Sector;

i) Stimulate the actions related to the prevention of natural disasters in close collaboration with the Geological Institute of Angola, the Civil Protection and other competent entities;
j) Ensure the improvement of working conditions in the Sector, such as the quality, safety, hygiene, health and environment of the companies in operation;
o) Ensure in coordination with the other State bodies, the fulfilment of the obligations arising from Angola's accession to the International Treaties;
y) Promote the training and permanent technical and professional improvement of the staff of the Sector.

MIREMPET comprises a group of agencies and services, in particular, the National Directorate of Industrial Safety, Quality, Emergencies and Environment, which is the Direct Executive Service of the Ministry that promotes and enforces the implementation of the national and sectoral policy on industrial safety, emergency management, prevention and control and environmental protection in mining, oil and biofuels

MIREMPET is the executive body that oversees a proponents' activities. For that reason, the regulatory ESIA would be submitted to this entity which will be forwarded to MCTA, and its opinion.

3.2.3 Ministry of Agriculture and Fisheries (MINAGRIP)

Presidential Decree No. 177/20, 23 June 2020, approves the new organizational structure of the Ministry of Agriculture and Fisheries (*Ministério da Agricultura e Pescas*, MINAGRIP). MINAGRIP has the responsibility to conduct, execute and control the policy of the Government of the agriculture, livestock, forests and food safety, management and planning of biological aquatic resources, sustainable fishing and aquaculture activities, salt production research, experimentation and technological innovation in the area of the sea, prospecting, use, exploitation and enhancement of aquatic resources in the perspective of sustainable development.

MINAGRIP is constituted by several departments of which the National Directorate of Forests is of relevance to projects impacting on forests.

3.2.4 Ministry of Water and Energy (MINEA)

The MINEA was restructured through Presidential Decree No. 223/20 of 28 August 2020. As a result, the Ministry of Energy and Water (*Ministério da Energia e Águas*, MINEA) is the Ministry of the Angolan Government responsible for proposing the formulation, conducting, executing, and controlling the Government policy for the energy and water sectors.

Departments and directorates constitute MINEA, and the Atomic Energy Regulatory Authority (*Autoridade Reguladora de Energia Atómica*, AREA) is also under its direction. This entity aims to pursue the nuclear energy use policy adopted by the State.

3.2.5 National Directorate for the Prevention and Evaluation of Environmental Impacts

The Executive Decree 297/20, of 30 November 2020, approves the internal regulation of the National Directorate for the Prevention and Environmental Impact Assessment (*Direcção Nacional de Prevenção e Avaliação de Impactes Ambientais, DNPAIA*). DNPAIA is responsible for the design and implementation of strategic policies to prevent environmental impacts, which establishes its legal framework, regulating its powers, organization and operation. In addition, the responsibility for EIAs falls under DNPAIA, which among other things, is responsible for reviewing and commenting on EIA reports.

Granting an Environmental Licence for a proposed project is based on the results and recommendations of the EIA for that project. If required, the MCTA invites different institutions and stakeholders to comment on and make suggestions relating to the EIA report.

3.2.6 National Waste Agency

The National Waste Agency (*Agência Nacional de Resíduos,* ANR), created by Presidential Decree No. 181/14 of 28 July 2014, is a legal entity governed by public law, endowed with legal personality, administrative, financial and patrimonial autonomy, created to implement the waste management policy, within the scope of, regulation, supervision and other applicable legislation in force, at a national level.

ANR is under the supervision of MCTA, and its duties include regulating public service as relates to the management of waste, implementing the waste management policy based on the hierarchy of applicable management principles. These include the prevention of waste production, reuse, recycling, recovery and disposal of waste, as relevant to environmental protection criteria, economic viability, quality and efficiency of services, and to study and propose legislative, technical and economic-financial measures on waste management policy. This aims to ultimately contribute to compliance with applicable laws, regulations and standards, and approval of its Organic Status, which defines all other duties of ANR, regulates its organic structure, financial and asset management.

A Waste Management Plan (*Plano de Gestão de Resíduos* - PGR) developed for a particular project or activity should be submitted to the ANR for consideration, and following review and approval may issue a certificate of approval.

3.2.7 National Institute of Water Resources

The National Institute of Water Resources (INRH) was created in 2010 through Presidential Decree No. 253/10 of 16 November 2010, including its regulations. In 2021, the organic statute was revoked by the Presidential Decree 118/21 of 6 May 2021 to promote the implementation of national water resources policy, succeeding to the extinct National Directorate of Water Resources.

INRH's mission is to ensure the execution of the National Water Resources Policy in matters related to integrated planning and management, its use, preservation, protection, supervision and control.

3.2.8 Atomic Energy Regulatory Authority

Presidential Decree No. 116/21, 5 May 2021, approves the organizational structure of the Regulatory Authority for Atomic Energy (*Autoridade Reguladora de Energia Atómica*, AREA). The purpose of this entity is to pursue the policy of nuclear energy uses adopted by the State, define its legal regime and powers and regulate its organization.

According to Article 4 of the Decree mentioned above, AREA is under the supervision of the Executive Power Holder and is under the supervision of the Ministry of Energy and Water, the Ministerial Department responsible for the Energy Sector.

Article 5(1) states that AREA coordinates, controls, and supervises nuclear fuel cycle activities and actions related to using sources, materials, devices and radioactive substances and wastes. Paragraph 2 of the same article states that AREA is responsible in particular for:

> *a) Assist the competent State bodies in security and safety relating to radioactive activities, installations and radioactive sources;*
> *b) Contribute to institutional coordination in the subject associated with environmental protection, public health protection, consumer protection and the promotion of the efficient use of atomic energy for peaceful purposes;*
> *d) Issue licenses, safety certificates and other authorizations related to the activities, facilities and sources provided by the law;*
> *e) Issue professional licenses for workers, whom operate in activities or with radioactive sources;*
> *f) Approve the regulations and safety plans of specific facilities;*
> *h) Carry out the actions that are affected to it in the plans of response to radiological emergencies;*
> *k) Establish, in collaboration with the competent authorities, the qualification and vocational training requirements of workers of all levels whom duties are related directly or indirectly to the activities and sources, and to grant professional licenses;*
> *p) Establish adequate method to inform the public about the risks of activities, installations and sources, as well as, the protective and safety measures in the event of a radiological emergency; and*
> *x) Charge fees for the services provided and receive donations.*

3.3 Legal Framework

There are several environmental legal requirements that regulate the way in which EIAs are undertaken and that are currently in force. These are:

1. The General Environmental Law No. 5/98, 19 June 1998;
2. Presidential Decree No.117/20 on General Regulation for Environmental Impact Assessment and Environmental Licensing Procedure (Revoked the Decree No. 51/04 on the Environmental Impact Assessment, 23 July 2004, and the Decree No. 59/07 on Environmental Licensing, 13 July 2007), 22 April 2020;
3. Joint Executive Decree No. 130/09 on Environmental Licensing Fees (substitutes the Annex Table of Joint Executive Decree No. 96/09, 6 October 2009), 26 November 2009;
4. Decree No. 1/10 on Environmental Auditing, 13 January 2010;
5. Executive Decree No. 87/12 on Public Consultation for Projects Subject to Environmental Impact Assessment, 24 February 2012; and
6. Executive Decree No. 92/12 on the Terms of Reference for Environmental Impact Studies, 1 March 2012.

Additional environmental legislation with relevance to the proposed project include:

1. Water Law No. 6/02, 21 June 2001;
2. Law No. 3/04, the Law on territorial and Urban Planning, 25 July 2004;
3. Law No. 9/04, Land Law, 9 November 2004;
4. Law No. 14/05 on Cultural Heritage, 7 October 2005;
5. Presidential Decree No. 26/20 (National Biodiversity Strategy and Action Plan 2019-2025), 6 February 2020;
6. Decree No. 58/07 on General Regulation on Land Concession, 13 July 2007;
7. Law No. 4/07, Atomic Energy Law, 5 September 2007;
8. Presidential Decree No. 194/11 on Liability on Environmental Damage, 7 July 2011;
9. Law No. 31/11, approves the Mining Code, 23 September;
10. Presidential Decree No. 261/11 on Water Quality, 6 October 2011;
11. Presidential Decree No. 12/12 on Radioprotection Regulation, 25 January 2012;
12. Presidential Decree No. 190/12 on Waste Management, 24 August 2012;
13. Executive Decree No. 17/13 on Construction and Demolition Waste Management, 22 January 2013;
14. Presidential Decree No. 82/14, approves the Regulation on the General Use of Water Resources, 21 April 2014;
15. Executive Decree No. 469/15 on the slaughter prohibition in the national territory of protected species of the fauna and wild flora, 13 July 2015;
16. Joint Executive Decree No. 201/16 on Animals that may not be Hunted, 26 April 2016;
17. Presidential Decree No. 117/16 on Resettlement, 30 May 2016;
18. Law No. 6/17, General Framework Law on Forests and Wildlife, 24 January 2017;
19. Executive Decree No. 252/18, that approves the Red List of Species of Angola, 13 July 2018;
20. Presidential Decree No. 171/18 on Forestry Regulations, 23 July 2018; and
21. Presidential Decree No. 203/19, that approves the Regulation on Landfills, 25th of June 2019.

The legislation above is briefly discussed below.

3.3.1 Environmental Legislation

3.3.1.1 The General Environmental Law No. 5/98

The General Environmental Law (*Lei de Bases do Ambiente*, LBA) was promulgated in accordance with the Constitutional Law of the Republic of Angola. The purpose of the law is to provide the framework for environmental legislation and regulations; more specifically, to *define the basic concepts and principles for the protection, preservation and conservation of the Environment, promotion of quality of life and the rational use of natural resources* (Article 1). The LBA incorporates international declarations which Angola has ratified and defines citizens' rights and responsibilities. Further, the LBA introduces the concept of legal penalties for illegal activities that have caused damage to the environment.

Article 4 includes several principles guiding LBA, including a principle in respect of liability: *all persons or organisations which through their actions cause harm to the environment, or the degradation, destruction or depletion of national resources, shall be held liable for the same, and shall be required to repair such damage and / or pay compensation for the damage caused*.

Article 16(1) of LBA stipulates that an Environmental Impact Assessment (EIA), including public consultation (Articles 10 and 32), is mandatory for all undertakings which have an impact on the balance and wellbeing of the environment and society. Article 16(2) states that more specific legislation on EIAs will be developed by the government.

An Environmental License is issued based on an EIA / EIS, and a license is required before any other approval required by law will be granted (Article 17(2)). According to the LBA, MINAMB (now MCTA) is responsible for issuing environmental licenses.

3.3.1.2 Decree No.117/20 on General Regulation for Environmental Impact Assessment and Environmental Licensing Procedure

This decree establishes the standards and procedures that regulate the environmental impact assessment of public and private projects and the environmental licensing procedure for activities that, due to their nature, location or dimension, may cause significant environmental and social impact (Article 1). Applies to all public or private activities that may directly or indirectly influence environmental components (Article 2).

This decree revokes the regulations previously in force on these matters (Decree No. 51/04, of 23 July 2004, on EIA, and Decree No. 59/07, of 13 July, on Environmental Licensing), as well as all legislation that contradicts its wording. Chapter II of the decree focuses on EIA, and Chapter III establishes the provisions applicable to Environmental Licensing. Chapter IV sets out the requirements for monitoring the decree's provisions, the fees to be paid and the fines and accessory penalties applicable to infractions.

Article 7 refers to the categorization of the activities, and therefore Annexes I to V list the activities that are classified under Category A, B, C, D and E, respectively, and specifies the requirements for each one of those categories. For activities under category A, an EIA is required as well as Terms of Reference (TOR) and an Environmental Pre-Feasibility Study and Scoping (EPDA) (Article 7 and 12); Category B requires an EIA and the preparation of TOR for its elaboration; and Category C will require a Simplified Environmental Study and TOR.

At the beginning of an Environmental Impact Assessment procedure, the owner of the project (Pensana in this instance) must register the proposed activity, under the terms of the applicable legislation in force, in the Integrated Environmental System (SIA). The Ministerial Department that oversees the proposed activity must, within 5 (five) days, after receiving the Environmental Impact Study, issue an opinion on the project to be licensed (Article 6 (3)).

Within a maximum period of 30 (thirty) days from the date of receipt of the documentation, the Ministerial Department responsible for the Environment Sector sends the respective opinion to the competent authority to license or authorize the project (Article 17). Therefore, the project that has received a negative opinion from the Minister responsible for the Environment cannot be given authorization or license (Article 18 (1)). The decision taken by MCTA can be appealed following the general terms of administrative procedures and litigation (Article 18 (2)).

This decree adopts provisions concerning requirements, criteria and administrative procedures related to Environmental Licenses. In terms of Article 26, any activity requiring an EIA must apply for an Environmental License, which are issued by the MCTA.

The EIA procedural framework is shown in Figure 3-1.

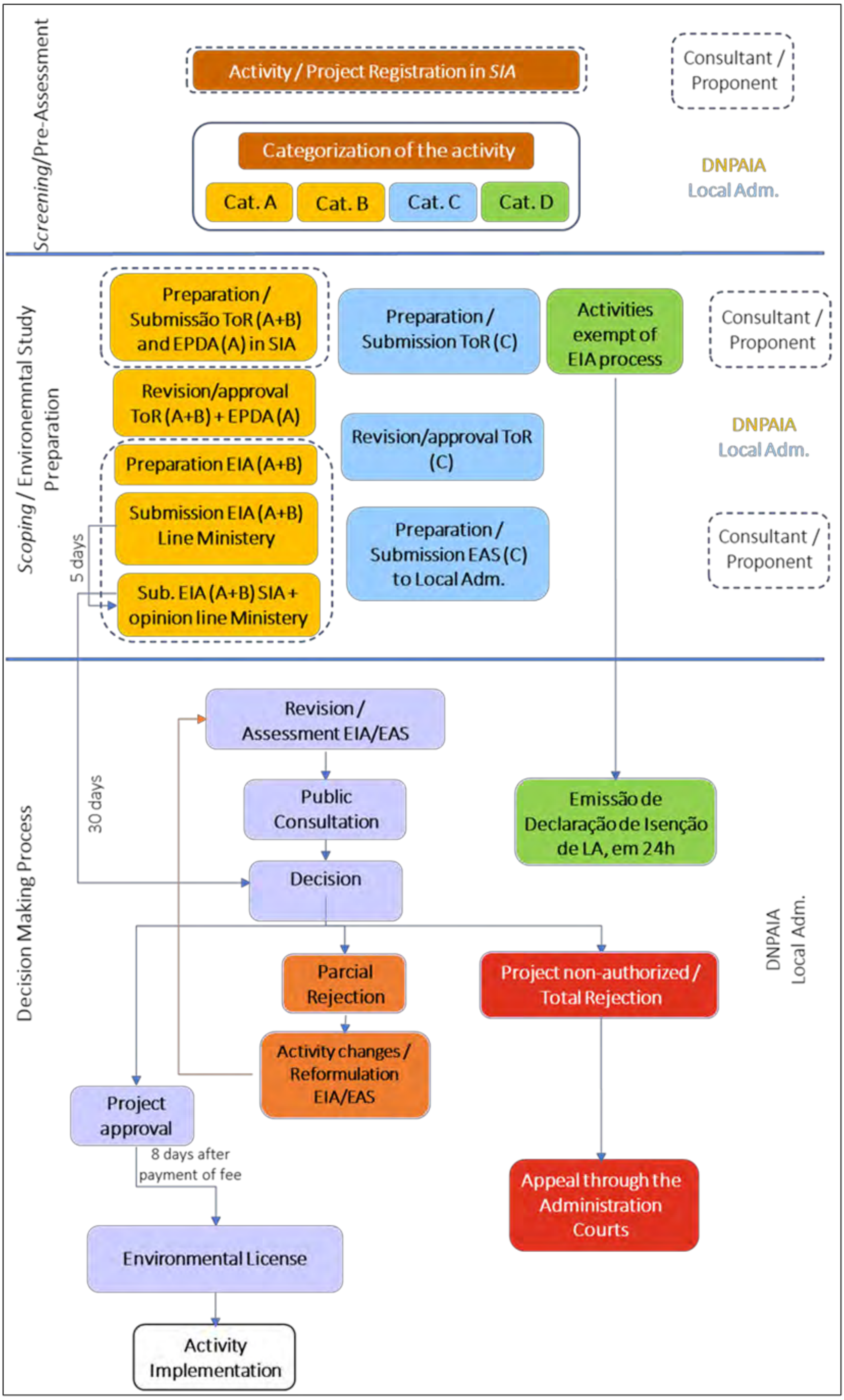


Figure 3-1: ESIA Procedural framework in Angola

Two types of environmental licenses are required for activities listed in terms of this Decree:

(1) A site environmental license is acquired first and is needed for the establishment (construction) of a listed activity (Article 29), and (2) an operation environmental license is issued once compliance with all the requirements of the EIA has been demonstrated (Article 30). The issuing procedures and contents of both licenses are stipulated in the Decree.

Article42 indicates that only technicians associated with companies registered as Environmental Consultancy Societies can carry out Environmental Impact Studies in Angola under the terms of the legislation in force.

The Pensana mining project is classified as Category A, as per Annex I, number 9, item f) “Mineral extraction and processing”. Therefore, an EPDA, TOR and EIA are required to be submitted under the SIA portal for approval.

3.3.1.3 Joint Executive Decree No. 130/09 on Environmental Licensing Fees

Decree No. 96/09 sets out the fees payable by the proponent when an Environmental License is granted and determines that 40% of the revenue from such fees is to be allocated to MINAMB. Executive Decree No. 130/09 (which substitutes the table annexed to Decree No. 96/09) sets out the fees payable by the proponent for an environmental license and other administrative costs. Fees for Installation (construction) and Operation Environmental Licenses are based on a percentage of the project cost are based on the investment value.

This decree sets out the fees payable by the developer for an environmental license and other relevant administrative costs. This decree includes tables of the investment values based on the Fiscal Correction Unit (*Unidade de Correcção Fiscal*, UCF) and the respective percentage to be applied. Order No. 174/11, of March 11th, provides the value of the Fiscal Correction that is the base for the license fee calculation. Currently, each UCF corresponds to 88 Kwanzas. For projects with a value over 2,830,000 UCF, the Installation Licence fee is 0.18% of the investment value, and the Operational Licence is 0.3% of the investment value. Point 4 of the same Decree states that the granting of the environmental license for installation and operation for the extractive mining industry is increased by 20%.

Ozango Minerals must pay a fee at the end of the Environmental Impact Assessment procedure to obtain the Environmental Installation License to implement the proposed activities, based on the value of the project investment and at a 20% increased rate.

3.3.1.4 Decree No. 1/10 on Environmental Auditing

Article 2 states that environmental auditing is a systematized and documented procedure for the management and objective evaluation of an organization and the functioning of its environmental management systems.

The decree establishes that the entity being audited should cooperate with the auditors, providing them with all documentation as requested and facilitating the execution of the audit. In addition, access shall be given to all premises, reports on the purchase of raw materials, energy and water consumption, use of manpower, and equipment (Article 11(1)).

Article 17(2) establishes that the execution of an environmental audit does not absolve the entities audited from the responsibility for environmental damage from polluting activities or those which cause environmental damage.

This Decree is a tool that must be used continuously after the environmental impact assessment process. It will enable the verification of the degree of implementation of mitigation measures recommended in the environmental impact study and the monitoring plan during and after the installation of the project. This audit process determines the level of implementation of mitigation measures so that actions can be taken to avoid non-compliance.

3.3.1.5 Executive Decree No. 87/12 on Public Consultation for Projects Subject to Environmental Impact Assessment

This executive decree defines and sets out the purpose of public consultation[15] for projects that require EIA. While the need for public consultation was prescribed in previous legislation, this Decree provides a more detailed and extensive explanation of the objectives and requirements for public consultation.
This Executive Decree aims to establish the rules for conducting public consultations of public or private projects subject to EIA (to gather opinions and contributions from the interested and affected parties).

3.3.1.6 Executive Decree No. 92/12 on the Terms of Reference for Environmental Impact Studies

This Executive Decree aims to establish the guidelines to conduct environmental impact studies necessary for the analysis of the environmental viability of projects subject to environmental impact assessment.

The Decree includes three annexes providing guidance for the information to be presented to the Ministry:

- Annex I is an application form for the project proponent to indicate which Environmental License is being applied for (the registration of the project);
- Annex II provides a form for the provision of simplified preliminary project information; and
- Annex III outlines the required general content and structure for the EIS, but does not provide details on the required content of each section.

The content and documents required in Annexes I and II forms are the same as in the SIA portal, when project registration is done and when the EIA is submitted.

3.3.2 Other project related legislation

3.3.2.1 Water Law No. 6/02

Article 10 states that the objective of the State is "to ensure the use of available water for all purposes through its rational and planned use for the sustained development of the national economy" and also to "promote, frame and regulate the use of water for agricultural, livestock, industrial and hydroelectric purposes".

The law states that private use of water cannot come before public use: "Common uses, as described in articles 21 and 22, have priority over any private use, so that private use cannot be granted or maintained to the detriment of those.

Pursuant to Articles 22 and 24, water uses are classified as (1) common (public) use, which refers to water taken from natural sources without any administrative approval, and (2) private water use, which requires a license. Common (public) water uses have priority over private water uses. Articles 24 and 26 of the Act further clarifies private uses that require and do not require a license or concession.

Water supply to the population for human consumption and health needs has priority over other private uses (Article 33(2)).

Article 41 (1) establish that private use of water depends on aa licensing, in which its use does not significantly change the quality and quantity of the water and the environmental balance, in accordance with the Regulation. n.º2 of the same Article states that the following also depends on a licensing: a) prospecting, pumping water and use of groundwater, except the activities described line c) of n.º1 of article 26 of this law[16]; b) deposits installation, the crops implantation or plantations and the cut down of trees on the beds and banks of the

[15] Public Consultation, according to DE 87/12, is the procedure that comprised in the scope of public participation and regulated under the terms of the present diploma, which aims to collect opinions, suggestions and other contributions from the interested public on the projects subject to Environmental Impact Assessment. This activity is promoted by MINAMB and takes place after submission of the EIAS for evaluation to the responsible authorities.

[16] According to Article 26 (1), holders of the right to use and benefit the land, in order to meet their domestic needs and the normal and foreseeable needs of agriculture, may, without license and free of charge, use: ((a) the waters of lakes, lagoons and marshes within their field, except in cases where, due to their volume or importance, such use requires a license or concession; (b) the flowing waters of springs that do not cross the boundaries of the respective field or do not flow into the stream; (c) **groundwater not included in protection zones, provided that it does not disturb its system or deteriorate its quality**; d) rainwater.

continuous or discontinuous natural currents and lakes, lagoons and marshes; and c) the extraction of inert materials, such as sand and gravel, from the beds and margins of continuous or discontinuous natural currents and from lakes, lagoons and marshes.

In terms of Article 68, Section 1 of the law, "the discharge of wastewater, wastes or other substances, and any activities that cause pollution or degradation of public water, is dependent on authorisation granted by the institution responsible for managing water resources".

3.3.2.2 Law No. 3/04, the Law on territorial and Urban Planning

The purpose of this law is the establishment of a system for spatial and urban planning. Spatial and urban planning policy relates to biophysical 'spaces' (made up of soils in urban and rural areas, the subsoil, the continental shelf and inland waters) to safeguard actions that result in the occupation and use of the spaces as mentioned above. This is achieved by implementing land- and town planning instruments provided for by this law (Article 1(2)).

3.3.2.3 Law No. 9/04, Land Law

The present law establishes the general bases of the legal regime of the lands integrated in the original property of the State, the land rights and the general regime of transmission, constitution, exercise and extinction of these rights (Article 2).

This law shall apply to rural and urban land over which the State constitutes any of the land rights provided for the benefit of natural persons or legal persons governed by public or private law, in particular with a view to pursuing agricultural purposes, livestock, forestry, mining, industrial, commercial, housing, urban or rural building, land use planning, environmental protection and anti-erosion (Article 3(1)).

The State respects and protects the land rights held by rural communities, including those based on custom or custom (Article 9(1)). Number 2 of the same Article establishes that land in rural communities may be expropriated for the purpose of public utility and to be an object of requisition, with fair compensation.

According to Article 16(1), "The occupation, the use, and usufruct of the land is subject to the rules on environmental protection, in particular those related to the protection of the landscape, and the species of flora and fauna, preservation of the ecological balance, and the citizens' rights to a healthy, and unpolluted environment".

Article 19(3) states that grantable land[17] is classified into urban and rural land. Rural land is considered to be the rustic building situated outside the area bounded by a charter or the area of an urban agglomeration and intended to be used for agricultural, livestock, forestry and mining purposes (Article 19(5)).

According to Article 22(1), rural land is classified according to the purpose for which it is intended and the legal regime to which it is subject, in **rural community land**, to agricultural land, forest land, **installation land** and road land. Rural community land is land occupied by families of local rural communities for their dwelling, practice of their activity or for other purposes recognized by custom or this law and its regulations (Article 22(2)). Number 5 of the same article defines that the installation land is the land provided for the implementation of mining, industrial or agro-industrial installations, under the terms of the present law and the respective legislation applicable to mining and oil activities and industrial parks.

Community rural land are considered, according to the Article 23(1), as land used by a rural community in accordance with customary land use, including, as appropriate, complementary areas for shifting agriculture, corridors transhumance for access by livestock to water sources and pastures and crossings, whether or not subject to the easement regime, used to access water or roads or access roads to urban areas.

[17] Land is grantable if the State owns the original property, assuming that it has not definitively entered to the private property of someone else.

It is competent, for the classification of a land as land of mining and oil installation, the body that oversees the planning of the territory and the environment, upon proposal or prior opinion of the entities that oversee the respective area (Article 25(2)).

3.3.2.4 Law No. 14/05 on Cultural Heritage

This law aims to establish the basis for policy and administration for the protection of cultural heritage. Cultural heritage is considered a special interest for the appreciation, retention and building of Angolan cultural identity.

Cultural heritage is defined as all material and immaterial goods, which should be subject to the protection of the right (Article 2(1)). Number 2 of the same article states that it constitutes Angolan Cultural Heritage any other goods that are considered, as such, by uses and customs and international conventions, which the Angolan State took part on. Thus, recognized as assets of relevant cultural interest, national languages, historical, paleontological, archaeological, architectural, artistic, ethnographic, biological, industrial, technical and all graphic, photographic, discographic, filmic, phonographic, bibliographic documents reflecting values of memory, antiquity, authenticity, originality, rarity, exemplarity, uniqueness and other cultural goods.

Article 13 defines that classified or pending classification properties cannot be demolished, in whole or in part, or be subject to restoration works without the prior opinion of the Ministry of Culture.

3.3.2.5 Presidential Decree No. 26/20 (National Biodiversity Strategy and Action Plan 2019-2025)

To implement the recommendations from the United Nations Convention on Biological Diversity (UNCBD, ratified by Resolution No. 23/97), the Government approved through Resolution No. 42/06 of 26 July 2006, the National Biodiversity Strategy and Action Plan (NBSAP). However, this Resolution was revoked by Presidential Decree No. 26/20 that approves the National Biodiversity Strategy and Action Plan 2019-2025, an annexe of this Presidential Decree.

This strategy aims to incorporate measures for the conservation and sustainable use of biological diversity and the fair and equitable distribution of biological resources favouring all Angolans into policies and development programmes.

The National Strategy and Action Plan for Biodiversity (NBSAP) of the Republic of Angola were developed to serve as an integrated strategic framework. As a result, the conservation and sustainable use of biodiversity can be organized and coordinated to fulfil an Action Plan over seven years (2019-2025).

3.3.2.6 Decree No. 58/07 on General Regulation on Land Concession

The regulation defines the legal framework for the concession of free lands, but the lands that constitute private property are under civil law discipline (Article 1(1)). The purpose of the regulation is to specify the general legal basis for land incorporated in the original property of the State, to define the process of granting, recognizing, transmitting, exercising and terminating land rights over those lands, to ensure the necessary publicity of the legal facts recognition, acquisition or modification of such rights and the legal status of their holders and to ensure the safety of legal trade (Article 1(3)).

3.3.2.7 Law No. 4/07, Atomic Energy Law

The Atomic Energy Law aims to (Article 1):

a) Establish rules for the activities directly or indirectly related to the production and use of atomic energy, as well as ionizing radiation sources;
b) Ensure the effective protection of the life and health of citizens and environment from the dangers of ionizing radiation activities or sources;
c) Prevent accidents with radiological consequences and reduce those consequences;
d) Establish the criteria for optimizing the protective and safety measures envisaged in order to reduce the magnitude of exposures, to prevent accidents and to reduce the consequences; and
e) Promote the safe, peaceful and appropriate use of sustainable development of nuclear energy and its applications.

Article 11(1) states that holders of licenses and certificates provided in this law, in addition, compliance with source requirements, must keep adequate security conditions to prevent damage or theft, as well as handling by any unauthorized persons. Number 2 of the same article states that no source may be transferred or abandoned without the prior authorization of the Authority. Finally, the Authority must periodically compile inventories of all mobile sources to verify if they are in the places provided in authorizations and kept in a safe condition Article 11(3).

The present law states that the exercise of any activity, as well as the construction, operation, conduct, suspension, closure or abandonment of any installation without the prior authorization of the Authority, is prohibited, except if the activities or installations are excluded under the terms of number 4 of Article 3 of this law (Article 12(1)). Number 2 of the same article states that the extraction, treatment, processing, design, manufacture, construction, assembly, acquisition, importation, exportation, distribution, sale, lease, receipt, placing, order, possession, operation, maintenance, repair, transmission, abandonment, disassembly, transport, storage or disposal are prohibited without the prior authorization of the Authority unless the source is excluded from the application of this law in terms of number 4 of Article 3.

The pursuit of any activities related to the treatment and disposal of radioactive waste is subject to the Authority's licensing, followed by an environmental impact assessment, protection and safety measures (Article 26 (1)). The Government approves by decree the rules and standards to be complied with for the treatment, handling, transport, storage and disposal of any radioactive waste, and the permitted levels of radioactive discharges (Article 26 (2)).

Radioactive waste exportation must comply with the rules provided in the relevant international instruments and is subject to prior authorization by the Authority as defined in the regulation (Article 26 (4)).

Article 50 states that in the event of contamination of land or water resources, appropriate decontamination measures have to be adopted, which should be mentioned in various radiological emergency plans, and consider the FAO guidelines and International Atomic Energy Agency on radiological accidents and measures to address them.

3.3.2.8 Presidential Decree No. 194/11 on Liability on Environmental Damage

This decree establishes strict liability for degradation of the environment. Aimed at preventing and repairing environmental damage, the decree establishes that all activities capable of causing damage to the environment (Article 3(1)) are considered liabilities and are subject to regulation under the "polluter pays" principle.

According to the decree, any entity responsible for pollution (the act of wilful misconduct or negligence) will be held responsible for cleaning up and restoring the environmental damage. Responsibility will be held for losses and damages caused to the environment by compensation for damages and environmental recovery measures.

Article 18º informs the right of the public to request intervention when there is concern that environmental damage has taken place. In Article 21º, the Decree also states that any individuals or legal entities which carry out activities that impose environmental risks shall have civil liability insurance.

3.3.2.9 Mining Law No. 31/11, approves the Mining Code

The Mining Code regulates all geological-mining activity, namely, geological research, discovery, characterization, evaluation, exploration, commercialization, use and exploitation of mineral resources in the soil, underground, inland waters, territorial sea, continental shelf, exclusive economic zone and in other areas of the territorial and maritime domain under the jurisdiction of the Republic of Angola, as well as the access and exercise of the rights and duties related to that.

The provisions of the Mining Code on the environment apply to the protection and conservation of flora and fauna, without changing the rules that are most beneficial for the conservation of these assets, with emphasis on the legislation on national parks and nature reserve areas (Article 3).

According to Article 8 of Chapter I, Part I, the mining sector has, among others, the following strategic objectives:

h) protect the environment by reducing the negative impact that geological and mining operations may have on the environment, and by remedying the adverse effects that may be caused;

i) combat practices that violate environmental rules.

The exploitation of mineral resources must be carried out sustainably and for the benefit of the national economy, with strict observance of the rules on safety, economic use of land, the rights of local communities and the protection of the environment (Article 9).

In order to ensure the harmonious development of the national economy to protect interests related to national defence, fauna, flora and the environment, the Executive Power may under the law establish areas excluded or restricted for mining geological activity (Article 14 (1)).

Consultation is mandatory in all cases where the implementation of mining projects may result in the destruction or damage of material, cultural or historical property that belongs to the local community as a whole (Article 16(4)).

Article 17(1) establishes that local people affected by housing damage, resulting in the displacement or disruption of their normal accommodation due to mining activities, are entitled to be relocated by the respective concession holder. However, the resettlement process must respect the habits, customs, traditions and other cultural aspects inherent in the communities, as long as the Constitution is not contradicted (Article 17(2)).

Article 64 sets out rules on environmental protection; in particular, number 1 states that mining rights holders shall ensure the conservation and protection of nature and the environment, complying with the respective legal standards. Without being against the establishment of specific environmental standards for mining, the use of minerals shall be carried out in compliance with the fundamental laws of the environment, biological and aquatic resources, water and environmental impact assessment rules (Article 64(2)).

Approval by the authority responsible for the environment of the Environmental Impact Assessment (EIA) prepared by the mining operator is a prerequisite to obtaining the mining rights at the exploration stage (Article 65(1)). The principle of tacit approval of the Environmental Impact Assessment does not apply to the mining industry (Article 65(2)).

3.3.2.10 Presidential Decree No. 261/11 on Water Quality

This decree serves as an addition to the national Water Law No. 6/02, dealing specifically with water quality. It establishes the roles within the Angolan governmental administration for overseeing water quality issues and addressing the water quality standards relating to human consumption and wastewater. The decree also lists the role of water quality monitoring and the standard parameters for drinking water, surface waters and emissions limits for wastewater discharge (in Annex VI).

According to item 3 of Article 1, this law also regulates the control standards of wastewater discharge in water bodies and soil to preserve the quality of the aquatic environment and the protection of public health.

Article 13 of Chapter III (Protection of Waters Against Pollution of Discharged Wastewater) defines that the discharge of wastewater from a treatment facility into water and soil requires a license issued by the Ministry of Environment, in which discharge standards for mitigation or prevention of damage are set.

3.3.2.11 Presidential Decree No. 12/12 on Radioprotection Regulation

Article 1 states that the objectives of the Regulation are: (a) *protected people against exposure to ionizing radiation, safety of radioactive sources, hereinafter referred to as "sources", the management of radioactive waste and the protection of the environment; hereinafter referred to as "radiological safety" or "radioprotection"; (b) prevent unauthorized access and / or transmission, damage, loss and theft of radioactive sources in order to reduce the likelihood of accidental exposure.*

This Regulation applies to the adoption, introduction, conduct, suspension, interruption or end of a practice and to the design, manufacture, construction or assembly, acquisition, importation or exportation, distribution, sale, loan or lease, location, commissioning, processing, possession, operation and use, maintenance or repair, transmission or commissioning, disassembly, transport, storage and recycling or treatment of radioactive sources within a practice (Article 2(1)).

Article 6(3) defines the general responsibilities of the main parties:

a) Establish radiation safety objectives, according to the requirements of this Regulation;

b) Develop, implement and establish a radiological safety program in line with the nature and extent of the risks associated with the practices and interventions under its responsibility. According to the requirements of this Regulation, the program shall provide the following actions:

i) Determine and continually maintain the necessary measures to achieve the radiological safety objectives, to ensure that the necessary resources are available for implementation and regularly verify that these objectives have been achieved;

ii) Identify, prevent or correct promptly any defects or defects inherent in radiological safety measures;

iii) Facilitate auscultation and cooperation between all parties, regarding radiological safety;

iv) Record data relating to the exercise of their responsibilities.

c) The main parties shall ensure that:

i) Radioactive sources are being use, according to the authorization; and

ii) When radioactive sources are not being used must be readily and properly stored.

3.3.2.12 Presidential Decree No. 190/12 on Waste Management

This decree establishes the rules concerning waste generation and disposal; discharges to water and the atmosphere; collection, storage and transport of any wastes, except for radioactive wastes or any other subject to specific regulations. These rules aim to prevent or minimize the negative impacts on people's health and the environment, without prejudice to establishing rules aiming to reduce, reuse, recycle, recover and dispose of waste. According to Article 2, this regulation applies to all activities that might generate wastes or are involved in waste management.

Article 7(1) establishes that all private or public entities producing wastes should develop a Waste Management Plan. This plan is valid for four (4) years and should be submitted to MINAMB 90 days before the expiry date, and every time there are substantial changes to the submitted plan.

3.3.2.13 Executive Decree No. 17/13 on Construction and Demolition Waste Management

This decree establishes the legal regime for managing wastes from construction and demolition of buildings and landslides, the so-called Construction & Demolition Wastes (CDW). The management concept includes prevention, re-use and collection, transport, storage, triage, treatment, recovery and disposal operations.

3.3.2.14 Presidential Decree No. 82/14, approves the Regulation on the General Use of Water Resources

This decree applies to surface water and groundwater, namely watercourses, lakes, lagoons, swamps, springs, reservoirs, estuarine areas and other water bodies, without prejudice to the respective watercourse bed, river banks and surroundings.

Article 17 states that water resources for private use need a specific title of use (concession or license).

Article 109(2) establishes that holders of rights to use water resources shall in general be prohibited from:

b) Accumulate solid wastes, liquids or any substances in places and conditions that may contaminate or create danger of water resources contamination;
c) Carry out any activities that imply or may imply the degradation or pollution of the water resources;
d) Make any changes to the regime, flow, quality and use of water resources that may affect the public health, natural resources, the general environment, security and national sovereignty;
e) Carry out any activities in the water protection zones.

Article 110 establishes that proponents shall consider a 200m buffer zone as follows: "*areas of protection of water resources, the water course beds, river banks and water courses adjacent zones of up to a distance of 200 metres*".

Article 111 defines, as it is forbidden, in the protection zones of the water resources, in the terms of the present Diploma and other applicable laws:

d) Install dumps or heaps resulting from mining activity;
f) Install pipelines and reservoirs of hydrocarbons or wastewater.

Article 119 states that: "*without prejudice the provisions of this legal document, the assignment of any permits for the use of water resources, independently of its end, is subject to prior approval by the corresponding environmental impact studies, provided that that the legislation in force to require, by virtue of its nature, size or location, which may have significant environmental and social impacts*."

Sections I and II from Chapter VIII (Fees) presents the calculations related with the fees to be paid for water abstraction and wastewater discharge.

3.3.2.15 Executive Decree No. 469/15 on the slaughter prohibition in the national territory of protected species of the fauna and wild flora

This executive decree establishes a ban on the slaughtering of wild fauna and flora (protected species) on national territory, in order to avoid the illegal hunting and trafficking of valuable objects, activities which, in recent years have assumed high levels, endangering the biodiversity, under the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES), assigning to the Ministry of Environment inspectors the responsibility for overseeing and define the regime of sanctions.

3.3.2.16 Joint Executive Decree No. 201/16 on Animals that may not be Hunted

The joint executive decree establishes a list of animals for which hunting is prohibited in Angola (Table 2) and a list of animals for which hunting is permitted in each season (Table 3) and respective compensation rates due to the State.

3.3.2.17 Presidential Decree No. 117/16 on Resettlement

This decree aims to define the rules, procedures and criteria that should govern the actions of the public administration and autonomous state in the resettlement and rehousing process of a group of people living in a given territory, households, residents who are affected by redevelopment and urban areas reconversion, under the principles governing public administration, ensuring the pursuit of the public interest and protection of rights and interests of citizens.

As per Article 3(1), the Provincial Governor is responsible for the operations of resettlement; however, the holder of executive power may indicate another entity to develop resettlement operations. Municipal Administrations are the competent authorities to develop resettlement operations Article 3(2). Number 3 of the same article states that where the relocation results from the expropriation process, the expropriating entity proceeds with the resettlement.

3.3.2.18 Law No. 6/17, General Framework Law on Forests and Wildlife

This law regulates the protection of forests and wildlife, with the objectives of conservation and sustainable use. Article 30(1) forbids tree felling and deforestation; article 30(2) states the need for authorisation from the Department responsible for Forest and Fauna sectors for any purpose, primarily agricultural, mining and public works.

According to Article 35 (Environmental Impact Assessment), projects that are likely to significantly impact forests, wildlife, and ecosystems require environmental impact assessments. This shall be emphasised by the Department responsible for Forests and Fauna sectors, collaborating with other departments.

3.3.2.19 Executive Decree No. 252/18, that approves the Red List of Species of Angola

This decree approves, the Angolan Red List of Species. According to Article 2, this list consists of four categories:

a) Category A - Extinct Species (Ex), when the species has a natural occurrence in Angola and is considered extinct or has never been seen in its habitat;

b) Category B - Threatened Species of Extinction (AEx), when several factors seriously threaten its existence, hindering its reproduction or natural regeneration, bringing its populations below sustainable levels;
c) Category C - Vulnerable Species (Vul), when human activity threatens its natural occurrence in the National Territory; and
d) Category D - Invasive Species, when the species does not occur naturally or is introduced into the National Territory.

The categories of each species are updated using available scientific information over five years.

3.3.2.20 Presidential Decree No. 171/18 on Forestry Regulations

This decree regulates the sustainable management forest resources and related ecosystems and aims to establish standards for its conservation and rational use, taking into account these resources' environmental, social, economic, and cultural dimensions. Article 14(1) provides that: "*Protected trees has the status of natural monuments and are identified on the ground by a sign indicating the common and scientific names of the species and classification*". Article 14(2) states that "*It is prohibited to cut or damage protected trees*".

3.3.2.21 Presidential Decree No. 203/19, Approves the Regulation on Landfills

This Presidential Decree establishes the legal regime for the disposal of waste in landfills, and the requirements to be observed in the design, construction, operation, closure, and post-closure of landfills. The decree applies to all facilities used to control waste, above or below ground. The landfill operation is subject to licensing, covering the design, construction, operation, closure, and post-closure phases.

Landfills are classified into three classes: i) Landfills for inert waste; ii) Landfills for non-hazardous waste, and iii) Landfills for hazardous waste. Depending on the class, landfills comply with different technical requirements.

The waste acceptance process comprises essential characterization by the producer or holder, compliance testing, and on-site verification by the operator. If the essential characterization and compliance testing show that the waste fulfils the criteria for the class of landfill in question, the operator issues a certificate of acceptance.

3.4 International conventions and treaties

The Angolan foreign policy aims to enable Angola to conform with multilateral environmental agreements (MEAs) and enable Angola to take part in international conservation programs and projects. International conventions and treaties to which Angola is a signatory and are relevant to the Project are listed in Table 3-1.

Table 3-1: International conventions and treaties that Angola is signatory to

No.	International conventions, treaties, agreements
1.	UN Framework Convention on Climate Change
2.	Kyoto Protocol to UNFCCC
3.	Montreal Protocol on Substances that Deplete the Ozone Layer (with London, Copenhagen, Montreal amendments)
4.	Vienna Convention on the Protection of Ozone Layer
5.	UN (Rio) Convention on Biological Diversity
6.	Convention on Migratory Species of Wild Animals
7.	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
8.	United Nations Convention to Combat Desertification
9.	International Convention on Oil Spill Preparedness, Response and Cooperation
10.	International Convention on Establishment of an International Fund for Compensation for Oil Pollution Damage
11.	Stockholm Convention on Persistent Organic Pollutants

3.5 International guidelines and standards

International standards most commonly refer to and meet the requirements of the International Finance Corporation Performance Standards (IFC PS); other vital standards include the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines) and Organisation for Economic Co-operation and Development (OECD) Common Approaches. Of these, the IFC PSs (and associated guidance notes) provide detailed guidance on identifying impacts and the related risks, and mitigation to conduct a proponent/developer's business sustainably.

Over time, IFC PS developed into an environmental and social risk management framework used internationally by financial institutions. The Equator Principles (EPs) are based on the IFC PS and have been widely adopted by funding institutes as a benchmark. Guidelines also include requirements for robust stakeholder consultation and disclosure.

The IFC published a wide range of industry-specific guidelines for Environmental, Health and Safety (EHS) management; and 'Good Practise Notes'. The guidelines/notes relevant to the proposed Project will be focussed on during the impact assessment phase, and the guidelines of these standards will be incorporated in the specific management plan components in the ESMP.

3.5.1 International Finance Corporation (IFC) Performance Standards (PS) (January 2012)

The IFC PSs comprise the following:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labour and Working Conditions;
- Performance Standard 3: Resource Efficiency and Pollution Prevention;
- Performance Standard 4: Community Health, Safety and Security;
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Performance Standard 7: Indigenous Peoples; and
- Performance Standard 8: Cultural Heritage.

Relevance of the IFC PSs are evaluated in Table 3-2.

Table 3-2: The relevance of IFC Performance Standards to the Longonjo Project

Performance Standard	PS Objective	Relevance to the Project	Note
PS1: Assessment and management of environmental and social risks and impacts	• To identify and evaluate social risks and project impacts • To adopt mitigation hierarchy • To promote improved environmental and social performance • To address grievances from affected communities • To promote and provide ways for adequate (stakeholder) engagement	Yes	The ESIA was undertaken to identify and evaluate environmental and social risks and impacts of the proposed Longonjo Project. As a result, an Environmental and Social Management Plan has been formulated and tailored to the Project to stipulate mitigation measures to manage the impacts identified in the ESIA.
PS2: Labour and working conditions	• To promote the fair treatment, non-discrimination, and equal opportunity of workers • To establish, maintain, and improve the worker-management relationship • To promote compliance with national employment and labour laws • To protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client's supply chain • To promote safe and healthy working conditions, and the health of workers • To avoid the use of forced labour	Yes	Pensana has proposed to use outsourced contractors and a local workforce for the construction and operational phases of the Longonjo mine.
PS3: Resource efficiency and pollution prevention	• To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities • To promote more sustainable use of resources, including energy and water • To reduce project-related GHG emissions	Yes	Emissions and waste streams will need to be minimized through the design; pollution prevention and control technologies and practices will be adopted to avoid or, where avoidance is not feasible, minimize or reduce adverse impacts on human health and the environment while remaining technically and financially feasible and cost-effective.
PS4: Community health, safety and security	• To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances • To ensure that the safeguarding of personnel and property is carried out in	Yes	There are six settlements but the limited social infrastructure around the Project footprint.

	accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the affected communities		
PS5: Land acquisition and involuntary resettlement	• To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs • To avoid forced eviction • To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of • information, consultation, and the informed participation of those affected • To improve, or restore, the livelihoods and standards of living of displaced persons. • To improve living conditions among physically displaced persons through the • provision of adequate housing with security of tenure at resettlement sites.	Yes	Two villages are near the Project boundary. Based on the preliminary design, no physical resettlement of the village is required. Physical resettlement will be avoided if possible. Communities make use of natural resources and services that will be affected by the Project. Villagers livelihoods are land-based. The loss of agricultural land and restriction of access to agricultural lands will require an economic resettlement plan and livelihood restoration plan (land-based livelihood resettlement strategy).
PS6: Biodiversity conservation and sustainable management of living natural resources	• To protect and conserve biodiversity • To maintain the benefits from ecosystem services • To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities	Yes	Land will be cleared resulting in loss of habitat.
PS7: Indigenous peoples	• To ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of indigenous • peoples	No	It was established during the consultation that indigenous groups, as defined by PS7, are not resident on the Project footprint nor the Projects area of influence.
PS8: Cultural heritage	• Where project activities have adverse effects on cultural heritage, measures must be	Yes	Cultural heritage may be affected by the Project. For example, the old ruins of a chapel are located on top of "Mount" Chimbilundo in

	taken for its protection. The objectives of this standard are: ● To protect cultural heritage from the adverse impacts of project activities and support its preservation; and ● To promote the equitable sharing of benefits from the use of cultural heritage.		the mining lease area but outside the Project development footprint. There are three informal graves sites in the zone of influence of the proposed TSF9/10, where one is within the footprint of TSF9/10. Informal graves sites should be fenced and actively protected by avoiding any mining activity in the vicinity of the graves. If this is not possible, a formal process of grave relocation must be followed, in accordance with the law and with thorough consultation with relevant families and community leadership.

There will be economic displacement as described in Performance Standard 5; this aspect is discussed in more detail. In addition, the IFC published a wide range of industry-specific guidelines for Environmental, Health and Safety (EHS) management and 'Good Practice Notes'. The IFC Performance Standard 5 recognises that project-related land acquisition and restrictions on land use can have adverse effects on communities and persons who use the same land. Involuntary resettlement refers to **physical displacement** (loss of shelter or home) and **economic displacement** (loss of assets or access to assets used to generate an income or sustain their livelihoods). Resettlement is considered involuntary when the communities living on the affected land do not have the right to refuse land acquisition or restricted access to the land they have previously utilized.

The standard applies therefore to **physical** or **economic displacement** resulting from land transactions where i) land rights are acquired by a private sector project through expropriation or compulsory procedures or ii) land rights are acquired by a private sector project through negotiated settlement with property owners (including traditional or customary rights recognised under the laws of the country)[18].

Guidance Note 5 articulates the following as essential for maintaining sustainable development when land acquisition and informal resettlement is potentially part of proposed development:

- Proper management of the resettlement process is essential to prevent long term hardship and impoverishment of the affected communities.
- Involuntary resettlement should primarily be avoided. Where it is unavoidable, it should be minimised and appropriate measures to mitigate adverse impact on the displaced persons and the host communities should be carefully planned and implemented.
- Eliminate the use of government authority to enforce relocation. Based on International Best Practice, involvement from the development partner (a third party), the client, can assist in more cost effective, efficient and timely implementation of resettlement activities.

The guidelines/notes relevant to the proposed Project will be focused on during the impact assessment phase, and the guidelines of these standards will be incorporated in the specific management plan components in the Environmental and Social Management Plan (ESMP).

3.5.2 Environmental, Health and Safety (EHS) Guidelines

The World Bank's EHS Guidelines (2016) and the industry-specific EHS guidelines and 'Good Practise Notes' which apply to the Project include:

- Mining (2007);
- Electric Power Transmission and Distribution (2007);

1818 IFC Guidance Note 5

- Waste Management Facilities (2007); and
- Water and Sanitation (2007).

3.5.3 The Equator Principles

The Equator Principles (EP) are used by Equator Principle Funding Institutes (EPFIs) to benchmark projects they lend funds to across all sectors. The EP are:

- Principle 1: Review and Categorisation
- Principle 2: Social and Environmental Assessment
- Principle 3: Applicable Social and Environmental Standards
- Principle 4: Action Plan and Management System
- Principle 5: Consultation and Disclosure
- Principle 6: Grievance Mechanism
- Principle 7: Independent Review
- Principle 8: Covenants
- Principle 9: Independent Monitoring and Reporting

3.5.4 Industry specific guidelines: Water

The IFC, FAO, and other organisations published a wide range of industry-specific guidelines for Environmental, Health and Safety (EHS) management, as well as 'Good Practise Notes'. The guidelines/notes relevant to the proposed project include:

- ASCE Publication on Agricultural Salinity Assessment and Management (Tanjii,1990)
- Australian Water Quality Guidelines for Irrigation Water Supplies (Hart, 1974; Hart et al, 1992)
- Canadian Irrigation Water Guidelines (Canadian Guidelines, 1987)
- USA Quality Criteria (USEPA, 1986);
- Canadian Water Quality Guidelines (CCREM, 1987);
- Australian Water Quality Guidelines (ANZECC, 1992)
- FAO's Guide for Evaluating the Suitability of Water for Irrigation (Ayers and Westcott, 1985)
- USDA Handbook on Diagnosis and Improvement of Saline and Alkali Soils (US Salinity Laboratory Staff, 1954)
- South African National Standard SANS 241-1:2015 Drinking water Part 1: Microbiological, physical, aesthetic and chemical determinants
- South African Water Quality Guidelines (DWS-SA) Volume 4: Agricultural Water Use: Irrigation Second Edition, 1996
- South African Water Quality Guidelines (DWS-SA) Volume 6: Agricultural Water Use: Aquaculture Second Edition, 1996
- South African Water Quality Guidelines (DWS-SA) Volume 7: Aquatic ecosystems Second edition1996
- FAO Irrigation and Drainage paper 29 Rev. 1: Water quality for agriculture
- Control of water pollution from agriculture - FAO irrigation and drainage paper 55USA Quality Criteria for Irrigation Water (US EPA, 1973)
- FAO Water pollution from agriculture: a global review Executive summary 2017

NOTE: The South African Water Quality Guidelines, referred toas "DWS-SA" for the Department of Water Affairs South Africa, was found to be the most comprehensive publications; they were derived from international guidelines, including those listed in this sub-section. This ESIA and related hydrology specialist study therefore refers to this Standard due to its geographic relevance to Angola and its comprehensive, as stated.

3.5.5 IRMA

The Initiative for Responsible Mining Assurance (IRMA) is focused on promoting socially and environmentally responsible mining. IRMA offers independent third-party verification and certification against a comprehensive standard for all mined materials that provides 'one-stop coverage' of the full range of issues related to the impacts of industrial-scale mines.

IRMA's approach to responsible mining is to certify social and environmental performance at mine sites globally using an internationally recognized standard that has been developed in consultation with a wide range of stakeholders.

HCV Africa is an IRMA registered member, and we draw on relevant components of the standard when proposing mitigation measures and formulating ESMPs.

3.5.6 Air quality guidelines

3.5.6.1 World Bank Requirements

The World Bank Pollution Prevention and Abatement Handbook 1998 provide guidelines on ambient air quality and emission limits for specific processes and individual pollutants (such as particulates, sulphur dioxide and oxides of nitrogen). Ambient standards provide the maximum allowable level of a pollutant in the receiving environment, whereas emission standards set the maximum amount of pollutants released.

As of April 30, 2007, new versions of the World Bank Group Environmental, Health, and Safety Guidelines (the 'EHS Guidelines') are now in use. These replace those documents previously published in Part III of the Pollution Prevention and Abatement Handbook and on the International Finance Corporation (IFC) website. The EHS Guidelines are technical reference documents intended to be used together with the Industry Sector EHS Guidelines for specific industry sectors. It provides performance levels and measures on what existing technology considers achievable at reasonable costs. It is made clear that these guidelines should be adapted to site-specific variables considering the sensitivity of the environment and other project factors as indicated by the environmental assessment and in the context of the host country. In general, the most stringent guidelines need to be applied. Thus, if the host country has more lenient guidelines, the EHS Guidelines should be applied. On the other hand, if less stringent levels or measures are appropriate given specific project circumstances, a complete and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment (IFC, 2007).

According to the World Bank 1998 Handbook, ambient air quality standards should be set once an agreement has been reached on the desired environmental quality objectives and the cost that society is willing to accept to meet the set objectives. Typically, the set of ambient air quality standards aim to protect human health, but some countries have established lately ambient standards for the protection of ecosystems. On the other hand, emission standards may be established in terms of what can be achieved with available technology or in terms of the impacts resulting from the emissions.

3.5.6.2 General Ambient Air Quality Guidelines

The new EHS Guidelines were developed as part of a two-and-a-half-year review process. The EHS Guidelines are intended to be 'living documents' and will be updated regularly going forward. The EHS provides a general approach to air quality management for a facility, including the following:

- Identify possible risks and hazards associated with the project as early on as possible and understand the magnitude of the risks, based on:
    - The nature of the project activities; and,
    - The potential consequences to workers, communities, or the environment if these hazards are not adequately managed or controlled;

- Prepare project- or activity-specific plans and procedures incorporating technical recommendations relevant to the project or facility;
- Prioritise the risk management strategies to achieve and overall reduction of risk to human health and the environment, focusing on the prevention of irreversible and / or significant impacts;
- When impact avoidance is not feasible, implement engineering and management controls to reduce or minimise the possibility and magnitude of undesired consequence; and
- Continuously improve performance through a combination of ongoing monitoring of facility performance and effective accountability.

Significant impacts to air quality should be prevented or minimised by ensuring that:

- Emissions to air do not result in pollutant concentrations exceeding the relevant ambient air quality guidelines or standards. These guidelines or standards can be national guidelines or standards or, in their absence, WHO Air Quality Guidelines or any other international recognised sources such as the relevant European Council Directives or the United States National Ambient Air Quality Standards. These standards are presented in Table 2-1.
- Emissions do not contribute significantly to the relevant ambient air quality guidelines or standards. Therefore, it is recommended that 25% of the applicable air quality standards are allowed to enable future development in a given airshed.

The EHS recognises the use of dispersion models to assess potential ground-level concentrations. However, the models used should be internationally recognised or comparable.

Table 3-3: Ambient Air Quality Guidelines for various international organisations as accepted by the World Bank (IFC, 2007)

Pollutant	Averaging Period	WHO Interim Targets (µg/m³)	WHO Guideline Value (µg/m³)	EC Directive Limits (µg/m³)	US NAAQS (µg/m³)
Particulate Matter (PM_{10})	24-hour	150 (a) 100 (b) 75 (c)	50	50 (d)	150 (e)
	annual	70 (a) 50 (b) 30 (c)	20	20	-
Particulate Matter ($PM_{2.5}$)	24-hour	75 (a) 50 (b) 37.5 (c)	25	-	35 (f)
	annual	35 (a) 25 (b) 15 (c)	10	-	12

Notes:

Interim target – 1
Interim target – 2
Interim target – 3
Not to be exceeded more than 7 times per calendar year.
Not to be exceeded more than once per year
98th percentile, averaged over 3 years

3.5.7 Degraded Airshed or Ecological Sensitive Areas

The IFC provides further guidance on projects located in degraded airsheds, i.e. areas where the national/ WHO/ other recognised international Air Quality Guidelines are significantly exceeded or where the project is located next to areas regarded as ecological sensitive such as national parks. As far as could be ascertained, project's area is not a sensitive ecological area.

3.5.7.1 World Health Organisation

During the 1990s, the WHO stated that no safe thresholds could be determined for particulate exposures and responded by publishing linear dose-response relationships for PM_{10} and $PM_{2.5}$ concentrations (WHO, 2005). This approach was not well accepted by air quality managers and policy makers. As a result, the WHO Working Group for Air Quality Guidelines recommended that the updated WHO air quality guideline document contains guidelines that define concentrations which, if achieved, would be expected to result in significantly reduced rates of adverse health effects. In addition, these guidelines would provide air quality managers and policy makers with explicit objectives when tasked with setting national air quality standards.
Given that air pollution levels in developing countries frequently far exceed the recommended WHO air quality guidelines (AQGs), the Working Group also proposed interim target (IT) levels, which are more than the WHO GV themselves, to promote steady progress towards meeting the WHO AQGs (WHO, 2005). There are between two to three interim targets starting at WHO interim target-1 (IT-1) as the most lenient and IT-2 or IT-3 as more stringent targets before reaching the GV. These are provided in Table 3-3 for the various pollutants.

3.5.7.2 European Community

The EC air quality criteria represented objectives/standards to be achieved by 2004/2005 and were designed primarily to protect human health. The EC standards have superseded the European Union (EU) standards. The current EU standards were determined through consultation regarding environmental conditions, the economic and social development of various regions, and the importance of a phased approach to attaining compliance. The Air Quality specialist study provides the EU ambient standards – Appendix C.

3.5.8 Environmental noise guidelines

Due to a lack of recommended environmental noise levels for new developments, it was decided to make use of the IFC Environmental Health and Safety (EHS) Guidelines (IFC 2007) (Ref 2). The guidelines values are specified as either a fixed noise limit or an increase of 3.0dB over the prevailing ambient noise levels. The guideline levels are set out in Table 3-4. The guidelines advise that, where noise levels attributable to an installation or operation exceed the guideline values at the façade of the nearest noise receptor, appropriate noise mitigation measures should be adopted.

Table 3-4: Recommended noise levels for residential areas and industrial areas

Receptor	Either		Or
	Period		Where baseline exceeds IFC guideline
	Daytime (07:00 – 22:00)	Night-time (22:00 – 07:00)	
Residential, institutional and educational	55	45	3 dB increase over baseline
Industrial and commercial	70	70	

3.5.9 Ground vibrations guidelines

Blasting may occur to dislodge large boulders on an intermittent basis when and if required. Vibration and air pressure level analysis is part of the assessment of this report. The following ground vibration intensities (mm/s) and effects illustrated in Table 3-5 may occur.

Table 3-5: Effects from different intensities of ground vibration

Ground Vibration Intensity, mm/s	Ground Vibration Effect
0.3 – 0.5	Becomes perceptible to humans
12.5	USBM recommended limit to prevent damage to weakest of building materials in well-built wood-frame structures (e.g., plaster-on-lath).
19.1	Recommended limit to prevent damage to drywall/sheetrock construction.
50.0	Recommended limit for construction blasting and quarry blasting at high frequencies.
75 - 125	Hairline cracks may start developing in plaster.
300 - 600	Micro-cracks may start developing in rock.

3.6 Pensana's Health, Safety and Environmental policy

PENSANA's health, safety and environmental policy is presented in Appendix A.

4 DESCRIPTION OF CURRENT STATE OF THE ENVIRONMENT (BASELINE ENVIRONMENT)

Section 4.1 to 4.9 presents the physical setting / baseline of the Project, Section 4.10 to 4.13 the biological setting / baseline and Section 4.14 the social and socio-economic setting / baseline.

PHYSICAL SETTING	Section number
Location	4.1
Climate	4.2
Topography	4.3
Air quality	4.4
Geology	4.5
Hydrology	4.6
Hydrogeology	4.7
Noise	4.8
Soils	4.9
Visual aspects	4.10
BIOLOGICAL SETTING	**Section number**
Aquatic ecology	4.11
Avifauna	4.12
Botany	4.13
Herpetology	4.14
Mammals	4.15
SOCIAL SETTING	
Social and socio-economics	4.16
Cultural heritage	4.17
Traffic	4.18

Methodologies applied by the respective specialists during the baseline field surveys are available in each respected specialist study in Appendices C – N.

PHYSICAL SETTING

4.1 Location

The Project is located in the Longonjo Municipality, Huambo Province (Figure 2-1). The municipality of Longonjo has four communes, Longonjo-sede, Catabola, Chilaia and Lepi, with a total of 206 localities (6% of the province's localities), being the most prominent part, 87%, classified as a rural area. The commune of Longonjo-headquarters has 46 villages on a surface of 1 593 km² in the (Provincial Government of Huambo, 2018).

4.2 Climate

Angola has varied climate zones influenced by geography and oceanic factors. Angola's interior plateau is roughly subdivided into three broad ecological areas:

- The northern area – warm and wet with high rainfall (> 1,500 mm p.a.) and high temperatures (annual average > 22°C);
- The central area (highlands) – tropical climate moderated by 1,000 – 2,500 masl altitudes. Annual rainfall of 1,250 –1,500 mm p.a. and moderate temperatures (annual average of 18°C –20°C); and
- The southwest area – is semi-arid, a mild hot season influenced by the cold Benguela Current and tropical continental air masses.

Based on climatic data since the 1960s climate, change trends in Angola reveal an annual temperature increase of 0.33°C per decade; this trend showed an increased occurrence of hot days in the dry season (June – August).

The occurrence of hot days also increased in all seasons. A trend of decreasing annual rainfall was also noted (2.4% per month per decade).

By 2100, increases in average temperatures might be as high as 4.9°C; most of the increases would be in the inland regions. Rainfall patterns might be more erratic; rainfall could decrease, particularly in the south. A sea-level rise in Angola is estimated to be between 13cm and 56cm by 2100 (USAID, 2018).

4.2.1 Local climate

The Project is in the tropical zone, but due to the altitude and effect of the cold Atlantic Ocean currents, the average temperatures range is between 17.7 °C - 22.6 °C and annual rainfall in Huambo is about 1,300 mm.

4.2.1.1 Temperature

Monthly mean, maximum and minimum temperatures are given in Table 4-1. Diurnal temperature variability is presented in Figure 4-1. Temperatures ranged between 11.9°C and 25.6°C. During the day, temperatures increase to reach a maximum at about 15:00 in the late afternoon. Ambient air temperature decreases to reach a minimum between 06:00 and 07:00.

Table 4-1: Monthly temperature summary (WRF data, January 2016 to December 2018)

Monthly Minimum, Maximum and Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	15.4	15.5	15.5	14.8	13.3	11.9	11.9	13.3	14.4	15.7	15.8	15.8
Average	18.4	18.7	18.7	18.5	17.9	17.2	17.4	19.0	20.1	20.1	19.3	18.6
Maximum	22.1	22.3	22.5	22.4	22.4	22.4	22.8	24.5	25.6	24.7	23.1	22.1

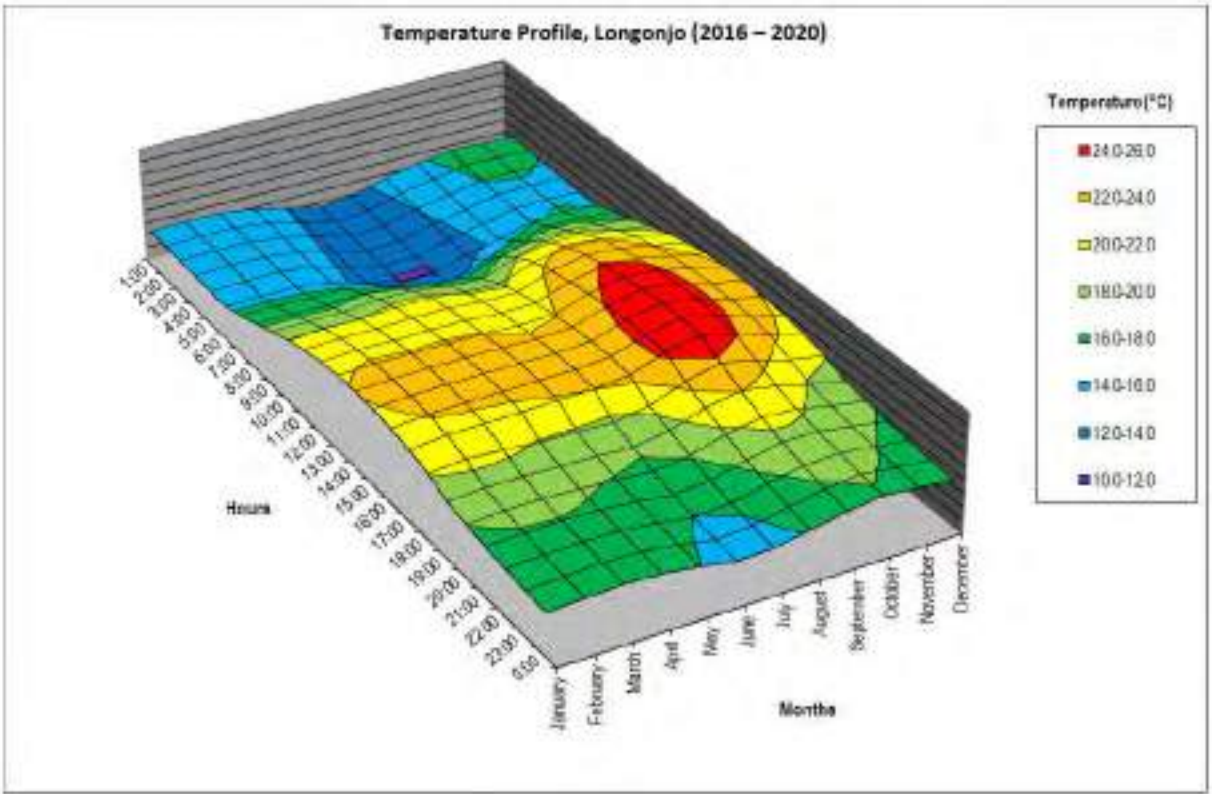


Figure 4-1: Diurnal temperature profile (WRF data, January 2016 to December 2020)

4.2.1.2 Wind

The wind roses comprise 16 spokes, representing the directions from which winds blew during a specific period. The colours used in the wind roses in Figure 4-2 reflect the different wind speeds categories; for example, the yellow area represents winds between 4 and 5 m/s. The dotted circles provide information regarding the frequency of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The period wind field and diurnal variability in the wind field are shown in Figure 4-2. The wind regime for the area is mainly from the south easterly and then from the north westerly sectors. The easterly flow is more dominant during daytime conditions, with southerly and north westerly wind flow more dominant during the night. Calm conditions occurred 12.93 % of the period summarised.

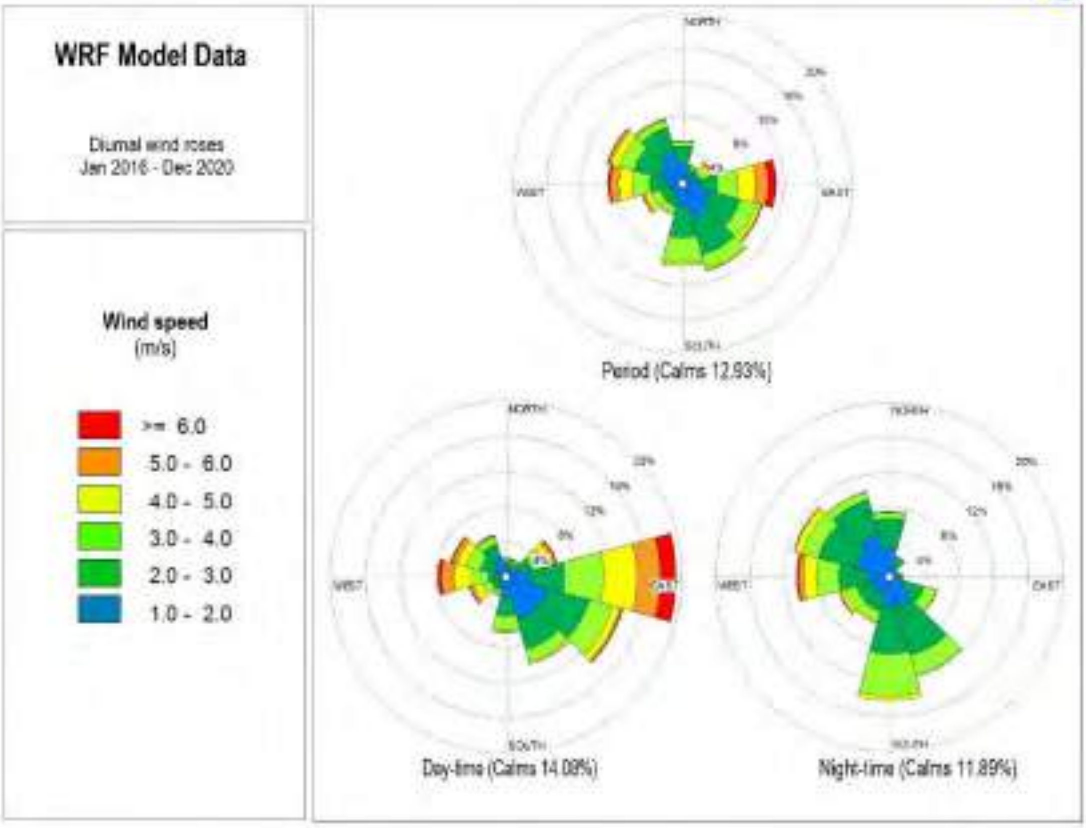


Figure 4-2: Period average, day-time and night-time wind roses (WRF data; 2016 to 2020)

4.2.1.3 Rainfall and humidity

The rainy season starts in October-November and ends in April. The annual average rainfall is around 1,300 mm. The relative humidity is highest in the rainy season and lowest towards the end of the winter months.

Table 4-2: Monthly temperature summary

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Rainfall (mm)	215	164	229	156	20	0	0	2	18	124	216	239
Relative Humidity	67	70.5	70	61	44.5	37	29.5	17.9	40	60.5	69	69.5

Figure 4-3: Rainfall distribution and average rainy days in the Huambo Province.

4.3 Topography

The Project is located on the western side of a basin, with elevation ranges of about 1,300 to just over 1,500 mamsl Figure 4-4. The basin is mainly flat and has an undulating character with few prominent hills, except for the Longonjo carbonatite named "Mount Chimbilundo". More weathering-resistant ridges surround the basin, rising steeply from 1,600 to over 2,500 mamsl. The basin opens up towards the north west with the Cuiva River and drainage channel flowing to the north-west. The slope character of the Project area, shown in Figure 4-5, emphasises the basin's flat nature, with steep rises of over 20° towards the ridges..

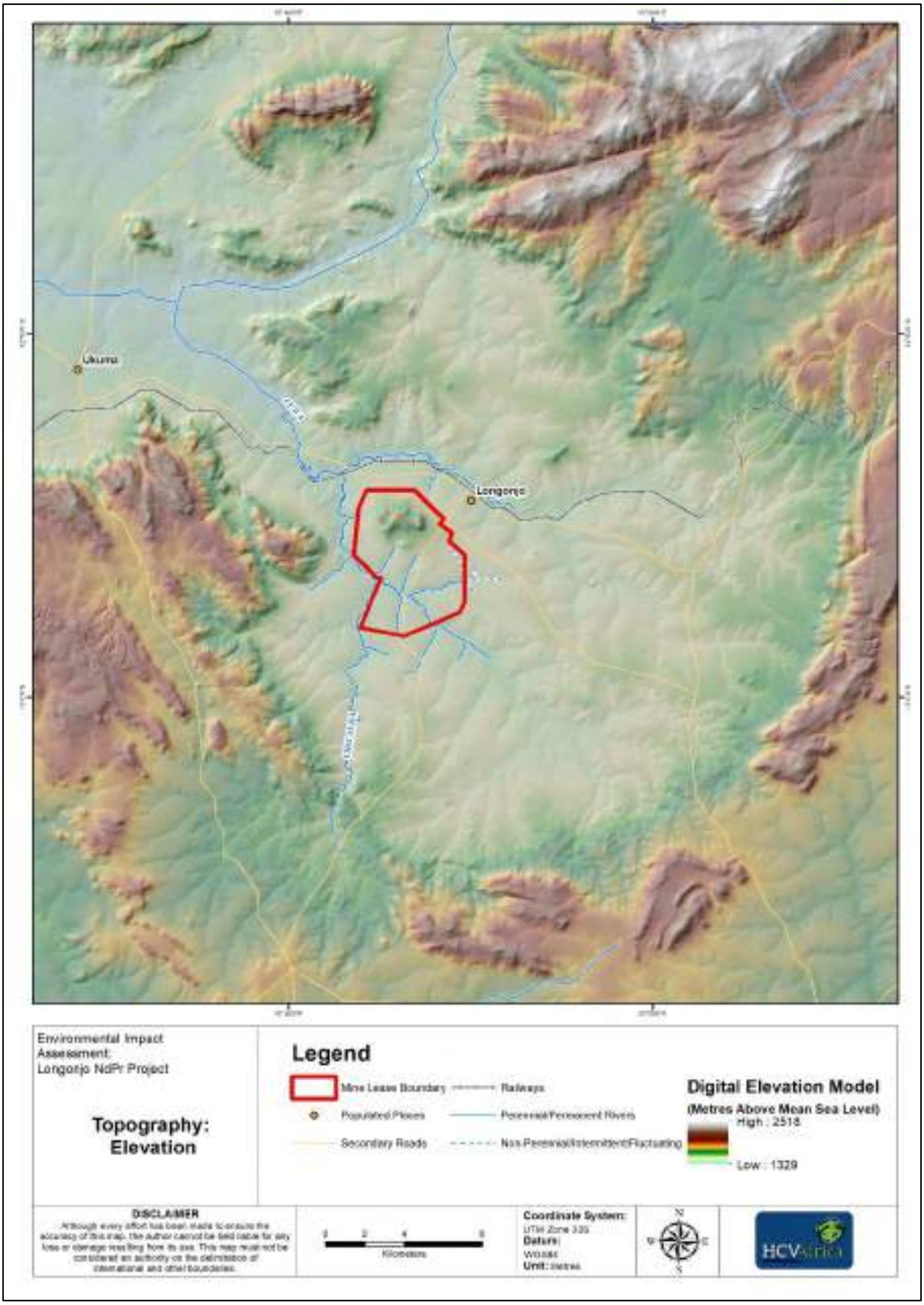


Figure 4-4: Project topography - elevation model

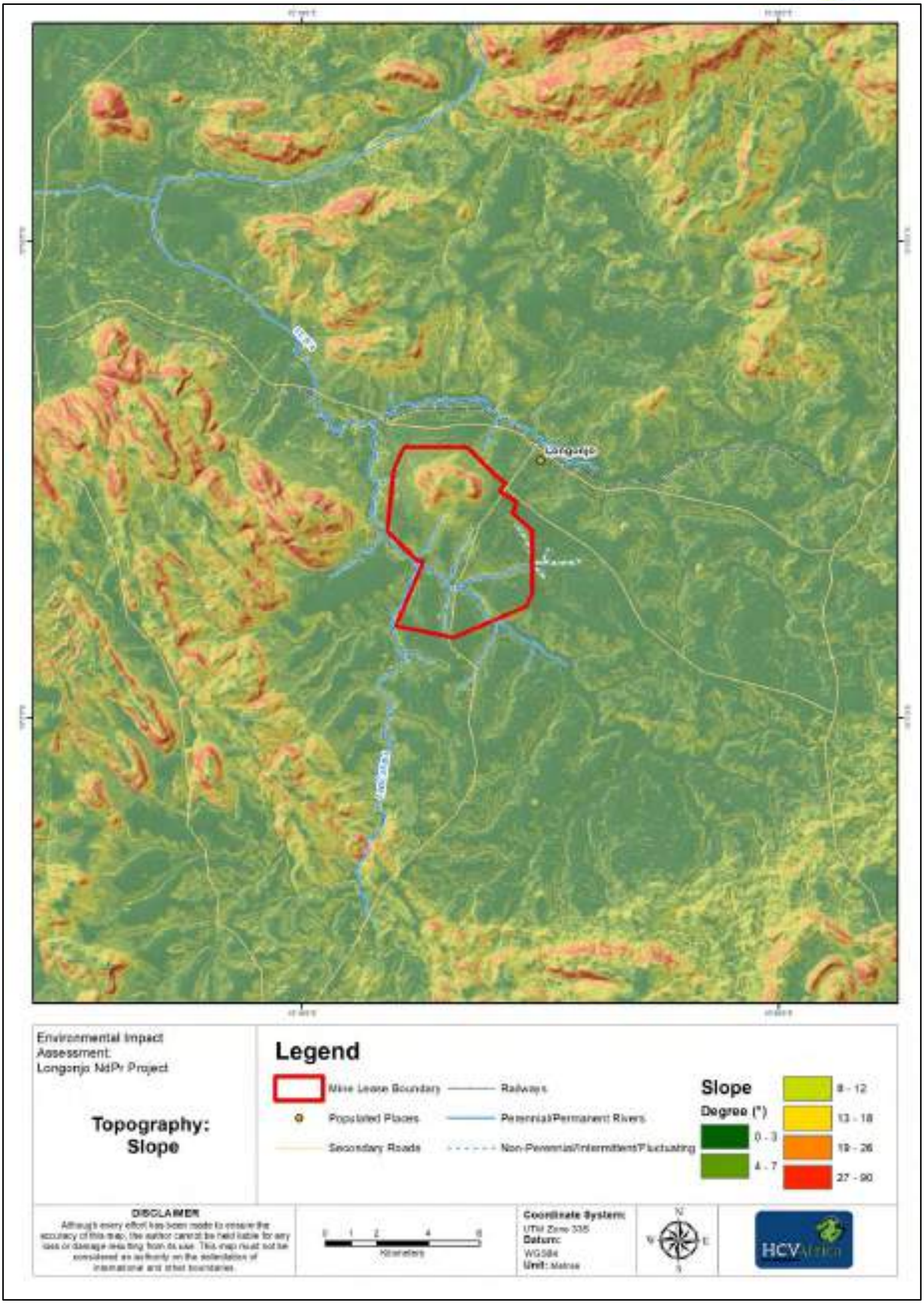


Figure 4-5: The Slope Character of the Study Area

4.4 Air quality

The only current sources of air pollution include wood-burning for domestic purposes such as cooking in local communities, emissions from traffic on the roads and in Longonjo, and dust raised by traffic and agricultural activity. Generally, the air is clear, as is typical of rural areas.

4.4.1 Baseline air quality

Members of the ESIA team collected baseline air quality data in Huambo in 2019, approximately 100km from the Longonjo site, in a similar rural setting. In the absence of any other available baseline air quality data for Angola, this data was used as an indicative baseline.

The baseline data is based on a rapid diffusion tube monitoring programme using *Radiello passive samplers* and *SKC badges.* These types of passive monitoring techniques are suitable for collecting indicative baseline air quality data in situations where there is no safe locality on a remote site to locate sophisticated and expensive monitoring equipment. Data available for Huambo is shown in Table 4-3.

***Radiello passive samplers*[19]**

The Radiello passive sampler comprises a radial diffusive body of porous polypropylene within which a cartridge with adsorbent is placed. The adsorbent bed can consist of a pure adsorbent material or a chemically coated support. Analytes access the adsorbent material throughout the 360° surrounding diffusive barrier/body resulting in a high uptake rate. By radial symmetry, the uptake rates with the same dimensions, Radiello's, are at least three times higher than for any axial diffusive sampler.

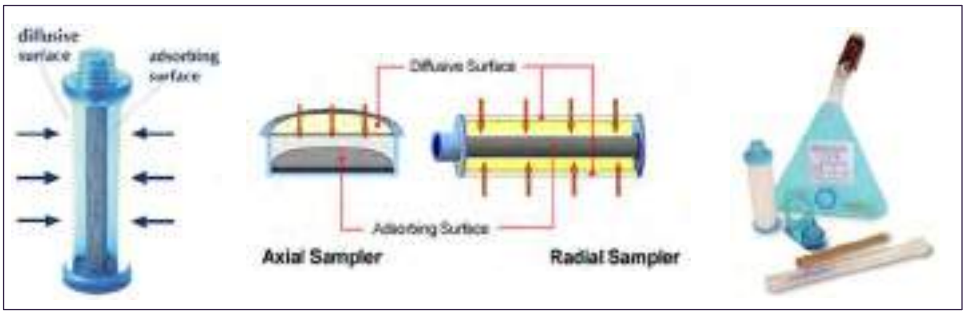


Figure 4-6: Radiello passive sampler for common pollutants

SKC VOC badges*[20] *(575 Series Passive Samplers for Organic Vapours)

Baseline conditions in Volatile Organic Compound (VOC) were confirmed based on passive methods using SKC supplied VOC badges. The SKC VOC badges are validated for 15 minutes and up to 8-hour exposure sampling.

[19] Adapted from https://www.sigmaaldrich.com/technical-documents/articles/analytical/radiello-air-sampler/diffusive-sampling-system.html

[20] Adapted from: https://www.skcinc.com/catalog/pdf/instructions/37088.pdf

Table 4-3: Background concentrations measured in Huambo rural setting

Constituent	Huambo AIRQ1 Sample ID: F-310-L	Huambo AIRQ2 Sample ID: F-311-L	WHO Guideline
	$\mu g/m^3$		
NO_2 Annual	<4,2	<4,6	40
NO_2 1 hour	<2,1	<2,3	200
SO_2 24 hour	<0,4	<0,5	20
SO_2 Annual	<1,5	<1,6	50
SO_2 10 minute	<1,15	<1,32	500

	Sample ID			
	Huambo AIRQ1 SKC0093		Huambo AIRQ2 SKC0845	
Determinant	µg/m3		µg/m3	
Acetone	<	0.112	<	0.123
Pentane	<	0.098		0.152
n-Hexane	<	0.335	<	0.368
Methylethylketone	<	0.132	<	0.145
Ethyl Acetate	<	0.169	<	0.185
Chloroform	<	0.243	<	0.267
1,1,1-Trichloroethane	<	0.218	<	0.240
1,2-Dichloroethane	<	0.264	<	0.290
Isopropyl Acetate	<	0.205	<	0.226
Benzene		0.106		0.270
Cyclohexane		0.228		0.521
Carbon Tetrachloride	<	0.259	<	0.285
Isooctane	<	0.114	<	0.126
Heptane	<	0.176	<	0.193
Trichloroethylene	<	0.202	<	0.222
1,4-Dioxane	<	0.489	<	0.537
Propyl acetate	<	0.120	<	0.132
Methyl Isobutyl Ketone	<	0.122	<	0.134
Toluene		8.187		21.439
Isobutyl Acetate	<	0.184	<	0.203
Tetrachloroethylene	<	0.271	<	0.298
1,2-Dibromoethane	<	0.227	<	0.249
Butyl Acetate	<	0.184	<	0.203
Chlorobenzene	<	0.116	<	0.128
Ethylbenzene	<	0.119	<	0.131
m+p-Xylene	<	0.127	<	0.139

Determinant	Sample ID Huambo AIRQ1 SKC0093 µg/m3		Huambo AIRQ2 SKC0845 µg/m3	
Styrene	<	0.130	<	0.143
o-Xylene	<	0.142	<	0.156
Nonane	<	0.141	<	0.155
Cumene	<	0.121	<	0.133
Propylbenzene	<	0.121	<	0.133
1,3,5-Trimethylbenzene	<	0.136	<	0.149
1,2,4-Trimethylbenzene	<	0.144	<	0.158
Decane	<	0.148	<	0.162
1,2-Dichlorobenzene	<	0.154	<	0.169
Naphthalene	<	0.343	<	0.377
Other Hydrocarbons (HC) found to be present: Positive (Pos) or Negative (Neg)				
Aliphatic HC [SQ57]		Neg		Neg
Aromatic HC [SQ91]		Neg		Neg

4.4.1.1 Dust / particulates

Dispersion of airborne substances (dust[21]) typically occurs where large exposed / disturbed / de-vegetated areas are present. Wind direction data for this study was based on (Weather Research and Forecasting (WRF[22])) data for the period 2016 to 2020 (see Figure 4-2).

In terms of nuisance dust levels, international guidelines[23] recommend that dust deposition levels should not exceed 130-350 mg/m^2/day. The deposition rate of dust is variable depending on ambient meteorological aspects (e.g., wind speed, wind direction). Larger particles are likely to settle closer to the site.

The World Bank published PM2.5 annual ground-level concentrations[24] of 32 µg/m^3 for Angola for 2017.

4.4.1.2 Greenhouse Gasses (GHG)

GHG emission rates for Angola was estimated in 2015 based on data between 1990 and 2011 to be the second highest of the Southern African countries (second only to South Africa) (USAID, 2015). This is largely attributed to the end of the 27-year civil war that ended in 2002. Angola has been repairing and expanding infrastructure to stimulate the economy and address development challenges. The South African Journal of Science[25] published research indicated that actual climatic data trends revealed a more significant change in the Southern African region south of Angola. Supports projections of NGOs regarding climate change trends, albeit not as severe as modelled.

Angola is highly dependent on the oil and gas sector, but this is also the largest contributor to GHG emissions. The GHG emission trends for Angola are summarised in Table 4-3 and the Angolan emissions profile in Table 4-5.

[21] Particulate Matter (PM) can result from various sources, including natural and human-induced (anthropogenic). The ISO Standard 4226:1993 (Air quality - General aspects - Units of measurement) uses the common term 'dust' to describe particulates with a diameter of between 1 µm and 75 µm. Nuisance dust is normally caused by dust particulates >10 µm (defined as PM_{10}). PM2.5 represents the fraction of particulates that pose health effects as it can enter the lung alveoli where gas exchange may be affected.

[22] WRF Model is a next-generation mesoscale numerical weather prediction system designed for atmospheric research and operational forecasting applications. WRF can produce simulations based on actual atmospheric conditions (i.e., observations and analyses) or idealized conditions. WRF offers operational forecasting a flexible and computationally-efficient platform while reflecting recent advances in physics, numerics, and data assimilation contributed by developers from the expansive research community.

[23] Federal Ministry for Environment, Nature Conservation and Nuclear Safety (2002). Technical Instructions on Air Quality Control – TA Luft

[24] https://data.worldbank.org/indicator/EN.ATM.PM25.MC.M3

[25] Jury MR. Climate trends in southern Africa. S Afr J Sci. 2013;109(1/2), Art. #980, 11 pages. http://dx.doi.org/10.1590/ sajs.2013/980

Table 4-4: GHG trends for Angola (1990 – 2011[26]) (USAID, 2015)

Statistic relevant to GHG	Magnitude
Total GHG Emissions ($MtCO_2e$)[27]	206
% of global emissions	0.44%
Population	20,180,000
tCO_2e per capita	10.22
GDP (US$)[28]	$52 billion
tCO2e/ million US$ GDP	3.941
Change in GHG emissions (1990–2011) ($MtCO_2e$)	+101 (96% increase)

[26] World Resources Institute Climate Analysis Indicators Tool (WRI CAIT) 2.0, 2015. Emissions including Land-Use Change and Forestry

[27] Million metric tons of carbon dioxide equivalent

[28] Gross Domestic Product (GDP) in constant 2005 US$

Table 4-5: Angolan GHG emission sources profile

GHG Emissions Sources[1]	Unit	Available Years	Latest Value	Per Capita	Absolute Change from Earliest to Latest Value
Total GHG Emissions Excluding Land-Use Change and Forestry	$MtCO_2e$	1990-2014	157.82	5.86 tCO_2e	202.21%
Total GHG Emissions Including Land-Use Change and Forestry	$MtCO_2e$	1990-2014	252.09	9.36 tCO_2e	57.25%
GHG Emissions by Gas (excluding LUCF) Sources	**Unit**	**Available Years**	**Latest Value**	**Per Capita**	**Absolute Change from Earliest to Latest Value**
Total CO_2 (excluding Land-Use Change and Forestry)	$MtCO_2$	1990-2014	33.29	1.24 tCO_2	424.63%
Total CH_4	$MtCO_2e$	1990-2014	107.63	4.00 tCO_2e	247.73%
Total N_2O	$MtCO_2e$	1990-2014	16.75	0.62 tCO_2e	12.27%
Total F-Gas	$MtCO_2e$	1990-2014	0.14	0.01 tCO_2e	6799.16%
GHG Emissions by Gas (Including LUCF) Sources	**Unit**	**Available Years**	**Latest Value**	**Per Capita**	**Absolute Change from Earliest to Latest Value**
Total CO_2 (including Land-Use Change and Forestry)	$MtCO_2$	1990-2014	107.26	3.98 tCO_2	19.53%
Total CH_4 (including Land-Use Change and Forestry)	$MtCO_2e$	1990-2014	123.85	4.60 tCO_2e	144.14%
Total N_2O (including Land-Use Change and Forestry)	$MtCO_2e$	1990-2014	20.84	0.77 tCO_2e	4.99%
GHG Emissions by Sector Sources	**Unit**	**Available Years**	**Latest Value**	**Per Capita**	**Absolute Change from Earliest to Latest Value**
Energy	$MtCO_2e$	1990-2014	124.54	4.63 tCO_2e	396.31%
Industrial Processes	$MtCO_2e$	1990-2014	1.39	0.05 tCO_2e	964.49%
Agriculture	$MtCO_2e$	1990-2014	29.58	1.10 tCO_2e	11.72%
Waste	$MtCO_2e$	1990-2014	2.3	0.09 tCO_2e	346.81%
Land-Use Change and Forestry	$MtCO_2$	1990-2014	94.28	3.50 tCO_2	-12.78%
Bunker Fuels	$MtCO_2$	1990-2014	1.87	0.07 tCO_2	76.42%
GHG Emissions - Energy Sub-Sector Sources	**Unit**	**Available Years**	**Latest Value**	**Per Capita**	**Absolute Change from Earliest to Latest Value**
Electricity/Heat	$MtCO_2$	1990-2014	3.7	0.14 tCO_2	670.83%
Manufacturing/Construction	$MtCO_2$	1990-2014	1.5	0.06 tCO_2	-14.77%
Transportation	$MtCO_2$	1990-2014	8.49	0.32 tCO_2	732.35%
Other Fuel Combustion	$MtCO_2e$	1990-2014	7.31	0.27 tCO_2e	355.46%
Fugitive Emissions	$MtCO_2e$	1990-2014	103.55	3.85 tCO_2e	411.85%
CO_2 Emissions Totals Sources	**Unit**	**Available Years**	**Latest Value**	**Per Capita**	**Absolute Change from Earliest to Latest Value**
Total CO_2 Emissions Excluding Land-Use Change and Forestry	$MtCO_2$	1950-2014	33.29	1.24 tCO_2	18072.71%
Socio-economic Data Sources	**Unit**	**Available Years**	**Latest Value**	**Per Capita**	**Absolute Change from Earliest to Latest Value**
Population	People	1960-2014	26,920,466	n/a	377.04%
GDP-PPP	Million Intl$ (2011)	1990-2014	168,526	6,260 Intl$ (2011)	215.09%
GDP-USD	Million US$ (2010)	1985-2014	100,886	3,748 Million US$ (2010)	269.44%

[1] Source: https://cait.wri.org/profile/Angola

4.4.2 Sensitive Receptors

Ambient international air quality guidelines are based on human exposure to specific criteria pollutants, and as such, possible sensitive receptors were identified where the public is likely to be exposed. As a result, several sensitive receptors were identified in the Project area (Figure 4-7 and Table 4-6). These sensitive receptors are small residential communities and individual residences in the vicinity of the Project.

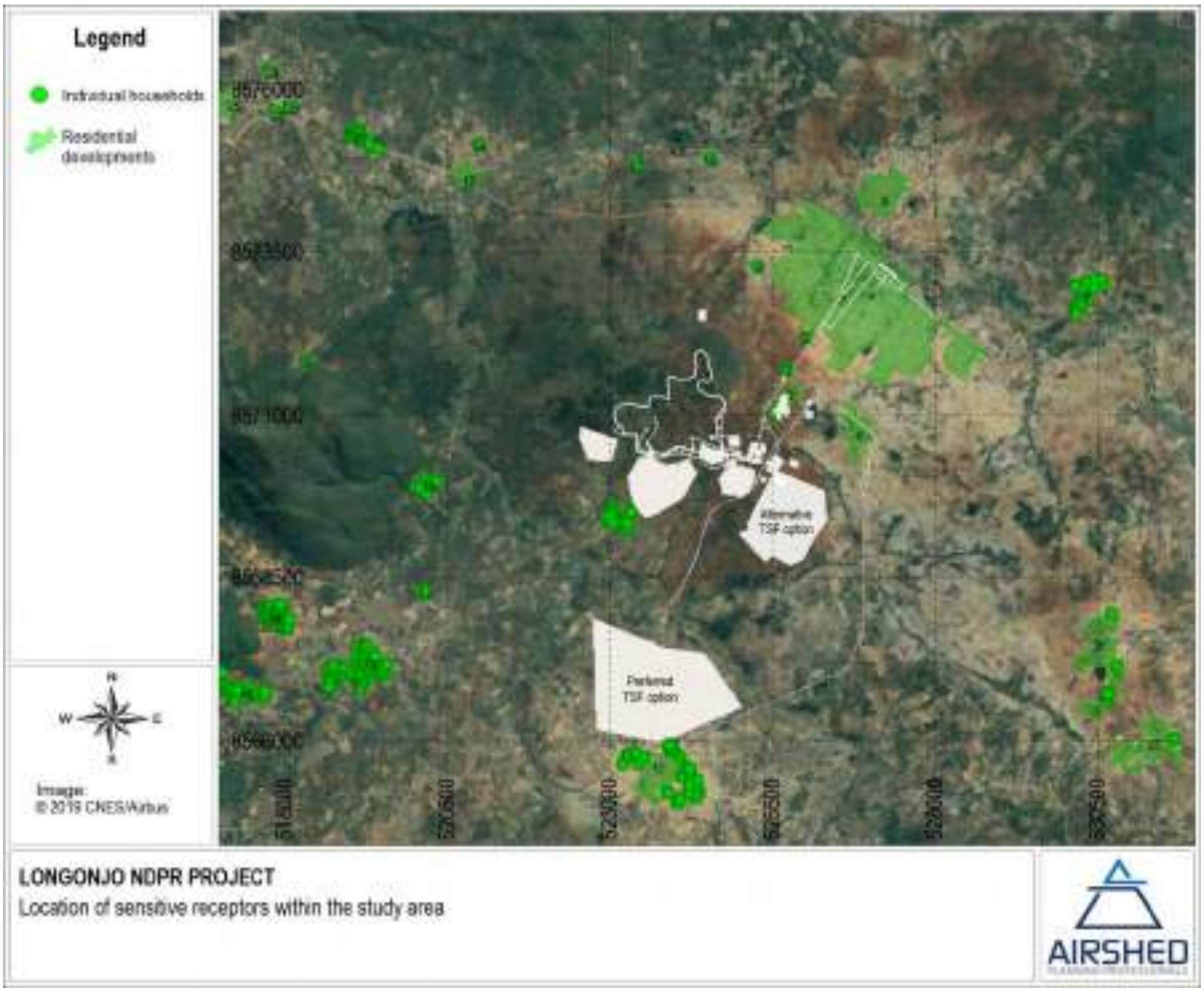


Figure 4-7: Location of potentially sensitive receptors in relation to the Project

Table 4-6: Description of potentially sensitive receptors in the Project area

Receptor	Description
R1	Tchakengenga
R2	Permanent Camp
R3	Individual households
R4	Lumingo
R5	Individual households
R6	Individual households
R7	Longonjo
R8	
R9	
R10	Tena/Cisto
R11	Individual households
R12	Lucamba
R13	Catocola
R14	Rafael
R15	Chingongo
R16	Individual households
R17	Individual households
R18	Individual households
R19	Chianga
R20	Individual households
R21	Chianga
R22	Individual households
R23	Individual households
R24	Individual households
R25	Centro Chenga
R26	
R27	

4.5 Geology

The geology of Angola includes large areas of Precambrian age formations and can be divided into five regional geological units.

The foundation of the Central Plateau is a vast slab of igneous granitic crystalline rock that frequently outcrops in the form of isolated rocks or massive peaks. The most prominent peak in the province is Mt. Môco in Londuimbali, with 2,620m, the highest point in Angola. The headwaters of the Kunene River rise on the Central Plateau near Huambo town. Much of the soil in Huambo Province is of poor quality and has been impoverished over many areas by overuse and erosion.

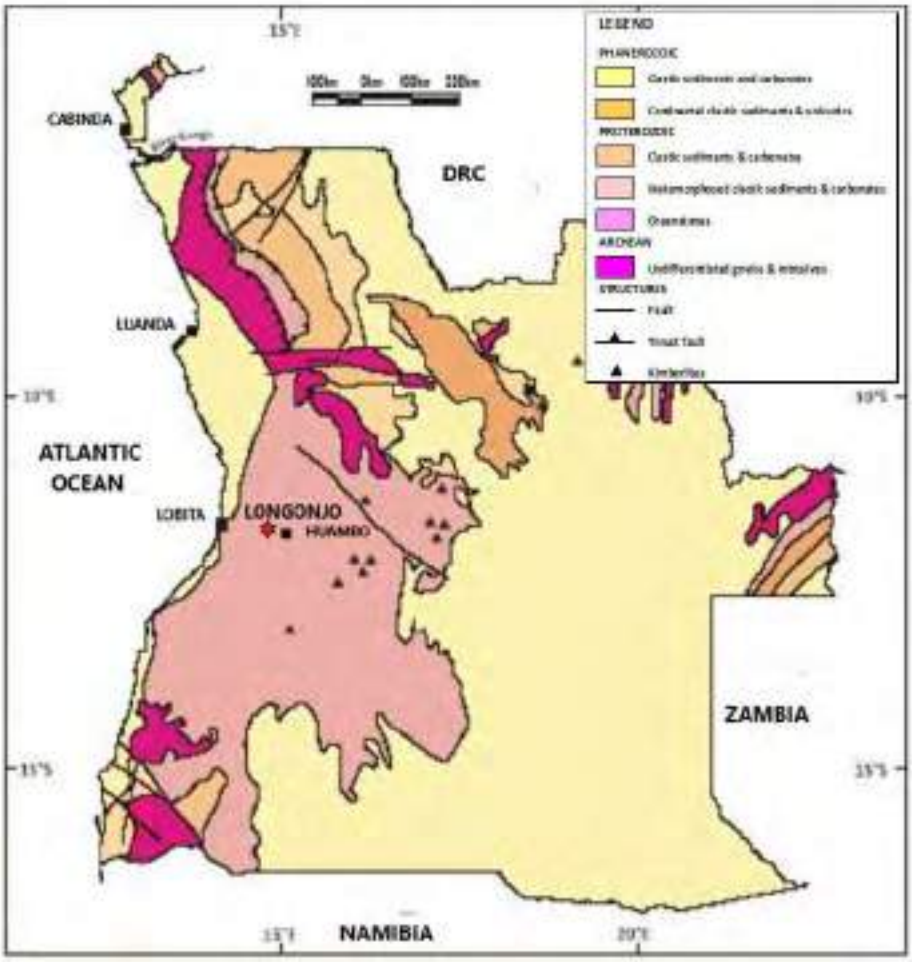


Figure 4-8: Simplified geology of Angola[30], with Longonjo Project located just west of Huambo.

The geology of Angola includes large areas of Precambrian age rocks, with the west of the country being characterized by meta-sedimentary rocks of the Proterozoic age, including tillites. Overlying these are a thick pile of limestones and other marine sediments laid down during the Mesozoic and Cenozoic eras.

In between these Proterozoic sequences are gneiss and granitic crystalline basement areas dating from the Archaean. In addition, carbonatites and kimberlite pipes resulting from magmatic activity during the Karoo period are found along a northeast-southwest line through Angola.

More recent continental sediments of the Kalahari Group are widespread in eastern Angola, while Mesozoic sediments deposited in Angola are rich fossil vertebrates, mainly marine reptiles. Economically, Angola's income is derived mainly from oil production, and it is also the fourth-largest producer of diamonds in Africa. Diamonds are obtained both from alluvial deposits and from the hundreds of kimberlite pipes scattered along a north east – south west line through Angola. The country is also a gold producer, the essential source being alluvium originating from Archaean greenstones predominantly located around Cabinda. Angola also has, largely untapped copper, gypsum, phosphate, iron ore, manganese and other base metal reserves.

4.5.1 Local geology and lithology

Geomorphologically, the Project is located roughly in the middle of a carbonatite plug or diatreme, which forms the local topographic high point or hill. Much of the softer carbonatite material has been eroded in the middle of the diatreme, leaving the metamorphosed Fenite ring as a prominent ring of hills surrounding the carbonatite or ore body. Fenite is the harder granitic material that was altered during the explosive emplacement of the

30 United Nations, 1989. *Groundwater in Eastern, Central and Southern Africa: Angola.*

diatreme, and outside this ring of harder material, the softer crystalline granites and gneisses are found forming the extensive lowland plains surrounding the ring of hills.

The central soft carbonatite core weathers to a maximum depth of about 30m and contain abundant calcium carbonate. As a result, some of this material is dissolved away by water leaving a carstic type terrain behind that includes some minor caves, solution cavities and hardrock pinnacles in the soft, weathered matrix. In addition, fault or fracture zones create conduits for surface and groundwater, along which increased dissolution of the carbonatites occur, leaving behind long linear valleys in the landscape.

Beyond the ring of resistant fenite hills, drainage takes place from this feature away to the lowlands and into the two major rivers draining the Longonjo region. Some springs are present on the flanks of these hills, where thick sequences of laterite are found. This material is porous and stores reasonable volumes of shallow groundwater.

NdPr rare earth mineralisation is particularly enriched in the weathered zone of the carbonatite and associated colluvium. Weathering processes have removed the original carbonate minerals, leaving behind a residually enriched, ferruginous mineralised zone. Mineralisation also occurs in fresh rock within a north-south orientated central zone and peripheral ring dykes.

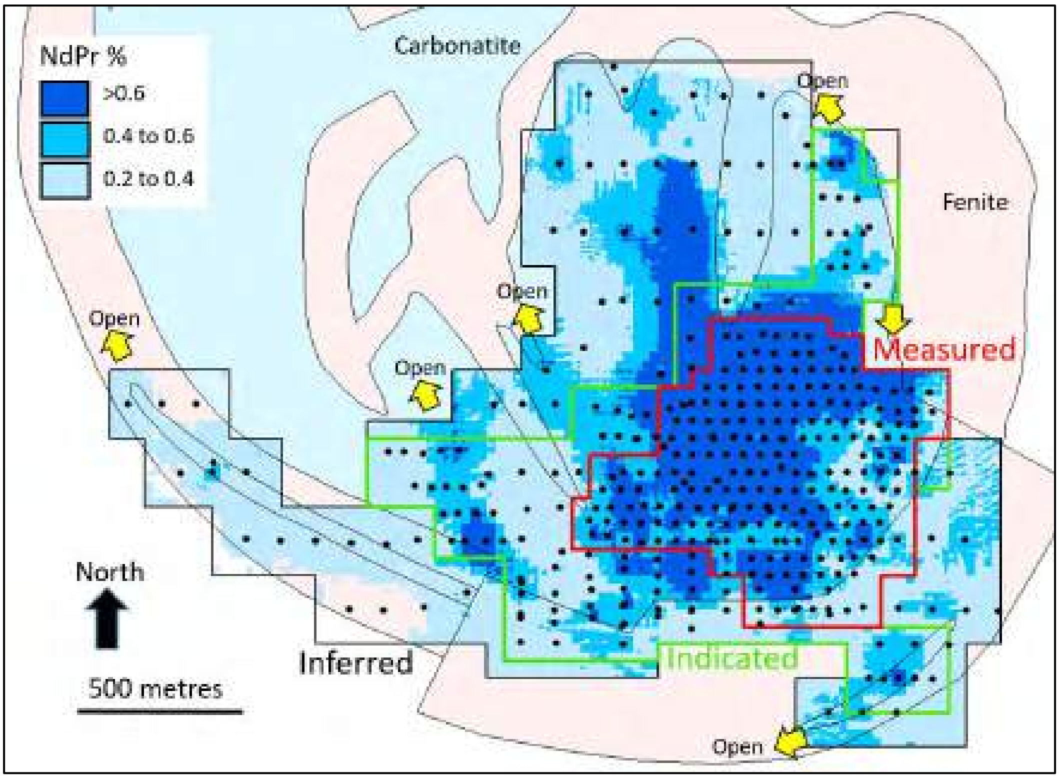


Figure 4-7: Plan view of the Mineral Resource block model for the weathered zone coloured by average NdPr grade over simplified geology of the Longonjo carbonatite. Resource categories highlighted

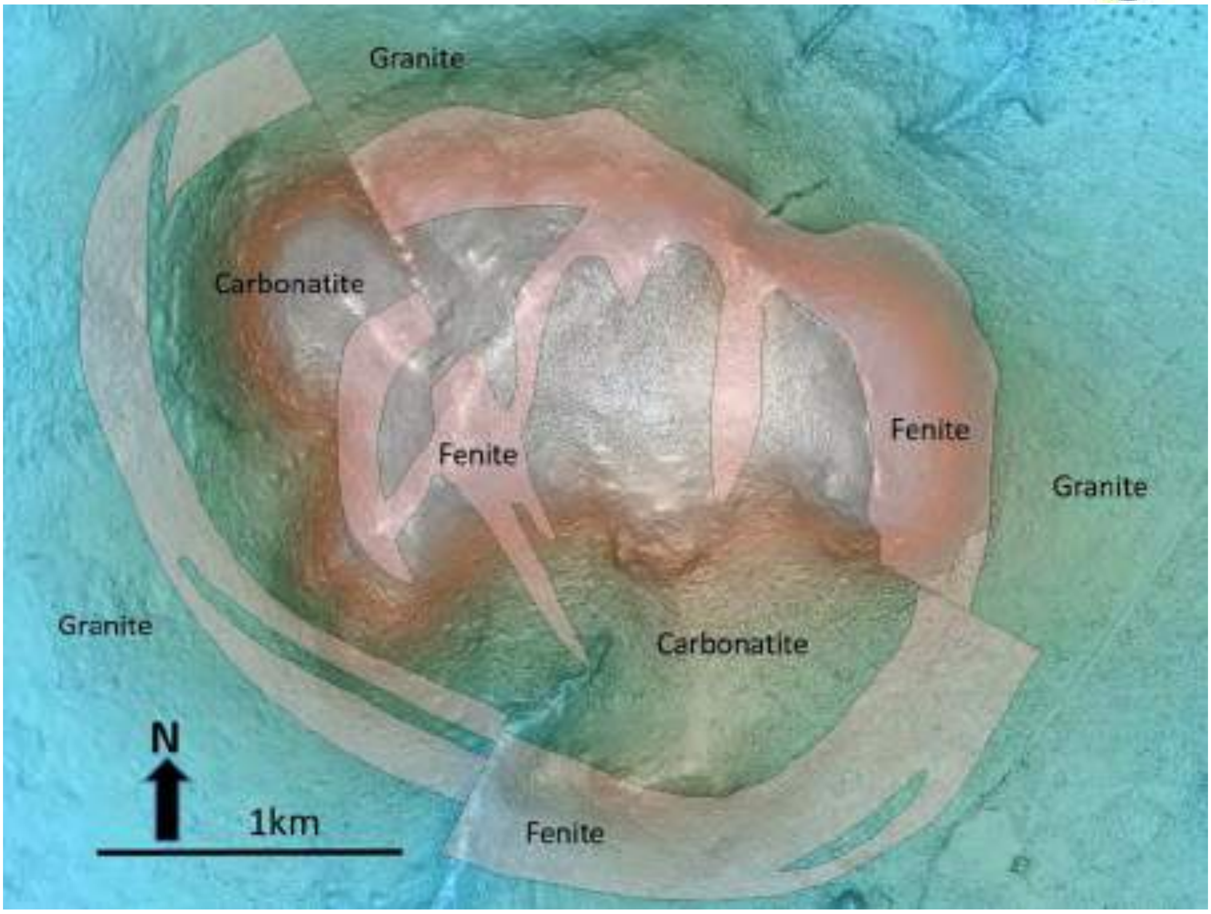


Figure 4-9: Circular Longonjo carbonatite and associated fenite rim over topographic image. The northern portion of the carbonatite is topographically elevated.

Natural weathering processes have removed the original carbonate minerals in the weathered zone through dissolution, thereby enriching the NdPr rare earth minerals left behind. The weathered zone and associated veneer of locally transported soil and gravel typically ranges between 20 to 30 metres in thickness but reaches 70 metres in some areas. Rare earth minerals in the weathered zone are predominantly monazite, with some bastnaesite occurring in peripheral areas.

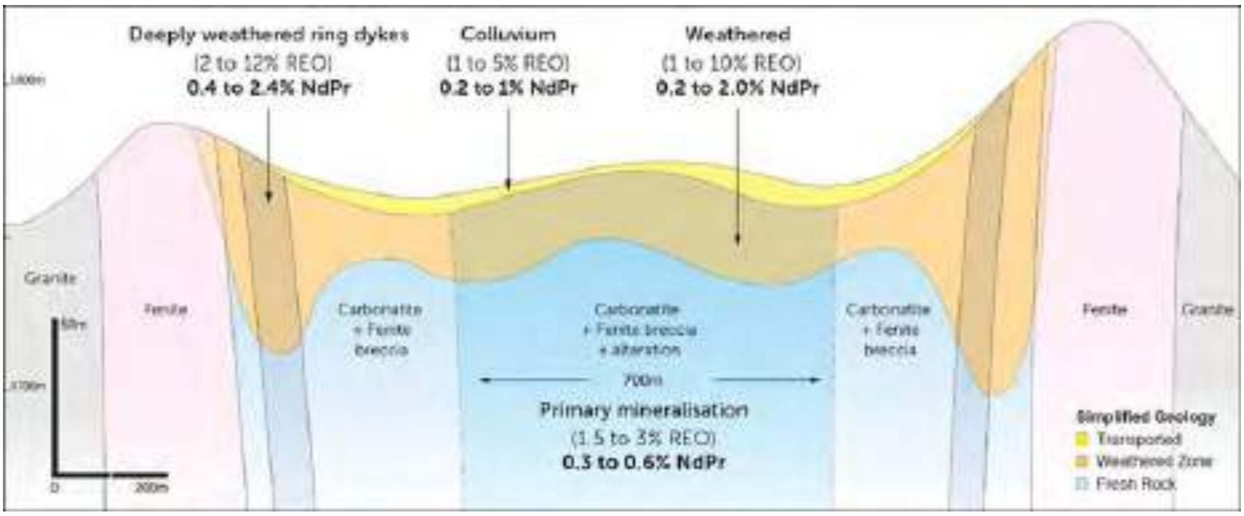


Figure 4-10: Schematic geological cross section across the Longonjo carbonatite showing the styles and typical grades of NdPr mineralisation (Note vertically exaggerated scale)

4.5.2 NORM – Naturally Occurring Radioactive Materials

Naturally occurring radionuclides such as uranium (U), thorium (Th) and radium (Ra) are often associated with rare earth deposits, such as those to be mined at the Longonjo mine. Therefore, the natural geology contains naturally occurring radionuclides, generally referred to as naturally occurring radioactive material or NORM. It should be noted that the NORM naturally present in the geology of the Project area is in the same physical form as they were initially billions of years ago (i.e. they do not leach). Therefore, anthropogenic activities (e.g. mining) that exploit rare earth deposits can generate radioactive material in the form of mining and processing residue.

4.5.2.1 U and Th host minerals

QEMSCAM data from mineralogical tests conducted by ALS Laboratories, Brisbane, Perth, shows that 94% of Thorium is contained in the rare-earth mineral monazite (Table 4-8).

Table 4-8: Thorium host minerals within the weathered zone NdPr mineralisation at Longonjo

Mineral	Rhabdophane-(Ce)	Rhabdophane-(La)	Goyazite	Crandallite	Bastnasite-(Nd)	Others
Gravel-N	92.54	6.00	0.00	0.00	1.12	0.34
Gravel-S	93.26	4.38	0.00	0.00	1.89	0.47
LJD002	99.98	0.00	0.00	0.00	0.00	0.02
LRC001	93.38	3.22	0.00	0.00	2.34	1.07
LRC003	97.49	0.00	0.00	0.00	0.00	2.51
LRC006	86.26	2.60	7.69	2.22	0.00	1.24
LRC007	87.87	3.59	6.96	1.42	0.00	0.16
LRC055	92.17	1.27	2.57	3.73	0.00	0.25
LRC057	96.03	3.34	0.00	0.00	0.51	0.12
LRC089	94.58	3.88	0.00	0.00	1.44	0.11
LRC119	78.63	3.12	7.64	10.28	0.00	0.33
LRC128	85.74	2.58	7.21	2.74	1.44	0.28
LRC131	84.12	0.68	3.46	3.49	6.76	1.49
LRC146	86.12	5.27	6.27	2.04	0.00	0.30
LRC158	84.13	8.38	3.00	4.10	0.00	0.38
LRC161	86.82	11.62	0.28	0.23	0.00	1.05
LRC171	89.04	4.43	2.34	1.06	0.00	3.13
Average	**89.89**	**3.79**	**2.79**	**1.84**	**0.91**	
Minimum	**78.63**	**0.00**	**0.00**	**0.00**	**0.00**	
Maximum	**99.98**	**11.62**	**7.69**	**10.28**	**6.76**	

*Thorium host minerals within the main weathered Monazite Zone. * Other minerals that may occur in proportions over 1% include: bastnaesite-(Ce)*

Uranium occurs in very low levels and has not been mapped by the mineralogical host using QEMSCAN. Statistical analysis suggests an association with phosphorous and rare earths, indicating apatite and monazite as possible main host minerals to the very low levels of uranium that can be detected at Longonjo.

4.5.2.2 U and Th in Soils

Although a complete radiation baseline survey has not been conducted to date, systematic soil sampling was completed over the Longonjo Carbonatite. Samples were analysed for a suite of elements including Th and U by four acids ICP-MS. Results illustrate the distribution and levels of U and Th as naturally occurring in the Project area and are shown in four acids geology (Figure 4-11 and Figure 4-12), where naturally occurring U and Th are expressed in oxide form (U_3O_8 and ThO_2). Drilling information and geological mapping thus indicate that more elevated natural levels of U and Th occur in iron-rich soils over the more strongly weathered carbonatite.

4.5.2.3 U and Th during the life of mine

The near-surface weathered rare earth mineralisation at Longonjo focuses on initial mining and will form the feed to the processing plant. Based on the Mineral Resource block model, the weathered material ("ore") that will be treated during the first 9-year LOM shows that average U_3O_8 and ThO_2 levels are 32ppm and 1,031ppm, respectively (Figure 4-13 and Figure 4-14). Remainder of the life of mine is expected to be in the same range but to be determined. As shown in Levels of U and Th are relatively more elevated in weathered, iron-rich near-surface zone rock types and pisolithic gravels in some areas of the carbonatite. However, levels reduce with depth into fresh rock, and the average composition of the feed, is presented in Table 4-9 compared with some other global rare earth deposits.

Table 4-9, the U content of the Longonjo ore is amongst the lowest of global rare earth deposits.

Thorium values are higher and are generally concentrated in the northern parts of the carbonatite, with lower values in the southern main rare earth zone.

The shallow open pit mining will enable ore sources from different areas of the deposit to be sourced simultaneously and blended to manage the thorium levels to a consistent average through the plant.

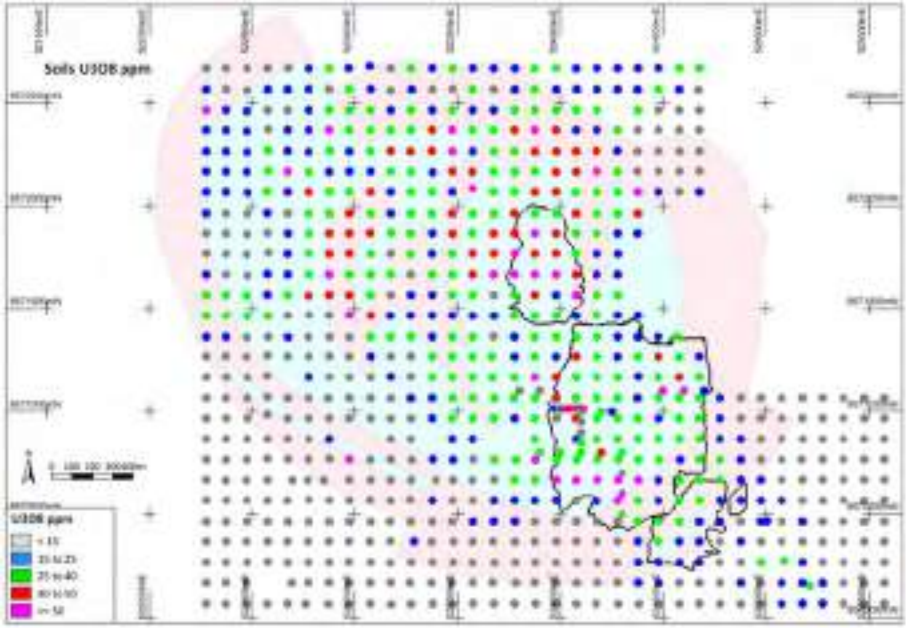


Figure 4-11: Uranium oxide in soils distribution over simplified geology of the Longonjo carbonatite

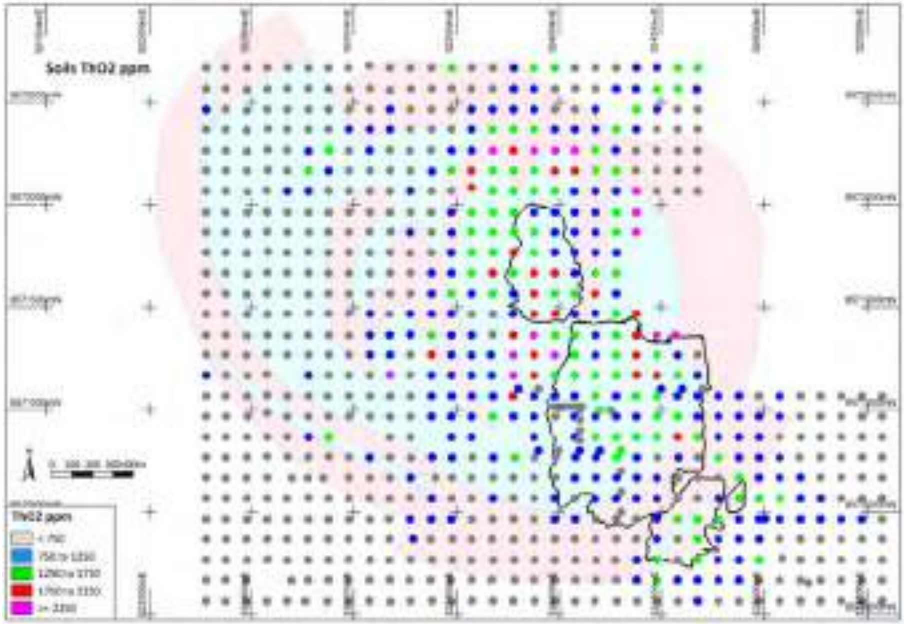
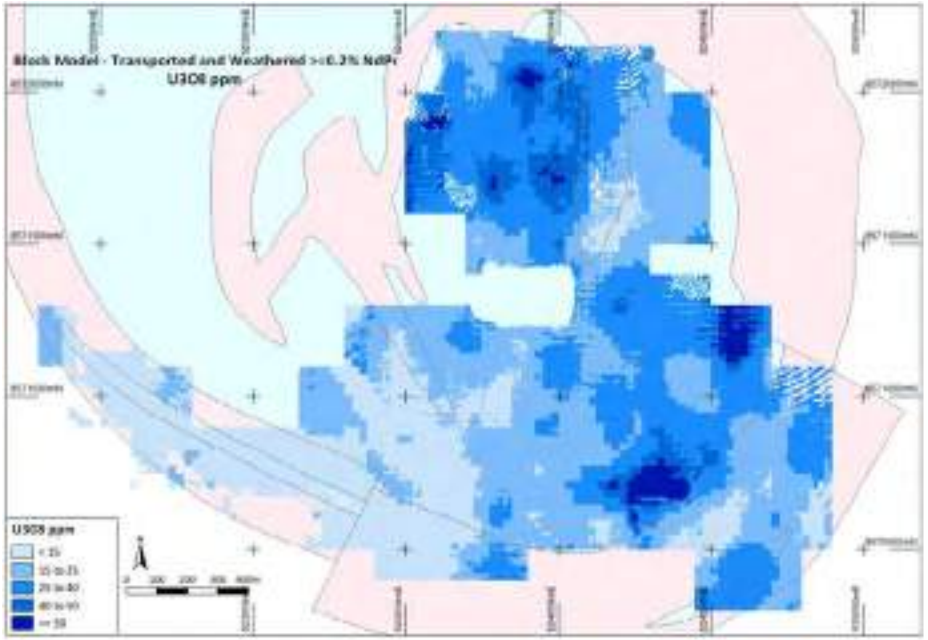


Figure 4-12: Thorium oxide in soils distribution over simplified geology of the Longonjo carbonatite



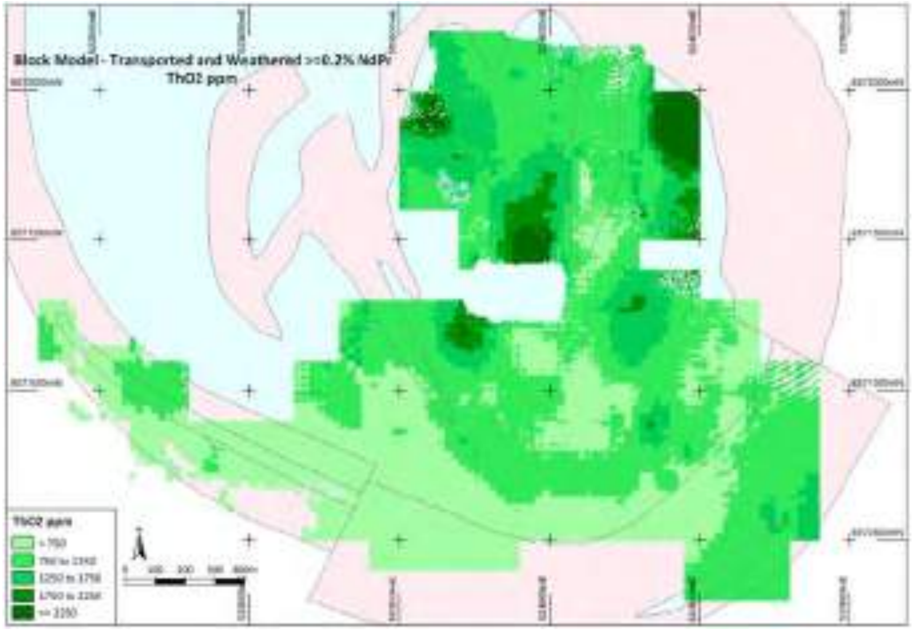


Figure 4-13: Average uranium oxide in weathered NdPr mineralisation above 0.2% NdPr over simplified geology of the Longonjo Carbonatite

Figure 4-14: Average thorium oxide in weathered NdPr mineralisation above 0.2% NdPr over simplified geology of the Longonjo Carbonatite

Levels of U and Th are relatively more elevated in weathered, iron-rich near-surface zone rock types and pisolithic gravels in some areas of the carbonatite. However, levels reduce with depth into fresh rock, and the average composition of the feed, is presented in Table 4-9 compared with some other global rare earth deposits.

Table 4-9: Comparison of U and Th activity concentrations for various rare earth projects

Project	ROM ore	Total Bq/g
Mt Weld, WA	660 ppm Th (2.64 BqTh/g) 35 ppm U (0.44 BqU/g)	3.08
Mountain Pass, USA	200 ppm Th (0.8 BqTh/g) 20 ppm U (0.25 BqU/g)	1.05
Nolans Bore, Northern Territory, Australia	5,000 ppmTh (20 BqTh/g) 200 ppm U (2.5 BqU/g)	22.5
Kvanefjeld, Greenland	620 ppmTh (2.5 BqTh/g) 260 ppmU (3.25 BqU/g)	5.75
Browns Range, Western Australia	35 ppmTh (0.14 BqTh/g) 50 ppmU (0.62 BqU/g)	0.76
Longonjo, Angola	ca 906 ppm Th (3.67 BqTh/g) 27 ppm U (0.33 BqU/g)	4.00

The above are 'Head-of-Chain' activities of U238 and Th232, worked based on 80 ppm U = 1 BqU238/g, and 250 ppm Th = 1 BqTh232/g.

For comparison, U in ordinary soils worldwide averages about 3 ppm and Th about 10ppm (UNSCEAR 1993); however, U *ores* range from ca 300 ppm up to >10,000 ppm U.

Although levels of U and Th are low, Pensana will implement management measures as discussed in Section 8.

4.6 Hydrology

The Project is located in the Catumbela River Basin (Figure 4-15), the fourth largest river catchment of the Atlantic draining watercourses originating in Angolan Territory (Matos, 2007). The Catumbela River Basin is divided into nine sub-basins; the Project is located in the Upper Cuiva River sub-basin. The primary water bodies associated with the Project are unnamed perennial streams and drainage lines which are tributaries of the Luluvila and Cuiva Rivers. The Project is located on the watershed between the Luluvila River to the south and the Cuiva River to the north. Flood events are unimodal in the watercourses are associated with the annual increase in precipitation between December and March.

4.6.1 Geomorphological Setting

The Project is located in the coastal river systems that drain the central Angolan highlands. These systems flow rapidly westwards over a steep escarpment to the Atlantic Ocean. The longitudinal profile of the upper Cuiva catchment is steep (Figure 4-16). Short high peak flow flood events are anticipated in the catchment given the steep gradients. These watercourses are typically short, highly erosive and carry large sediment loads (Huntley, 2019).

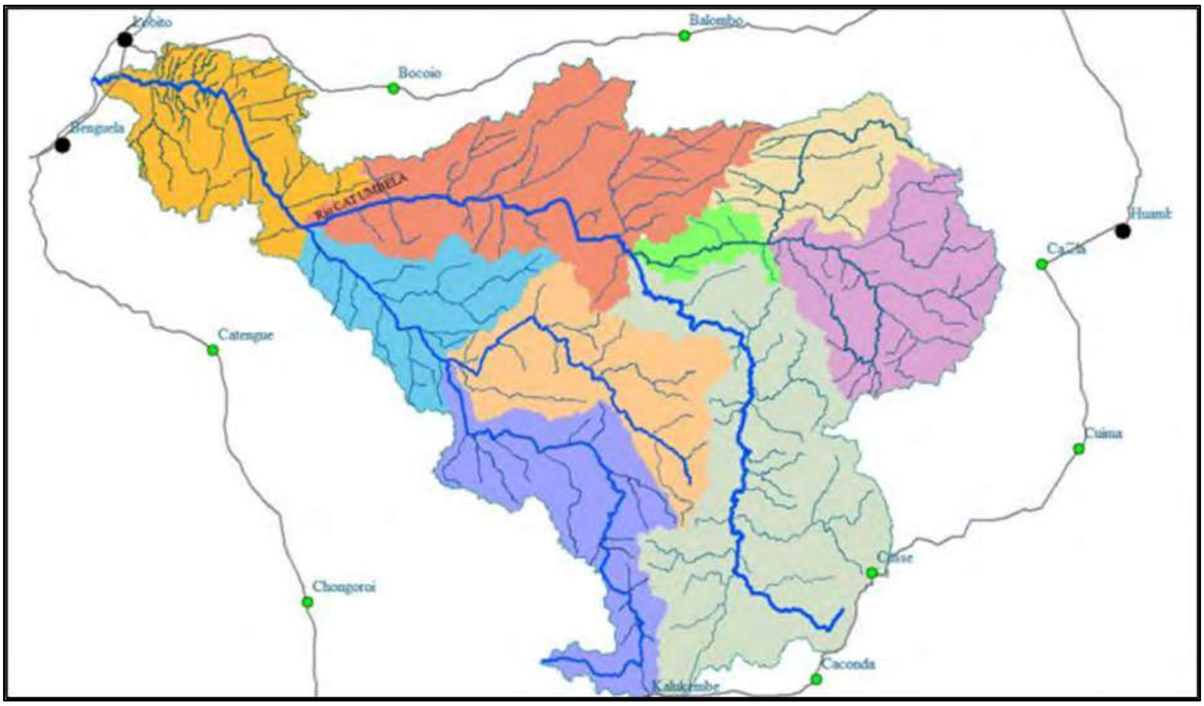


Figure 4-15: The Catumbela River Basin (Matos, 2017)

The perennial streams enter into the 6th order reach of the Luluvila River and the similarly sized 5th order stream of the Cuiva River. The catchment areas of the watercourses were determined to be approximately 652 km^2 for the Luluvila River, including that of the Cuiva River, and 373 km^2 for the Cuiva River.

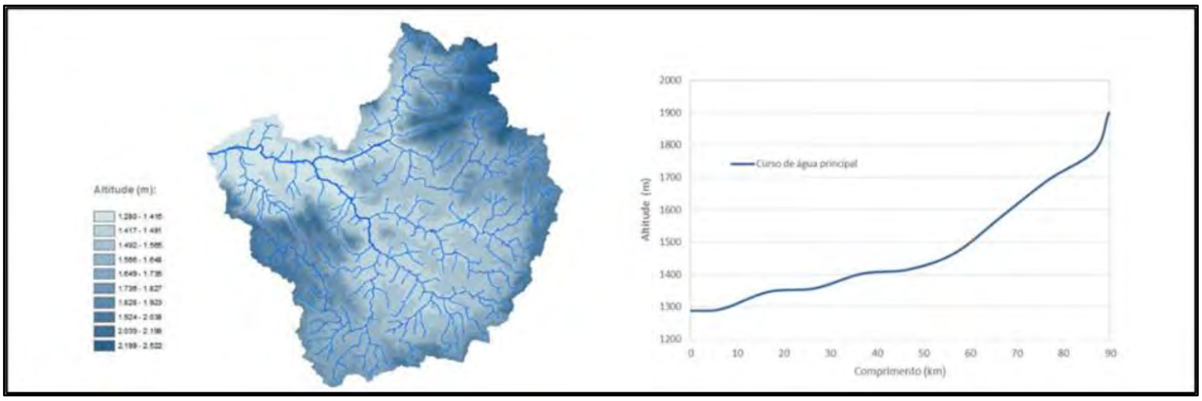


Figure 4-16: Digital Elevation of the Upper Cuiva Catchment and its longitudinal Profile (Matos, 2017)

The watersheds / catchments relevant to the Project are presented in Figure 4-17 and Figure 4-18.

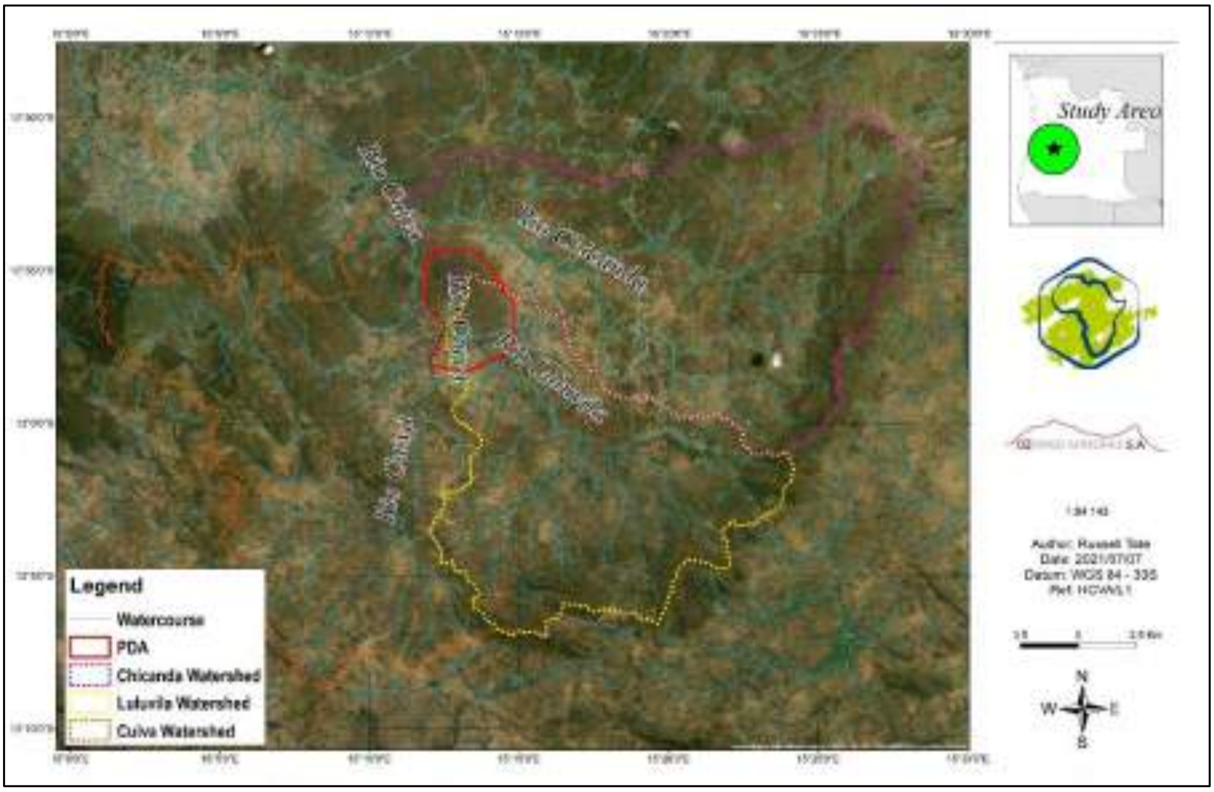


Figure 4-17: Local hydrological setting of the Project showing relevant watersheds

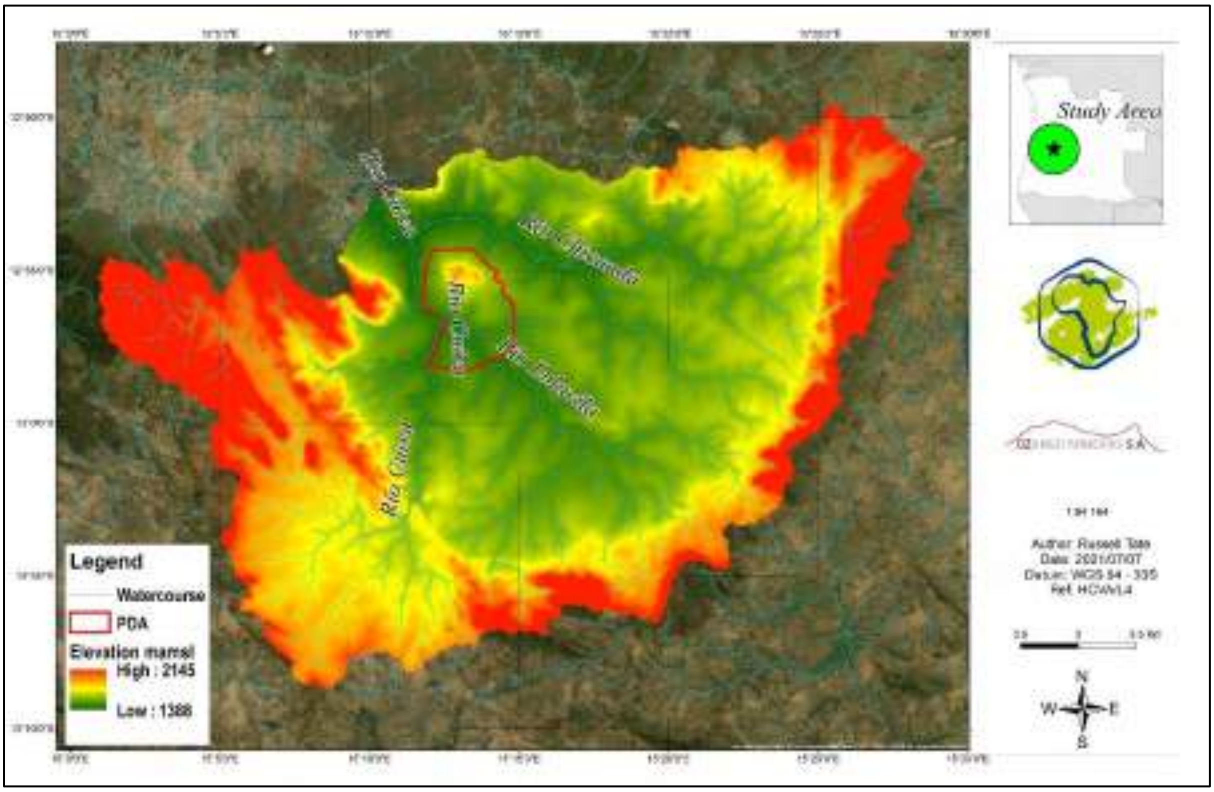


Figure 4-18: Elevation of the Cuiva River watershed

4.6.2 Land use in the context of Hydrology

The Project area can be classified as rural, with large scale subsistence agriculture. The source zone catchments of the headwaters of the Luluvila and Cuiva Rivers are dominated by extensive flood recession agricultural activities. Canalization and encroachment of the agricultural fields were evident in the assessed aerial imagery, as shown in Figure 4-19. Subsistence agriculture dominates the Project area landscape, with dryland, flood recession (farming in the *'nacas´* as generally referred to in Angola) and irrigated agriculture observed during the survey. Crops observed included vegetables, sugar cane and maize production. The urban area of Longonjo is also located in the Cuiva River catchment, and thus some associated urban activities occur in the region. Livestock activities and cattle watering were noted in the Luluvila catchment, whilst downstream agricultural activities included fish farming and impoundments. Rural settlements and associated small scale domestic water uses were noted in the Project area.

Figure 4-19: Aerial image of the upper Luluvila River (Google Earth)

Figure 4-20: Agricultural activities in the Luluvila River catchment (July 2019)

Figure 4-21: Landuse in the drainage lines and perennial streams feeding into the Luluvila River (July 2019)

Figure 4-22: Land-use in the Chicanda River basin (July 2019)

Figure 4-23: Livestock watering in the Luluvila River catchment (July 2019)

4.6.3 Baseline surface water flow

The Project has established six V-notch structures in the streams near the proposed mining activities. Localities of the V-notches are shown in Table 4-10. The examples of the V-notch structures are shown in Figure 4-24.

Table 4-10 : Weir flow measurement location in UTM -33 WGS 84 format

Weir no	X	Y
VN-01	523869	8568870
VN-02	523501	8570738
VN-03	525088	8572963
VN-04	526166	8572876
VN-05	523631	8567631
VN-06	526346	8570130

The average flow rates recorded are as follows:

- VN-01 – 11 L/s
- VN-02 – 3 L/s
- VN-03 – 4 L/s
- VN-04 – 3 L/s
- VN-05 – 8 L/s
- VN-06 – 5 L/s

Figure 4-24: V-notch weirs #1 and #2

4.6.4 Stormwater runoff and Mean Annual Runoff (MAR)

The Project area has a hilly topography; therefore, there are no upstream catchments. Instead, most surface water (i.e. precipitation in the Project area) will flow in a south western direction via two streams (Figure 4-25).

The hydrology specialist study delineated the catchments of relevance to the Project.

Table 4-11 was derived from Table 4-12 for the 24-hour storm rainfall, which is the storm duration used for the SCS[31] method.

[31] Universal Soil Loss Equation (USLE) as a complete technology was first published in 1965 in USDA Agriculture Handbook 282. An updated version was published in 1978 in Agriculture Handbook 537

Table 4-11: Storm rainfall

RETURN PERIOD	5	10	20	50	100
DAILY RAIN (mm)	84	99	118	133	149

Table 4-12 : Storm rainfall distribution

Time (hours)	24-Hour Rainfall Distribution to Return Period (years)				
	5	10	25	50	100
0	0	0	0	0	0
1	33.7	39.6	47.4	53.3	59.5
2	50.5	59.5	71.1	80.0	89.2
3	58.9	69.4	82.9	93.3	104.1
4	67.3	79.3	94.7	106.7	118.9
5	71.6	84.2	100.7	113.3	126.4
6	75.8	89.2	106.6	120.0	133.8
7	76.7	90.4	108.0	121.6	135.6
8	77.7	91.5	109.4	123.1	137.3
9	78.7	92.7	110.7	124.7	139.0
10	79.7	93.8	112.1	126.2	140.8
11	80.7	95.0	113.5	127.8	142.5
12	81.7	96.1	114.9	129.3	144.2
13	81.9	96.4	115.2	129.7	144.6
14	82.1	96.6	115.5	130.0	145.0
15	82.3	96.9	115.8	130.3	145.3
16	82.5	97.1	116.1	130.7	145.7
17	82.7	97.4	116.4	131.0	146.1
18	82.9	97.6	116.7	131.3	146.5
19	83.1	97.9	117.0	131.7	146.8
20	83.3	98.1	117.3	132.0	147.2
21	83.5	98.4	117.5	132.3	147.6
22	83.8	98.6	117.8	132.7	147.9
23	84.0	98.9	118.1	133.0	148.3
24	84.2	99.1	118.4	133.3	148.7

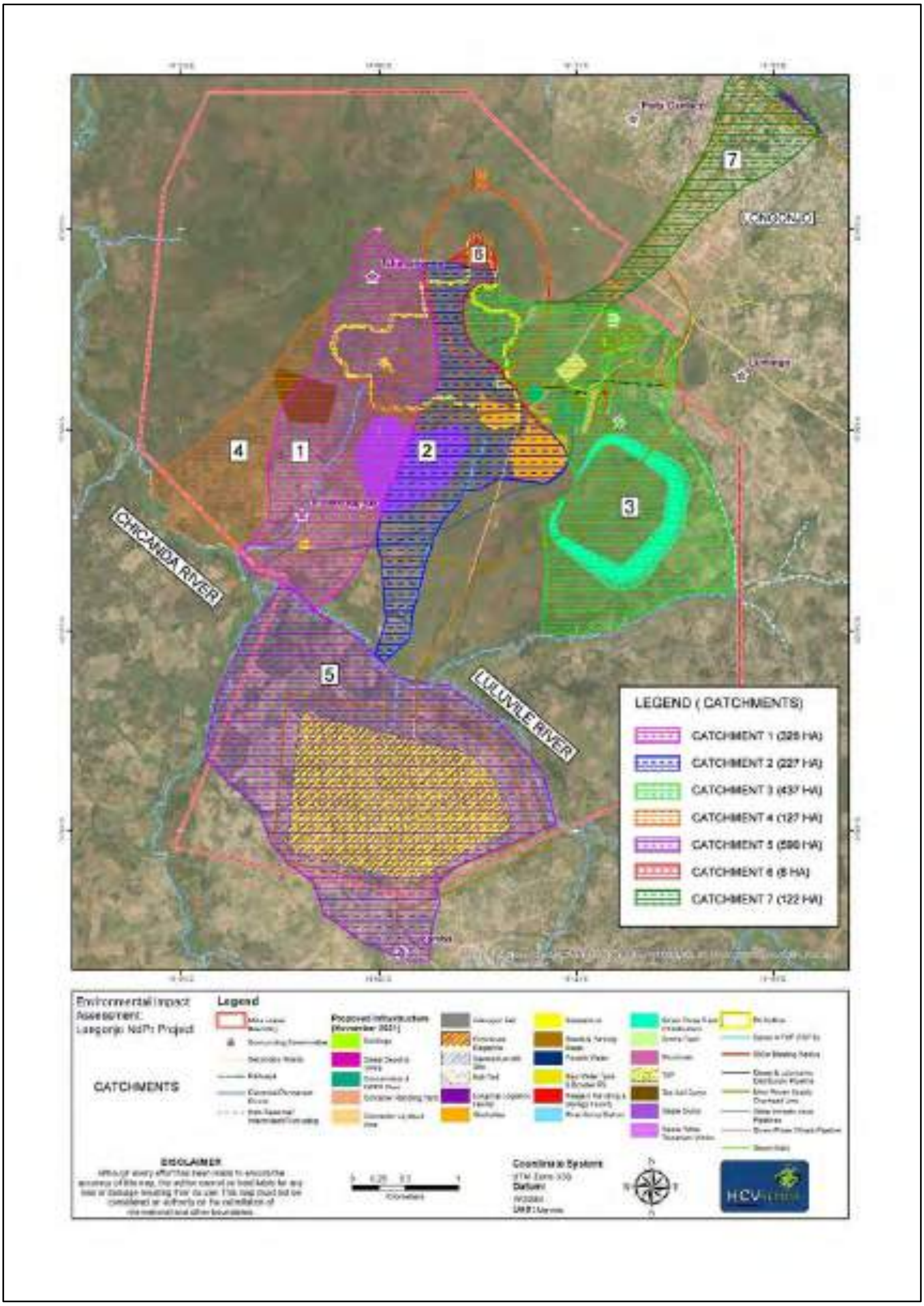


Figure 4-25 : Stormwater catchments areas pertaining to the Project at IFS stage design

The original CN values obtained from the original SCS method literature have been multiplied by the factors from the graph below.

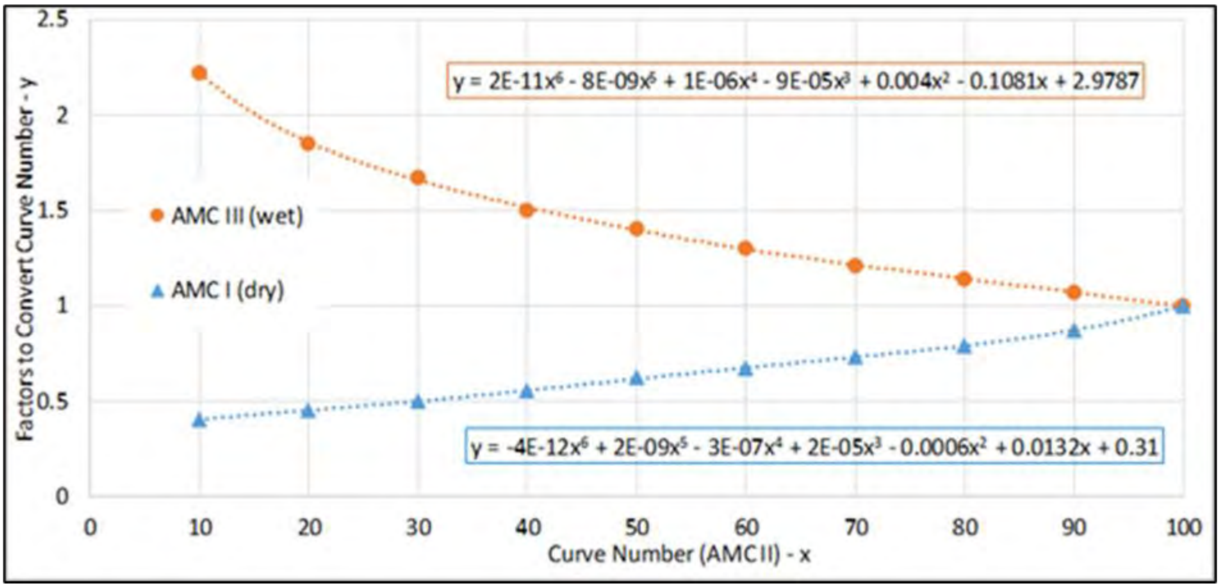


Figure 4-26 : Factors for wet and dry season conversion of CN numbers

See the Hydrology Specialist Study for more information on the calculation methods (Appendix E).

Table 4-13 : Wet season peak storm flows: baseline

NO	CATCHMENT AREA (km^2)	STREAM LENGTH (km)	SLOPE STREAM (%)	OVERLAND FLOW LENGTH (km)	OVERLAND SLOPE (%)	OVERLAND ROUGHNESS n	TC	AVE CN	PEAK DISCHARGE FOR RETURN PERIODS AS INDICATED (m^3/s)					VOLUME FOR RETURN PERIODS AS INDICATED ($Mm^3/10$)				
									5	10	20	50	100	5	10	20	50	100
1	3.3	3.20	8.5%	0.10	10%	0.3	**0.62**	85	48	61	78	92	107	1.6	2.0	2.6	3.0	3.5
2	2.3	2.34	8.0%	0.10	5%	0.3	**0.57**	87	38	48	61	72	83	1.2	1.5	1.9	2.2	2.5
3	4.4	3.00	5.0%	0.10	5%	0.3	**0.73**	87	59	74	94	110	127	2.2	2.8	3.6	4.2	4.9
4	1.3	1.80	14%	0.10	10%	0.3	**0.42**	81	23	29	39	46	54	0.5	0.7	0.9	1.0	1.2
5	5.9	2.35	2.5%	0.10	1%	0.3	**0.87**	88	67	84	107	126	144	3.1	3.9	5.0	5.8	6.6
6	0.1	0.35	17%	0.10	5%	0.3	**0.29**	84	2	3	4	5	5	0.0	0.0	0.1	0.1	0.1
7	1.2	2.70	4.5%	0.10	15%	0.3	**0.65**	92	22	27	33	39	44	0.8	0.9	1.2	1.3	1.5

Note that results for volumes have to be divided by 10 for actual volumes in million cubic meters. This has been done due to table space constraints.

Table 4-14 : Dry season CN values: baseline

CATCHMENT NO	WOODS FAIR (ha)	WOOD - GRASS FAIR (ha)	GRASS FAIR (ha)	FARMLANDS GOOD (ha)	RESIDENTIAL ROADS,ETC. (ha)	TOTAL CATCHMENT AREA (ha)
CN VALUE	39	46	53	55	68	
SOIL CLASS ESTIMATE	B	B	C	B	C	
1	50	40	43	190	3	326
2	10	18	43	150	6	227
3	26	40	30	330	11	437
4	75	20	6	25	1	127
5	30	25	25	500	10	590
6		2	5	1		8
7	1	6	10	10	95	122

Table 4-15 : Dry season peak flows: baseline

NO	CATCHMENT AREA (km^2)	STREAM LENGTH (km)	SLOPE STREAM (%)	OVERLAND FLOW LENGTH (km)	OVERLAND SLOPE (%)	OVERLAND ROUGHNESS n	TC	AVE CN	PEAK DISCHARGE FOR RETURN PERIODS AS INDICATED (m^3/s)					VOLUME FOR RETURN PERIODS AS INDICATED ($Mm^3/10$)				
									5	10	20	50	100	5	10	20	50	100
1	3.3	3.20	8.50%	0.10	10.0%	0.30	**0.62**	51	4	9	15	22	29	0.1	0.3	0.5	0.7	0.9
2	2.3	2.34	8.00%	0.10	5.0%	0.30	**0.57**	53	4	8	14	19	25	0.1	0.2	0.4	0.6	0.8
3	4.4	3.00	5.00%	0.10	5.0%	0.30	**0.73**	53	7	12	21	29	38	0.3	0.5	0.8	1.1	1.4
4	1.3	1.80	14.00%	0.10	10.0%	0.30	**0.42**	44	1	2	4	7	10	0.0	0.0	0.1	0.2	0.2
5	5.9	2.35	2.50%	0.10	1.0%	0.30	**0.87**	54	8	14	24	33	43	0.4	0.7	1.1	1.5	2.0
6	0.1	0.35	17.00%	0.10	5.0%	0.30	**0.29**	51	0	0	1	1	1	0.0	0.0	0.0	0.0	0.0
7	1.2	2.70	4.50%	0.10	15.0%	0.30	**0.65**	64	6	8	12	16	20	0.2	0.3	0.4	0.5	0.7

Note that results for volumes have to be divided by 10 for actual volumes in million cubic meters. This has been done due to table space constraints.

4.6.5 Baseline sediment yield

The following baseline sediment yield figures have been derived using methodology as described the Hydrology Specialist Study (Appendix E).

Table 4-16 Rainfall erosivity factor (Godollo University Hungary. The Role of Soil Protection in Angola)

Rainfall erosivity factor	700

Table 4-17 Baselines areas and factors for soil loss prediction

CATCHMENT NO	OVERLAND SLOPE (%)	WOODS FAIR (ha)	WOOD - GRASS FAIR (ha)	GRASS FAIR (ha)	FARMLANDS GOOD (ha)	RESIDENTIAL ROADS,ETC. (ha)	TOTAL AREA (ha)
C - CROPPING AND MANAGEMENT		0.06	0.06	0.06	0.20	0.20	
P- SUPPORT PRACTICE FACTOR		1	1	1	0.5	0.5	
L - SLOPE LENGTH (m)		100	100	100	50	50	
K - SOIL ERODIBILITY FACTOR		0.3	0.3	0.3	0.3	0.3	
1	10	50	40	43	190	3	326
2	5	10	18	43	150	6	227
3	5	26	40	30	330	11	437
4	10	75	20	6	25	1	127
5	1	30	25	25	500	10	590
6	5		2	5	1		8
7	15	1	6	10	10	95	122
TOTAL AREA (1-5)		191	143	147	1195	31	1707
TOTAL AREA (6+7)		1	8	15	11	95	130

Table 4-18 : Baseline soil loss tons/annum

CATCHMENT NO	OVERLAND SLOPE (%)	WOODS FAIR (Ton)	WOOD - GRASS FAIR (ton)	GRASS FAIR (ton)	FARMLANDS GOOD (ton)	RESIDENTIAL ROADS,ETC. (ton)	TOTAL (ton)
1	10.0	5126	4101	4408	22754	399	36788
2	5.0	126	226	540	2200	98	3189
3	5.0	326	502	377	4839	179	6224
4	10.0	7689	2050	615	2994	133	13481
5	1.0	70	58	58	1367	30	1584
6	5.0		25	63	15		103
7	15.0	837	5023	8372	9780	103229	127241
TOTAL AREA (1-5)		13336	6937	5998	34154	840	61265
TOTAL AREA (6+7)		837	5048	8434	9794	103229	127343

Table 4-19 : Base line soil loss tons/ha/annum

CATCHMENT NO	OVERLAND SLOPE (%)	WOODS FAIR (Ton/ha)	WOOD - GRASS FAIR (ton/ha)	GRASS FAIR (ton/ha)	FARMLANDS GOOD (ton/ha)
1	10.0	103	103	103	120
2	5.0	13	13	13	15
3	5.0	13	13	13	15
4	10.0	103	103	103	120
5	1.0	2	2	2	3
6	5.0	13	13	13	15
7	15.0	837	837	837	978
TOTAL AREA (1-5)		70	49	41	29
TOTAL AREA (6+7)		837	631	562	890

4.6.6 Baseline surface water quality

Surface water sampling localities including aquatic biomonitoring localities are shown in Figure 4-27.

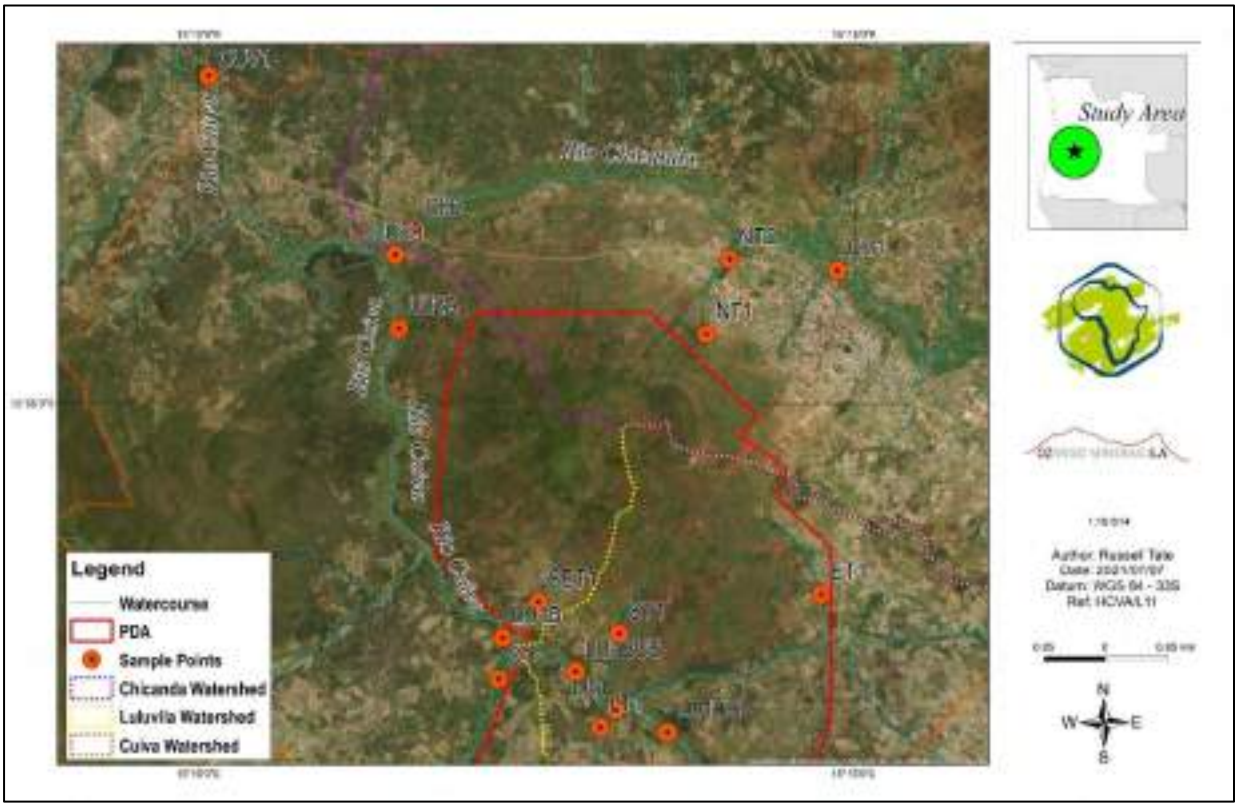


Figure 4-27: Aquatic sampling localities (water chemistry and aquatic biomonitoring)

The results of the *in situ* water quality assessment are provided in Table 4-20, whilst the chemical analyses are presented in Table 4-22 and

Table 4-23. The assessment results indicate neutral pH levels across the sampling points ranging from 7.5±0.13 in the Chicanda River, 7.4±0.28 in the Cuiva and Luluvila Rivers, to 7.3±0.23 in the various tributaries. The pH values fluctuate seasonally, whereby increased pH levels were noted in the rainy season (high flow) period. A similar observation was made in the 2021 survey. The pH fluctuations observed in the waterbodies were noted at LU1B in the July 2019 low flow survey, whereby pH levels were reduced to 5.9. In addition, the pH level at ET1 was also noted to be lower than the background levels . This was, however, not confirmed in the May 2021 survey. The pH levels observed during the study serve to establish the baseline conditions during the sampling periods. For this reason, no comparisons to guidelines are applicable. However, it is noted that the neutral pH levels observed would not be a factor limiting the ecological state of the sampled river systems.

The concentrations of dissolved solids, as reflected through conductivity, were noted to be low, which is expected for a watercourse of this geomorphological composition. Furthermore, the ranges of values between the various river systems were noted to be similar for the Luluvila (69±5.0 µS/cm) and Chicanda (57±2.1 µS/cm) Rivers and slightly elevated for the various tributaries at 96±11 µS/cm. The increased level of conductivity observed in the tributaries was attributed to consistently elevated levels of dissolved elements at ET1 (this is attributed to anthropogenic activities at the sampling point, with a rural settlement in the vicinity of the source of the tributary), livestock agriculture and encroachment of agricultural field into riparian areas).It is noted, however, that the source of the elevated salts may also be attributed to geological conditions at the site.

Elevated turbidity was noted during both surveys but worse in the April 2019 high flow survey (Figure 4-28). The elevated turbidity was attributed to the extensive erosion taking place in the upper reaches of the waterbodies due to agricultural activities (farming in the *'nacas'*). Overall, the turbidity of the Luluvila and Cuiva River 36±11

NTU were less murky than the 69±31 NTU of the Chicanda River. Observations made in May 2021 were consistent with the established results of increased turbidity.

The phosphate concentration was below the instrument's detection limit (<5mg/l). However, it is noted that phosphorous bound molecules enrich the nutrient content of local waterbodies at concentrations lower than 5 mg/l. Therefore, there is probably a degree of phosphorus enrichment given the extent of the agricultural activities observed in the riparian areas. Variable ammonia concentrations were observed during the study, with the site CUV1 at 1.84 mg/l being the highest level recorded. Overall, total nitrogen (ammonia, nitrate and nitrites) was low, below the <0.5 mg/l thresholds and thus classified as oligotrophic.

Figure 4-28: Unimodal flooding and high turbidity levels in the Cuiva River (left: April 2019 right: July 2019)

Dissolved metals were determined to be at detectable ranges within the sampled sites. The dissolved iron concentrations iron ranged from 4.7 mg/l at ET1 to 0.06 mg/l at SET1, indicating a wide range in the AoI. The dissolved iron concentrations were below toxic thresholds. The concentrations of dissolved chromium were at detectable concentrations at CH1 (0.38 mg/l), LU2B (0.34 mg/l) and CUV1 (0.18 mg/l) in July 2019. These concentrations were noted to be exceeding or within proximity to the Acute Effect Value (AEV) of 0.2 mg/l as established in DWAF (1996). These high levels of the element were not expected, and further assessment of these levels is recommended during post-SEIA monitoring. Copper toxicity is correlated to water hardness, with toxicity increasing at low water hardness or water classified as soft water (<60 mg/l $CaCO_3$). Water across the AoI consisted of soft water. The Chronic Effect Value (CEV) for copper is 0.53 µg/l (0.0005 mg/l), and therefore the levels of copper observed in this watercourse would be considered to have a chronic effect on local riverine fauna (DWAF, 1996). Manganese concentrations were typically low throughout the study area but were notably high at CH1 (0.12 mg/l), ET1 (0.3 mg/l) and NT2 (0.18 mg/l). The CEV for manganese toxicity occurs at 0.37 mg/l, and therefore no toxicity was anticipated in the study area. Dissolved nickel was also observed at high concentrations ranging from below detection to a high of 0.33 mg/l at ET1. No reliable toxic limits for dissolved nickel are available. The concentrations of dissolved aluminium were noted to be typically below detection.

In conclusion, the water quality results established during the surveys indicate oligotrophic conditions, neutral pH levels, low water hardness and conductivity. In addition, some metals were determined to be elevated in the dissolved component of the water column, including chromium, copper and manganese.

In line with the IFC guidelines for maintaining Ambient Water Quality (IFC, 2007), establishing a more robust baseline surface water chemistry assessment is recommended. This can be achieved through additional monthly sampling.

Table 4-20: *In situ* water quality in the Project area (April and July 2019)

Constituent/Site		pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)		pH	Conductivity (µS/cm)	DO (mg/l)	Temperature (°C)
LU1	April 2019	7.2	48	7.31	22.2	July 2019	7.3	71	6.5	20
LU1B		N/A	N/A	N/A	N/A		6.6	89	6.2	18
LU2A		N/A	N/A	N/A	N/A		7.6	59	6.8	15
LU2B		6.9	23	7.39	22.9		7.6	60	6.3	15
CH2		7.2	48	5.32	23		7.2	52	5.9	18
CH1		6.9	21	7.65	20.5		7.6	59	6.1	18
CUV1		N/A	N/A	N/A	N/A		7.6	61	7.3	14
NT1		7.4	79	-	24.6		N/A	N/A	N/A	N/A
ST1		6.9	82	7.93	22.5		7.1	71	5.1	14
SET1		7.3	139	7.02	21		7.6	150	4.2	16
ET1		6.9	67	3.05	23.5		6.2	89	4.3	16
NT2		6.9	57	5.05	20		7.0	75	5.3	17
N/A – sites were not included during the survey										

Table 4-21: In situ results from the May 2021 Survey

Constituent/Site	pH	Conductivity (µS/cm)	DO (mg/l)	Temp (°C)
ET1	7.0	72	5.9	16
LU1US	7.1	50	6.0	17
LT1	7.3	76	5.8	17
LU1	7.1	55	6.1	16
LU1BUS	7.0	56	6.1	19
C1	6.9	68	6.5	17
LU1B	6.9	70	6.2	16
SET1	7.2	128	5.9	16
LU2B	6.9	71	6.2	17
CUV1	7.1	73	7.1	18

Table 4-22: Water chemistry from the July 2019 baseline survey

Site/Constituent	Unit	LU1	LU1B	LU2A	LU2B	CH1	CH2	CUV1	ST1	SET1	ET1	NT2
pH	pH	7.4	5.9	7.5	7.4	7.4	7.3	7.5	7.2	7.4	6.0	7.1
NTU	NTU	26	24	15	13	22	20	14	4	7	19	8
Conductivity	µS/cm	77	95	62	63	59	63	62	76	152	95	78

Site/Constituent	Unit	LU1	LU1B	LU2A	LU2B	CH1	CH2	CUV1	ST1	SET1	ET1	NT2
Sulphate	Mg/l	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5
P_2O_5	Mg/l	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0.15
NH_4	Mg/l	0.11	0.1	0.2	0.03	0.34	0.04	1.84	0.02	0.21	0.03	0.3
NO_3	Mg/l	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5
NO_2	Mg/l	0.03	0.02	0.02	0.01	0.03	0.02	0.02	<0,005 (LQ)	0.01	0.02	0.02
Fe	Mg/l	1	0.8	0.6	0.62	0.66	0.69	0.59	0.1	0.06	4.7	0.37
Cr	Mg/l	0.08	0.05	0.34	<0,03 (LQ)	0.38	<0,03 (LQ)	0.18	<0,03 (LQ)	0.05	<0,03 (LQ)	0.03
Cu	Mg/l	0.13	0.12	0.09	0.11	0.16	0.14	0.12	0.05	<0,01 (LQ)	0.13	0.06
Mn	Mg/l	0.07	0.07	0.04	0.04	0.12	0.03	0.07	0.08	0.04	0.3	0.18
Ni	Mg/l	0.19	0.14	0.1	0.14	0.16	<0,10 (LQ)	0.13	<0,10 (LQ)	<0,10 (LQ)	0.33	0.25
Zn	Mg/l	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0.2
Al	Mg/l	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)	<0,020 (LQ)
LQ= below instrument detection limit												

Table 4-23: Water chemistry from the April 2019 survey

Site/Constituent	Unit	LU1	LU2	CH1	CH2	ET1	ST1	SET1	NT2
pH	pH	8,4	7,9	7,8	7,8	7,4	8	8,1	7,9
NTU	NTU	81	83	84	151	11	39	74	116
Conductivity	µS/cm	69	55	54	54	73	86	139	70
Sulphate	Mg/l	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)
P_2O_5	Mg/l	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)	<0,15 (LQ)
NH_4	Mg/l	0,08	0,16	0,16	0,15	0,26	0,06	0,09	0,19
NO_3	Mg/l	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)	<5 (LQ)
Fe	Mg/l	0,49	0,64	0,65	0,69	0,24	0,1	0,23	0,47
Cr	Mg/l	<0,030 (LQ)	<0,030 (LQ)	<0,030 (LQ)	<0,030 (LQ)	<0,030 (LQ)	<0,030 (LQ)	0,03	<0,030 (LQ)
Cu	Mg/l	0,03	0,02	0,04	0,04	0,05	0,08	0,07	0,01
Mn	Mg/l	0,01	0,02	0,02	0,03	0,02	0,01	0,04	0,04
Ni	Mg/l	<0,05 (LQ)	<0,05 (LQ)	<0,05 (LQ)	<0,05 (LQ)	<0,05 (LQ)	<0,05 (LQ)	<0,05 (LQ)	<0,05 (LQ)
Zn	Mg/l	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)	<0,20 (LQ)

Table 4-24: Water chemistry from the August 2021 survey

Determinands	Units	SANS 241	ANG PD	S1	S2	S3	S4	S5	S6	S7	S8	N1	N2	N3	N4	Camp BH1
Bacterial Coliforms	Number/100 ml			>2420												3
E. coli	Number/100 ml	0		308												0
Faecal Coliforms	Number/100 ml	10	20	436												0
Total Organic Carbon	mg/l C	10						62			93				100	
Total Alkalinity	mg/l CaCO3			27	47	25	37	44	27	67	34	29	42	27	42	34
Ammonia as N	mg/l N	1.5	1	0.08	0.02	0.04	0.06	0.04	0.07	<0.015	0.04	0.12	0.05	<0.015	0.05	<0.015
Ammonia	mg/l NH3			0.1	0.03	0.05	0.08	0.05	0.08	<0.02	0.04	0.15	0.07	0.02	0.06	<0.02
Ammonium	mg/l NH4		0.05	0.1	0.03	0.05	0.08	0.05	0.09	<0.02	0.05	0.16	0.07	0.02	0.06	<0.02
Total Nitrogen	mg/l N		1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cyanides free	mg/l CN-	200	50	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Cyanide	mg/l CN-	200	50	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chlorides	mg/l Cl	300	200	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Fluoride	mg/l F	1.5	0.7	0.2	<0.10	0.2	0.3	0.2	<0.10	0.6	0.1	<0.10	0.2	0.4	<0.10	0.3
Phosphate	mg/l PO4			<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	0.19	<0.15	<0.15	<0.15
Phosphorous as P	mg/l P			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phosphorous trioxide	mg/l P2O3		0.4	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
Nitrates	mg/l NO3	50	25	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Nitrites	mg/l NO2	3		0.04	0.01	0.01	<0.005	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.03	0.01
Total Dissolved Solids	mg/l	1200		30	45	26	39	47	30	67	36	32	54	29	38	35
Suspended Solids	mg/l		25	35	25	50	50	<5	<5	<5	15	50	155	<5	15	<5
Sulfates	mg/l SO4	500	150	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Calcium	mg Ca/l	150		5.24	7.47	4.71	8.08	7.90	5.76	15.30	7.04	5.99	9.64	7.97	5.47	7.00
Potassium	mg K/l	50		3.86	2.40	3.00	2.04	3.58	2.51	3.07	2.54	2.68	6.52	2.28	2.94	6.57
Dissolved Magnesium	mg Mg/l			1.82	2.07	1.16	2.84	2.26	1.77	5.97	2.11	1.88	2.86	2.11	1.78	2.61
Sodium	mg Na/l	200		3.23	5.60	4.43	3.75	10.40	4.57	5.55	5.64	4.83	5.80	2.45	5.10	3.25
Dissolved Aluminium	µg Al/l	300		21.0	43.0	202.0	132.0	264.0	122.0	53.0	64.0	44.0	43.0	37.0	32.0	12.3
Dissolved Arsenic	µg As/l	10	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Boron	µg B/l	2400	1000	1.6	1.7	2.1	1.4	3.2	2.9	1.4	3.2	2.5	3.8	2.4	2.7	1.1
Dissolved Barium	µg Ba/l			662	76	185	1024	183	50	1122	135	62	395	1079	79	1369
Dissolved Beryllium	µg Be/l	700	100	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Cadmium	µg Cd/l	3	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Cobalt	µg Co/l	500		1.10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Chromium	µg Cr/l	2000	20	<1	<1	<1	<1	1.40	<1	<1	<1	<1	<1	<1	<1	1.50
Dissolved Copper	µg Cu/l	50	50	1.30	1.10	1.10	2.30	3.10	1.40	16.30	13.20	2.30	1.40	8.10	1.20	3.30
Dissolved Iron	µg Fe/l	2000	100	708	1140	2101	75	286	759	36	180	211	47	27	157	43
Dissolved Mercury	µg Hg/l	6	0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.80
Dissolved Lithium	µg li/l			<1	<1	1.80	<1	<1	<1	1.60	<1	<1	1.00	<1	<1	4.80
Dissolved Manganese	µg Mn/l	400	10	1795.0	138.0	231.0	271.0	222.0	42.0	120.0	71.0	34.0	634.0	68.0	53.0	1.3
Dissolved Nickel	µg Ni/l	70		1.4	<1	1.4	3.4	3.0	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Lead	µg Pb/l	10	50	<1	<1	<1	1.40	<1	<1	1.20	<1	<1	<1	<1	<1	<1
Dissolved Antimony	µg Sb/l	20		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Selenium	µg Se/l	10	10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Uranium	µg U/l	30		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Vanadium	µg V/l	200		<1	<1	<1	<1	<1	<1	<1	<1	<1	3.50	<1	<1	<1
Dissolved Zinc	µg Zn/l	5000	500	4.9	3.7	4.3	13.1	14.7	3.7	8.9	7.3	6.9	10.6	25.0	5.1	19.2
Water temperature	pH Units	5 - 9.7	6.5 - 8.5	23.67	23.93	26.47	23.80	21.63	24.30	22.27	19.40	19.37	21.50	19.97	19.40	26.07
pH	mg/l		50%	6.61	6.95	6.69	7.03	7.33	7.38	7.17	7.22	7.38	7.02	6.63	7.17	6.02
Dissolved Oxygen	mS/m	170	100	5.75	7.07	6.33	6.72	8.28	7.49	7.14	7.53	7.59	6.11	6.55	7.43	5.63
Conductivity	Deg.C			68.87	71.83	58.27	80.77	97.83	65.40	144.30	77.63	68.83	115.30	62.20	69.80	75.73
Turbidity	NTU	1		43.87	17.30	29.50	5.86	17.27	20.30	5.41	34.70	74.77	224.67	6.49	83.90	0.66
Date/Time	**29.08.2021**			10h08	13h10	12h49	12h30	11h37	11h45	11h00	08h20	08h51	09h15	09h40	07h50	14h37

4.7 Hydrogeology

Limited data is available on the hydrogeological characteristics and groundwater potential of Angolan aquifers; most of the information is available for the southwestern provinces of Huíla, Namibe and Cunene. In addition, limited research has been conducted on groundwater resources, and no national resource estimates have been completed. However, based on the identified potential and the limited level of existing development, it is safe to assume that only a tiny portion of national groundwater resources are currently being utilized (SRK Consulting (Pty) Ltd, 2002).

A National Directorate of Water (DNA) report in 2015 stated that 73% of known water systems across Angola use groundwater sources. Boreholes equipped with hand pumps represented 36% of all water supply systems (Cowater, 2015). The use of groundwater varies across the country, with some provinces obtaining over 90% of their water supplies from groundwater, with the norm ranging between 40% and 80%. Only three provinces obtain less than 20% of water supplies from groundwater (Cowater, 2015).

The provincial capitals of Malange, Bengucia, Lubango and Namibe, and the urban centres of Tobwa and Lobito, rely primarily on groundwater. In general, groundwater use in urban areas is concentrated in southern and coastal areas, where the climate is more arid, and less surface water is available. Further, groundwater is being increasingly developed for local systems to augment water supplies in rapidly growing peri-urban areas, particularly Luanda (SRK Consulting (Pty) Ltd, 2002).

Rural areas rely almost entirely on groundwater from boreholes, hand-dug wells and springs. However, surface water is used in areas where existing groundwater supply systems are no longer functional or have not been developed (SRK Consulting (Pty) Ltd, 2002). The other primary user of groundwater is for livestock watering in the arid southern provinces. The Ministry of Agriculture and Forestry (MINAGRIF) coordinates water supply for livestock watering, and groundwater is supplied through boreholes and wells equipped with either manual or powered submersible pumps.

Table 4-25 presents the regional classification of aquifers in Angola.

Table 4-25: Regional classification of aquifers[32] in Angola

AQUIFER CLASSIFICATION	AQUIFER DESCRIPTION	AQUIFER PRODUCTIVITY	AQUIFER PROPERTIES & WATER QUALITY
Quaternary Unconsolidated Aquifers	Alluvium - Quaternary	Low to High	Aquifer productivity depends on the aquifer lithology (whether dominated by permeable sands and gravels or low permeability fine-grained deposits), thickness and lateral (areal) extent. At their most productive, alluvial sediments in river valleys form the best aquifers in Angola, with recorded borehole yields of 15 to 50 l/s (DNA, 2005). The largest alluvial aquifers are found in the provinces of Huíla, Benguela, Cuanza Sul, Bengo and Zaire (DNA, 2005). Some groundwater in alluvial aquifers is reported to have high iron and sulphate concentrations, probably linked to the low precipitation and high potential evapotranspiration. In some deltas and low parts of alluvial plains the quality of groundwater is influenced by salt water (DNA, 2005).
Sedimentary Aquifers - Intergranular flow	Kalahari Group - Tertiary–Quaternary	Moderate to High	Thought to form a moderate to high productivity aquifer. The water table in the Kalahari Group is shallower in the north, and becomes deeper towards the south, where the Kalahari Group is typically completely dry (Groundwater Consultants Bee Pee (Pty) Ltd, SRK Consulting (Pty) Ltd, 2002).
	Small coastal aquifers - Cretaceous–Tertiary	Moderate	Argillaceous sandstones along the coast have proved to be moderately productive aquifers. Groundwater can be relatively highly mineralised, sometimes associated with salt-bearing formations.
	Karoo Supergroup, Carboniferous–Jurassic	Moderate	Groundwater can be relatively highly mineralised
Karoo Supergroup (inland) - Carboniferous–Jurassic	Metasedimentary rocks - Precambrian (locally Lower Cambrian)	Usually Moderate; sometimes High	Some quartzites, sandstones and conglomerates may form useful aquifers. These are scattered throughout most of the areas with Precambrian rocks in southwest Angola. Average borehole yields are thought to be around 3 l/s (DNA, 2005). Metamorphosed sandstones, limestones, dolomites, greywackes and volcanic rocks of the Pan-African orogen, which occur in various parts of the country, may form the highest productivity Precambrian aquifers, with average borehole yields of 3 to 6 l/s or even greater (DNA, 2005).
Basement Aquifers	Crystalline basement - Precambrian	Usually Low, sometimes Moderate	Basement rocks form local aquifers, generally with low productivity but sometimes up to moderate productivity. Groundwater is only found where the rocks are fractured and/or weathered. Different lithologies within the basement have different hydrogeological properties. In general, the most common yields of boreholes in granites and gneisses is less than 1 l/s, especially where boreholes are less than approximately 50 m deep (DNA, 2005). The basic rocks in Angola such as gabbros and norites are probably the best aquifers, and in the hydrogeological map of Angola their productivities are often indicated as being 3-5 l/s with a drill success rate of 70-80% (DNA, 2005). Basic intrusive rocks are found both in the north and south of the country. One study showed that borehole yield was directly related to the direction of tectonic structures (fracture orientation). For example, where fractures are in a NE-SW direction, yields are less than 3 m³/hour; and where fractures are in a N-S direction, yields are more than 8.5 m³/hour (United Nations, 1989). The best groundwater potential may be in zones of quartz veins and basic rocks; contact zones between crystalline rocks of different texture and composition; zones of fractured granitogneiss; and contact zones between metavolcanic and quartz-schist rocks.

Regionally, the Project area is located in the crystalline basement aquifer system. Typically, these basement lithologies, like granites and gneisses, form local aquifers systems that are generally low in productivity, but they can be classified as moderately productive in some rare instances. Groundwater is only found in secondary pore spaces where the rocks are fractured and / or weathered, with different lithologies in the basement having different hydrogeological properties. Generally, the most common yields of boreholes in granites and gneisses of the Longonjo area is less than 1 L/s, especially where boreholes are less than about 50 m deep (Ministry of Energy and Water, 2005).

32 United Nations . 1989. *Groundwater in Eastern, Central and Southern Africa: Angola*.

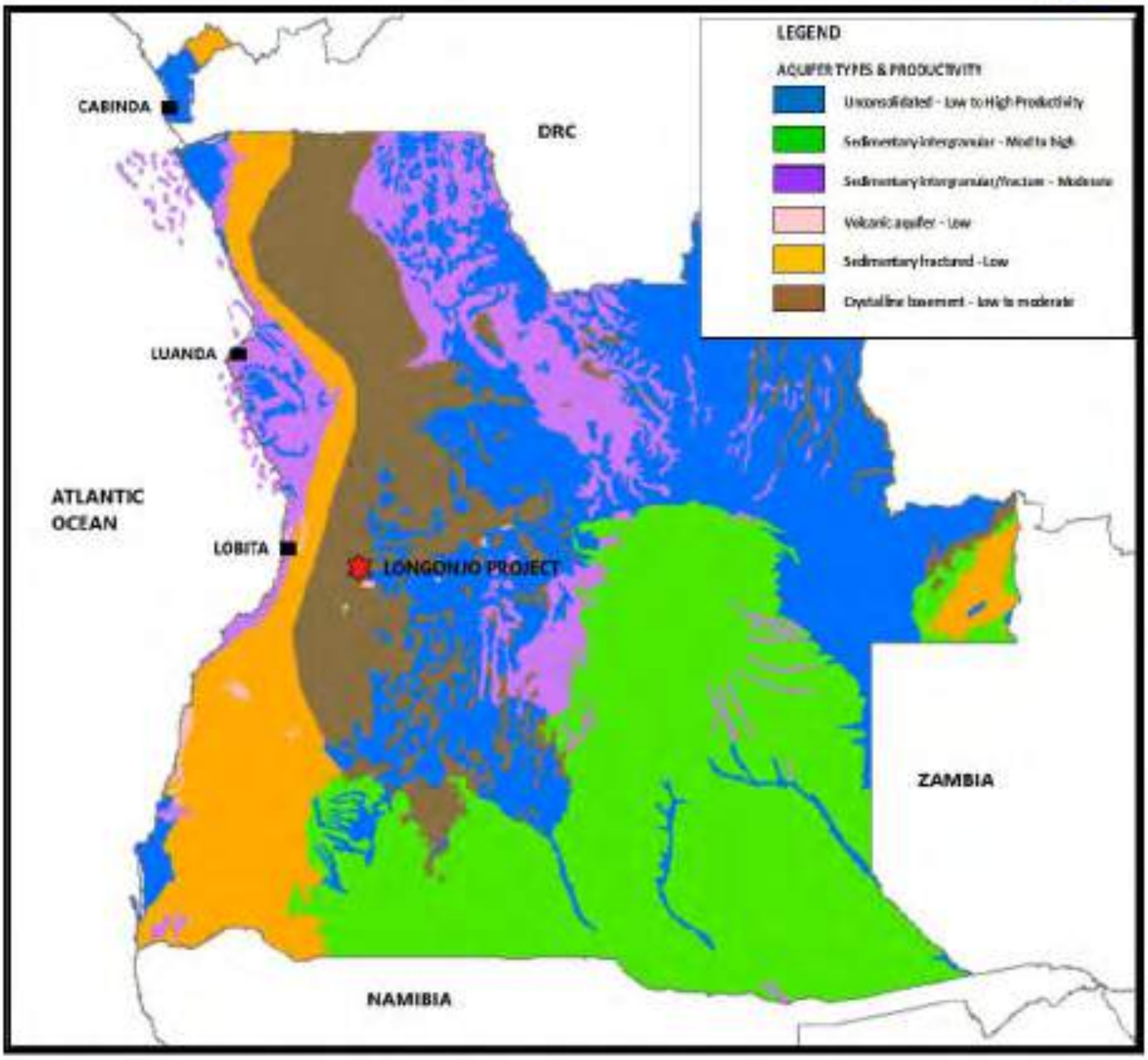


Figure 4-29: Hydrogeological map of Angola showing the broad aquifer classes[33]

4.7.1 Local area hydrogeology

The exploration boreholes in the Project Area provides valuable data to characterize the hydrogeological conditions in the Local Study Area. Unfortunately, limited groundwater information is available over the entire footprint of the Ozango/Pensana mine lease area, mainly because the local population does not utilize groundwater outside of Longonjo town.. Likely, Longonjo town was initially established due to easy access to surface and groundwater resources. It is estimated that the town has at least 100 hand-dug wells and boreholes, mostly privately owned, from which most people obtain their potable and domestic water supplies.

Accordingly, the description of the hydrogeological baseline conditions is limited to an area roughly 1km around the proposed mine lease area. See Section 4.5.1 for the position of all the boreholes drilled concerning the footprint of the proposed site and other infrastructure.

4.7.2 Drainage

Minor drainages lines run from the middle of the Project Area in all directions as this is a local topographic high point. The main secondary drainage lines drain towards the main perennial rivers to the north and south of the

[33] http://earthwise.bgs.ac.uk/index.php/Africa_Groundwater_Atlas_Hydrogeology_Maps

Project Area. These minor drainages are primarily seasonal and are expected to become active during high rainfall events and the wet season and dry-up during the middle of the dry season..

4.7.3 Groundwater recharge

The rainfall averages (See section 4.2) coupled with the moderate to high evaporation averages recorded in the region limit the recharge to groundwater in the Project Area to around 3% of MAP. This figure is in the low to moderate range, and it is expected that the main recharge takes place within the highly weathered carbonatite sequences, laterite outcrops and fenite lithologies. The lowest recharge is anticipated within the unweathered massive gneiss and granite rocks surrounding the Project Area.

4.7.4 Groundwater use

Groundwater is used extensively in the urban and peri-urban areas in Longonjo, primarily for drinking and domestic supply purposes. Some groundwater is used for the irrigation of small vegetable patches, but this is limited by the technology used to abstract the water from both hand-dug wells and community boreholes. The wells are mostly equipped with rudimentary rope and bucket systems and boreholes with handpump mechanisms.

In the deeper rural settings, some of the springs and streams are used to irrigate banana and mango plantations together with patches of cassavas, tomatoes and other vegetables. This occurs mainly by diverting the water from these sources located on the flacks of the hills along with small man-made canal systems and into the irrigation fields where the water is required. However, this occurs on a small scale as all the planting, watering, weeding and harvesting is done exclusively by hand.

4.7.5 Groundwater elevations

During the hydrocensus (conducted by HCV Africa as part of the Hydrogeology specialist study for the ESIA), groundwater elevations were measured at 23 different locations across the Mine Lease Area (MLA) and the Longonjo town. These included 15 boreholes, 5 community wells and 3 springs. A further 93 additional groundwater level measurements were made in June 2019 within all the exploration boreholes by the Pensana/Ozango geology team members based at the Project location and provided to HCV Africa for analysis.

Generally, groundwater elevations tend to mirror the local topography, with deeper elevations being found in higher-lying areas and shallower levels found near drainage systems within the lower-lying reaches. However, the baseline study results of the hydrogeological impact assessment were fascinating as the data was largely the opposite of the normally expected trend (

Figure 4-30). In other words, shallower watertables were found at higher elevations within the carbonatite, becoming deeper of the flanks on the system and deepest on the flat areas surrounding the diatreme.

These results indicate several discrete and very different aquifer systems in the area. Each is associated with different groundwater elevations or water tables. For this to occur, it implies that every system needs to be separated from the adjacent system by impermeable or less permeable rock formations or geologic structures.

In groundwater movement or flow, this will generally follow the topographic contours unless the water encounters barriers to flow like faults, dykes or any other semi- or impervious features. The groundwater flow will be towards the lowest groundwater elevations encountered in that area (

Figure 4-30). For example, there will be groundwater movement from the perimeter of the diatreme towards the middle in this instance as the watertable is deepest at such a point.

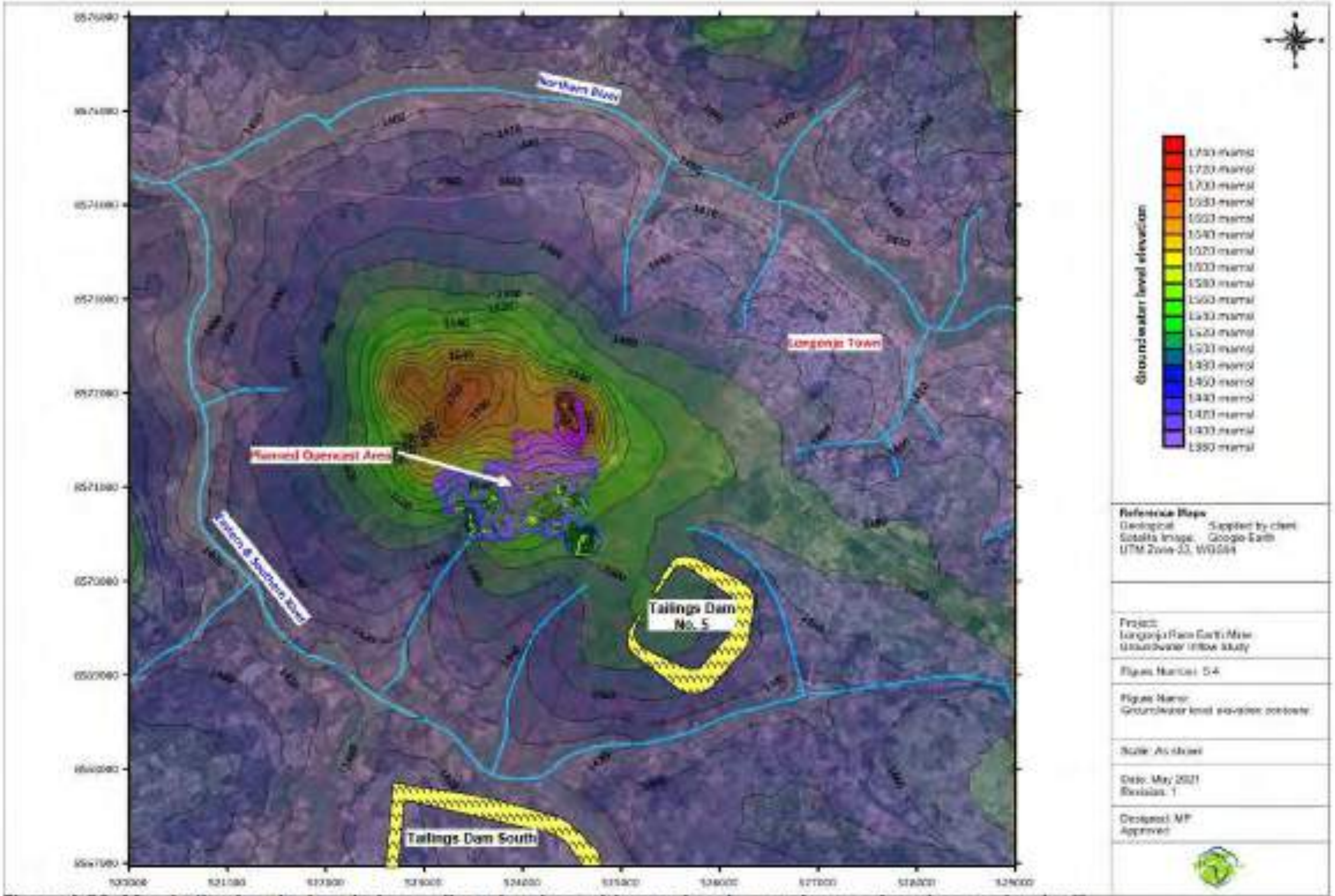


Figure 4-30: Map indicating the boreholes, wells and springs with associated groundwater elevations or depths.[34]

[34] Please note, that the groundwater elevations contoured above (Fig 2.3) represent a combination of measured water levels from local boreholes and Well's and those modelled during HCVA's 3D numerical modelling exercise conducted in May 21. The spatial coverage of boreholes, Well's and springs reduces significantly from the MLA in all directions, besides within the town of Longonjo itself where community Wells remain abundant. As a result, it is not possible to accurately contour the groundwater elevations under the footprint of both the proposed TSF 5 location of the TSF South site until additional groundwater level information has been gathered. This also information also remains mostly anecdotal until each of the groundwater measuring locations is accurately surveyed, especially in terms of collar height. This is mostly, as a small variation in topographic height may have a disproportionately large impact on the underlying groundwater elevations which do not typically fluctuate significantly.

4.7.6 Aquifer types

Based on the interpretation of the groundwater levels and local geology, preliminary indications are that there are at least 4 distinct aquifer systems prevalent in the Project Area, each hosted in a different rock type:

(1) **Shallow, high-level aquifer system:** situated within the highly weathered carbonatites and surrounded by a more resistant Fenite rock ring. The latter is defined by the hills surrounding the diatreme in the north, east and west. To the south, a large east–west trending normal fault acts as an impervious barrier to groundwater. Groundwater levels in this aquifer vary from about 3m to 12m deep. The highly weathered carbonatites are karstic due to their carbonaceous nature. As a result, the aquifer thickness related to the depth of weathering can vary significantly from a couple of meters thick to about 35m.

(2) **Unconfined fractured aquifer:** located mainly in the carbonatites and fenites south of the central diatreme and on the flanks of the hill and low-lying areas. Groundwater elevations within this system vary from 15 to 20mbgl, with the deepest encountered on the slopes or flanks of the higher lying ground. This aquifer is hosted primarily in fractured fenites and carbonatites, with some of the fracturing (ring fracturing) relating directly to the diatreme's emplacement and later fracturing accoutring due to prevailing extensional and compressive stresses.

(3) **Extremely shallow semi-confined laterite aquifer** system mainly located on the flanks of the carbonatite complex to the north. This occurs within a relatively thick laterite layer (estimated max thickness of 15m) developed mainly on the crystalline granites and gneisses. Waterlevels within this range from 0 to 2.5m, and it supplies most of Longonjo's residents with water. Several springs emanate from the flanks of the carbonatite in this region, and they are thought to be associated with the fenite/granite contact or faulting/fracturing within the granites.

(4) **Deeper seated unconfined to semi-confined crystalline granitic aquifer** located beyond the fenite perimeter and within the fractured and weathered granites. This system is associated with the deepest groundwater elevations ranging from about 20 to 25mbgl. This is likely to be the least productive of the 4 aquifers, and the drilling of any successful boreholes within this aquifer will depend heavily on the degree of weathering and fracturing encountered within the granites or the degree of secondary porosity developed.

At the time of the ESIA, these systems were theoretical and needed to be subjected to aquifer testing (scheduled for 2020). The aquifer testing provides aquifer statistics or parameters like volumes of water in storage (storativity), the permeability of the host rock formations and transmissivity or availability of groundwater for utilization.

4.7.7 Groundwater quality

4.7.7.1 First round of groundwater quality testing - 2019

The HCV Africa hydrogeologist took groundwater samples during the hydrocensus of April 2019 (Figure 4-31). Preparation for groundwater sampling was not ideal, as the boreholes were not purged but merely bailed with a PVC bailer from mostly open exploration boreholes. Laboratory certificates (sample analyses were undertaken in Luanda by Ambi Africa water laboratory) are available in the Hydrogeology specialist report. The result indicates that the groundwater is of good quality and is suitable for drinking in most instances. However, the volumes of water submitted to the lab did not allow for a comprehensive suite of chemicals to be analysed. Thus certain key elements like Ca and Mg were omitted. At least 2L of water should be sampled during future sampling activities, and the boreholes should be pumped or purged before sampling.

The groundwater quality results were compared to Angola's DMA water quality standards and the World Health Organization's (WHO) Drinking Water Guidelines, published in 2011 and summarized in Table 4-26. Sampling results indicate:

- Groundwater generally has a very low salinity (total dissolved solids (TDS));

- The pH of the water is generally in the neutral range (around pH7) but decreases within the laterite aquifer, where the pH averages 6.2 (CW01 and CW03);
- Metals like Copper and Iron are found in moderate to high concentrations, but neither exceed the WHO guidelines (2011);
- There are elevated levels of ammonia and detergents in certain boreholes and wells. These are likely to indicate some contamination from domestic activities, especially within community wells;
- Fluorides are present in high concentrations in some boreholes exceeding the WHO guidelines in borehole LRC048. These are likely to be naturally occurring and associated with high levels of Ca and Mg associated with the carbonatite. These do not, however, represent an immediate health risk; and
- Sulphate levels are all below laboratory detection limits, likely related to the $CaCO_3$ rich groundwater environment.

Table 4-26: Inorganic chemistry results for the boreholes and wells sampled, April 2019

Analyte	Units	Angola Max Recom	Angola Max Allow	WHO Guide-lines	WB01	LRC30	LRC048	LRC106	LRC120	LRC077	CW01	CW02	CW03
Ammonia	*mg/L NH 4*	0.05	1.5		<0.02	0.04	0.09	0.13	0.19	0.09	0.03	<0.02	<0.02
Boron	*mg/L B*	1	-		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	<0.05	<0.05
BOD	*mg/L O2*	3	-		2.1	2.1	3.1	37	2.4	3.1	1.5	1.4	1.3
Odour	*Factor*	3	-		0	0	0	1	0	0	0	0	0
Cyanide	*mg/L CN*	-	0.05		<0.01	<0.01	0.02	<0.01	<0.01	0.01	0.02	<0.01	0.02
Chlorides	*mg/L Cl*	200	-	**350**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Copper	*mg/L Cu*	0.02	-		0.04	0.02	0.04	0.04	0.05	0.03	0.09	0.04	0.18
Conductivity	*µS/cm*	1000	-		81	94	170	545	190	54	134	99	23
Colour	*mg/L PtCo*	10	100		6	30	30	17	18	19	51	15	51
Chromium	*mg/L Cr*	-	-		<0.030	0.038	<0.030	<0.030	<0.030	<0.030	0.055	0.03	<0.030
COD	*mg/L O2*	-	-		<15	<15	<15	37	<15	<15	<15	<15	<15
Detergents	*mg/L*	0.2	-		0.1	0.1	0.2	0.1	0.1	0.2	0.3	0.1	0.3
Iron	*mg/L Fe*	0.1	2	**0.3**	0.06	0.06	0.12	0.15	0.16	0.19	0.18	0.14	0.12
Flourides	*mg/L F*	0.7-1.0	7	**1.5**	0.6	0.5	**1.5**	1.4	1.3	0.35	0.2	0.26	<0.10
Phosphates	*mg/L P2O5*	0.4	-		<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
Manganses	*mg/L Mn*	0.05	-		<0.010	0.03	0.04	0.04	0.04	0.05	0.02	0.02	<0.010
Nickel	*mg/L Ni*	-	-		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrates	*mg/L NO3*	-	50	**50**	<5	<5	10	<5	14	<5	25	9	15
Oxidizability	*mg/L O2*	-	-		<0.47	<0.47	<0.47	1.9	<0.47	<0.47	<0.47	<0.47	0.48
pH	*E.Sorensen*	6.5-8.5	0 -		6.9	7.2	7.5	7.8	6.8	6.8	6.1	7.1	6.3
TDS	*mg/L*	-	-		47	260	1460	2830	1160	300	33	40	67
Sulphates	*mg/L SO4*	150	250	**500**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Turbidity	*NTU*	-	-		<1	239	483	1350	1390	209	23	17	98
Zinc	*mg/L Zn*	0.5	5		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
		<	***Below laboratory detection limits***										
		XXX	***Above World Health Organisation drinking water standards***										

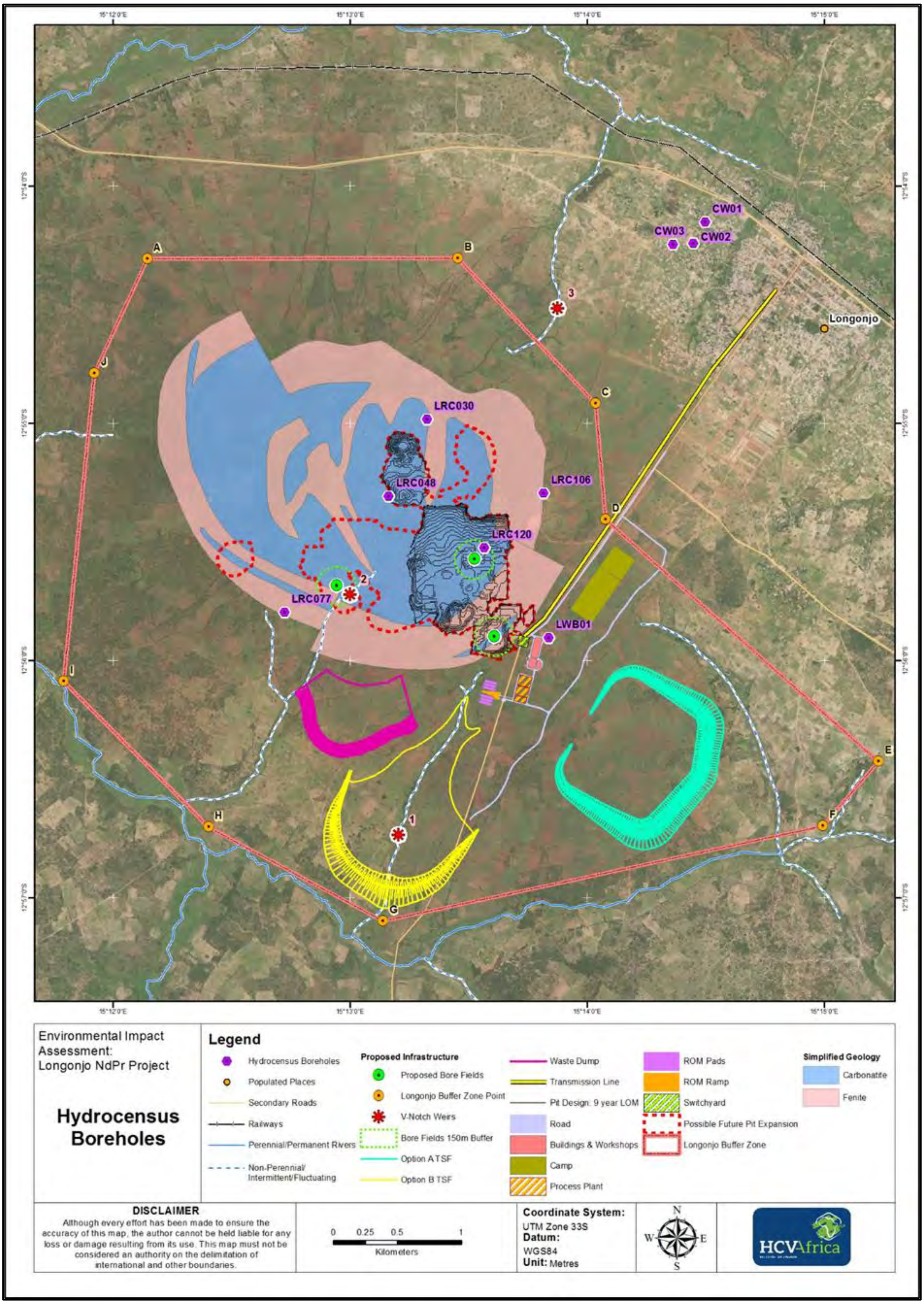


Figure 4-31: Groundwater sampling localities during 2019

4.7.7.2 Second round of groundwater testing - 2021

On completion of the drilling of the TSF monitoring boreholes, together with their equipping with piezometers and aquifer testing groundwater was sampled for analyses. Note that there are 7 physical monitoring locations around both the TSF 5 site and the TSF South (TSF9/10) site most of which are equipped with a shallow and deep piezometer (Figure 4-31).

Figure 4-32: Field water quality testing conducted on Site in Longonjo, 2021

The following water quality trends were observed from the 2021 sampling (Table 4-26):

- Good quality water with low salinity or Total Dissolved Solid (TDS) levels;
- Many of the chemical elements including metals were found to be below lab detection limits (grey cells in Table 4-26);
- Some analytes including ammonia, suspended solids and manganese exceed the local Angolan limits as set out within the presidential decree 261/11;
- Elements including fluoride, aluminium, cadmium, manganese and selenium also exceed both WHO and SANS 241 water quality standards in most instances (yellow);
- Additional chemical elements that are found in elevated concentrations are calcium, magnesium and barium; and
- Arsenic is also find in higher concentrations within LMB05 and LMB12/13 monitoring pair.

Other trends observed include are chemically stable groundwater environment on a month-by-month timescale on borehole BH1. There is some concern related to faecal coliform contamination within the drinking water borehole located adjacent to the camp (BH1), this should be monitored and adherence to proper sterile sampling protocols including cooling and 24 hour delivery to the laboratory need to be observed in order to obtain accurate bacterial concentrations.

Finally, there are subtle chemical differences within the shallower and deeper water qualities measured and certainly enough of a variation to indicate that the aquifer systems being sampled have different and distinct chemical footprints.

Table 4-26: Groundwater quality results based on the Laboratory Analysis, November 2021

ANALYTE	UNITS	DOMESTIC STANDARDS SANS 241	DOMESTIC STANDARDS WHO	ANGOLA PRESIDENT DECRETO 261/11	BH1 (Aug21) Deep Borehol	BH1 (Oct21) Deep Borehol	BH1 (Nov21) Deep Borehol	LMB01 (Nov21) Deep Piezo	LMB02 (Nov21) Shallow Piezo	LMB03 (Nov21) Deep Piezo	LMB04 (Nov21) Shallow Piezo	LMB05 (Nov21) Deep Piezo	LMB06 (Nov21) Deep Piezo	LMB07 (Nov21) Shallow Piezo	LMB08 (Nov21) Deep Piezo	LMB09 (Nov21) Shallow Piezo	LMB10 (Nov21) Deep Piezo	LMB11 (Nov21) Shallow Piezo	LMB12 (Nov21) Deep Piezo	LMB13 (Nov21) Shallow Piezo	LWB02 (Nov21) Deep Borehol	LWB05 (Nov21) Deep Borehol
Total Alkalinity	mg CaCO3/ℓ				34.00	34.00	35.00	99.00	96.00	192.00	74.00	158.00	173.00	542.00	121.00	128.00	96.00	175.00	244.00	234.00	163.00	155.00
Ammonia as N	mg N/ℓ	1.5	1.5	1	<0.015	<0.015	0.09	0.08	0.11	0.23	0.11	0.13	0.15	0.17	0.21	0.03	0.12	0.05	0.07	0.02	0.48	<0.015
Ammonia	mg NH3/ℓ				<0.02	<0.02	0.12	0.09	0.14	0.28	0.13	0.15	0.18	0.20	0.25	0.04	0.15	0.07	0.09	0.02	0.58	<0.02
Ammonium	mg NH4/ℓ			0.05	<0.02	<0.02	0.12	0.10	0.15	0.30	0.14	0.16	0.19	0.21	0.27	0.04	16.00	0.07	0.10	0.02	0.62	<0.02
Nitrogen as N	mg N/ℓ			1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cyanide Free	µg Cn/ℓ	200	70	50	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Cyanide	µg Cn/ℓ	200	70	50	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride	mg Cl/ℓ	300	250	200	<5	<5	6.00	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluoride	mg F/ℓ	1.5	1.5	0.7	0.30	0.30	0.21	1.00	0.70	0.70	0.20	0.70	1.10	0.40	<0.10	0.10	0.20	0.20	6.30	1.80	2.40	3.30
Phosphorus as P	mg P/ℓ				<0.15	<0.15	<0.15	0.18	0.21	0.33	0.21	0.23	0.36	0.40	0.65	0.38	0.17	<0.15	0.21	0.25	0.51	0.15
Phosphate	mg PO4/ℓ				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.06	0.32	<0.05	<0.05	<0.05	<0.05	0.19	<0.05
Phosphorus trioxide	mg P2O3/ℓ			0.4	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	1.00	<0.15	<0.15	<0.15	<0.15	0.68	<0.15
Nitrate	mg NO3/ℓ	50	50	25	<5	<5	<5	<5	<5	<5	<5	<5	<5	8.00	11.00	<5	27.00	<5	11.00	<5	<5	<5
Nitrite	mg NO2/ℓ	3			0.01	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	0.02	0.03	<0.005	0.01	<0.005	<0.005	<0.005	0.13	<0.005
Total Dissolved Solids	mg/ℓ 180℃	1200			35.00	35.00	34.00	90.00	87.00	166.00	73.00	144.00	155.00	55.00	115.00	114.00	90.00	156.00	286.00	219.00	156.00	141.00
Suspended solids	mg/ℓ			25	<5	<5	<5	<5	20.00	30.00	37.00	1080.00	43.00	47.00	113.00	440.00	77.00	1020.00	107.00	1080.00	13.00	15.00
Sulphate	mg SO4/ℓ	500		150	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5.00	<5	7.00	<5	31.00	10.00	6.00	5.00
Dissolved Calcium	mg Ca/ℓ	150			7.00	7.00	7.51	31	31	47	22	47	41	16.6	34	36	21	54	25	58	32	32
Dissolved Potassium	mg K/l	50			6.57	6.57	1.52	2.96	3.88	9.34	3.93	4.50	8.04	5.41	15.4	15.1	15.6	16.3	16.3	8.10	4.94	2.82
Dissolved Magnesium	mg Mg/ℓ				2.61	2.61	2.57	5.75	4.31	12.0	4.65	17.7	6.08	1.22	2.39	3.03	2.77	4.67	2.08	17.0	20	20.0
Dissolved Sodium	mg Na/ℓ	200	50		3.25	3.25	5.46	4.96	4.35	11.9	4.73	26	25	5.53	10.9	11.3	11.4	9.12	175	80	5.67	6.63
Dissolved Aluminium	µg Al/ℓ	300			12.30	12.30	9.5	64	184	438	239	5052	634	666	474	1058	580	1423	2766	6589	608	536
Dissolved Arsenic	µg As/ℓ	10	10	10	<1	<1	<1	<1	<1	<1	<1	48	2.3	<1	<1	1.5	<1	<1	5.8	2.8	<1	<1
Dissolved Boron	µg B/ℓ	2400	2400	1000	1.10	1.10	<1	<1	<1	3.5	<1	17.3	10.4	2.7	2.1	4.9	2.9	3.5	50	38	1.5	<1
Dissolved Barium	µg Ba/ℓ				1369.00	1369.00	1392	1627	1314	1985	802	1351	633	234	320	487	378	178	92	923	609	552
Dissolved Beryllium	µg Be/ℓ	700		100	<1	<1	<1	<1	<1	<1	<1	1.5	<1	<1	<1	1.0	<1	<1	<1	7.4	<1	<1
Dissolved Cadmium	µg Cd/ℓ	3	3	10	<1	<1	<1	2.0	11.6	<1	3.1	13.1	<1	6.8	4.5	6.3	14	12.0	<1	6.2	<1	<1
Dissolved Cobalt	µg Co/ℓ	500			<1	<1	<1	<1	<1	1.3	<1	4.2	<1	<1	<1	2.9	<1	1.1	1.2	16.7	<1	<1
Dissolved Chromium	µg Cr/ℓ	2000	2000	20	1.50	1.50	6.0	4.9	8.4	4.5	3.3	<1	4.0	36	7.4	11.1	3.4	1.6	5.3	18.7	4.1	7.1
Dissolved Copper	µg Cu/ℓ	50	50	50	3.30	3.30	3.5	2.2	78	5.0	2.5	7.4	2.0	5.3	7.0	17.6	6.2	1.9	9.0	34	4.3	17.6
Dissolved Iron	µg Fe/ℓ	2000	2000	100	43.00	43.00	35	59	1347	227	135	1140	295	395	181	280	302	144	947	3411	708	3680
Dissolved Mercury	µg Hg/ℓ	6	6	0.5	2.80	2.80	<1	<1	<1	<1	<1	1.4	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Lithium	µg Li/ℓ				4.80	4.80	3.2	2.9	1.6	1.5	3.8	28	8.8	2.8	2.8	3.2	2.7	1.4	12.5	23	4.6	4.0
Dissolved Manganese	µg Mn/ℓ	400	400	10	1.30	1.30	10.6	55	94	752	121	1233	134	36	94	159	48	126	49	555	892	345
Dissolved Nickel	µg Ni/ℓ	70	70		<1	<1	3.0	3.1	5.3	4.5	2.4	14.2	2.5	3.6	5.7	13.2	3.8	2.4	5.3	24	2.7	4.2
Dissolved Lead	µg Pb/ℓ	10	10	50	<1	<1	<1	7.2	7.2	14.0	8.5	29	8.4	7.8	14.1	16	38	17.3	17.6	21	7.1	7.0
Dissolved Antimony	µg Sb/ℓ	20	20		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3.8	<1	<1	<1
Dissolved Selenium	µg Se (vi)/ℓ	10	10	10	<1	<1	<1	<1	<1	1.0	2.1	83	1.6	1.3	<1	8.2	12	3.3	1.3	11.9	1.7	1.2
Disolved Uranium	µg U/ℓ	30			<1	<1	<1	<1	<1	1.8	<1	12.8	<1	<1	<1	1.1	<1	1.8	7.0	7.7	<1	<1
Dissolved Vanadium	µg V/ℓ	200			<1	<1	<1	2.4	4.6	5.2	2.9	4.1	7.0	6.9	6.0	8.3	3.5	6.1	54	35	2.0	<1
Dissolved Zinc	µg Zn/ℓ	5000	3000	500	19.20	19.20	18.2	25	32	12.0	15.1	113	17.7	30	14.8	35	65	8.3	19.0	82	18.7	16.0
Total Alkalinity	mg CaCO3/ℓ				26.07	26.07	25.30	27.97	25.73	26.90	25.80	26.97	26.97	27.10	27.03	28.07	25.40	25.87	25.90	25.53	24.00	23.70
pH	pH units	5-9.7		6.5-8.5	6.02	6.02	5.64	6.70	6.61	7.25	6.50	7.60	7.50	6.34	6.81	6.88	6.89	7.03	9.19	7.69	7.81	8.03
Electrical Conductivit	mS/m	170		100	7.57	7.57	7.52	20.04	18.57	34.07	14.89	29.47	35.93	12.32	25.40	26.20	14.09	34.17	72.77	49.07	34.10	30.90
Water Temperatur	Deg.C				26.07	26.07	25.30	27.97	25.73	26.90	25.80	26.97	26.97	27.10	27.03	28.07	25.40	25.87	25.90	25.53	24.00	23.70
Total Coliforms	no. per 100ml				3.00	3.00	16.00															
E.coli	no. per 100ml	0			0.00	0.00	0.00															
Faecal Coliforms	no. per 100ml	10		20	0.00	0.00	2.00															

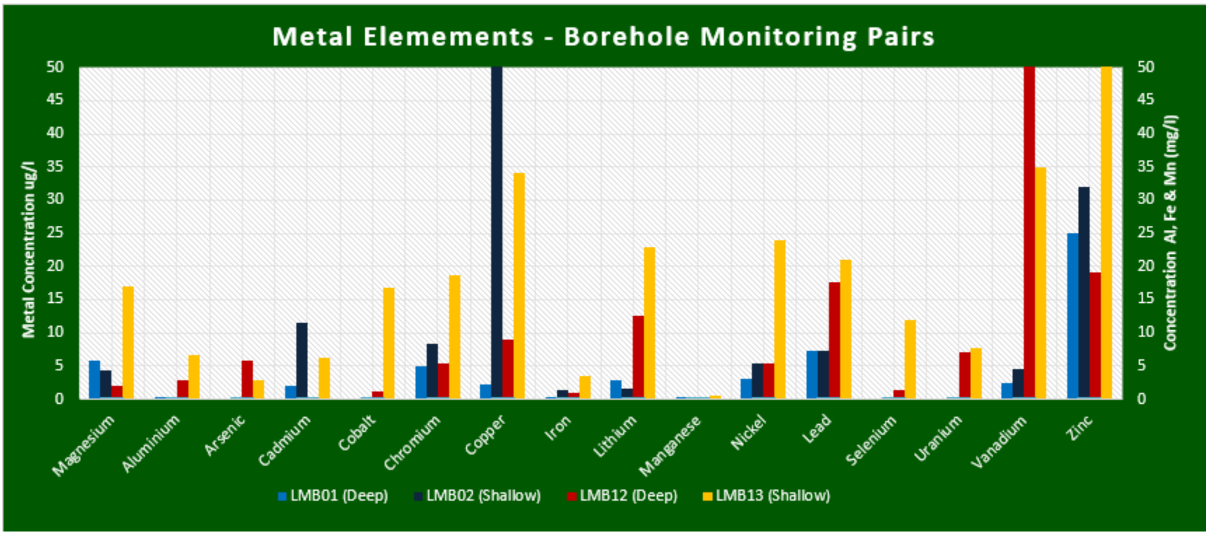


Figure 4-33: Comparrision of metal concentations in the groundwater of the deep and shallow aquifer systems

In general, the shallow aquifer systems appear to have higher concentrations of both macro chemical elements (sulphate, nitrate and fluoride) and metals. This trend is also reflected in the TDS concentration which reflects a lower salinity in the shallow aquifer rather than the deeper-seated system. Elevated metal concentrations were mostly observed in the shallower aquifers. There are, however, so exception which include chemical elements like arsenic which appear more prevalent deeper down in the groundwater column.

4.7.8 Conceptual model of the hydrogeology

This section draws on all the available hydrogeological information of the Project Area into a conceptual hydrogeological model (CHM), including the 2021 drilling program at the proposed TSF localities (TSF 5 and TSF 9/10). Typically, the CHM interprets the geology and hydrogeology of the area, which is updated regularly as more information becomes available and improvements are made regarding the knowledge relating to groundwater. Conceptually four aquifer systems have been identified in the Project Area (section 4.7.6), defined as the:

- Elevated weathered carbonatite aquifer;
- Fractured fenite hosted aquifer;
- Crystalline semi-confined fractured granitic aquifer; and
- Shallow unconfined lateritic aquifer.

The laterite aquifer is the shallowest and the granitic aquifer the deepest. It is interesting to note that if the groundwater levels are plotted in meters above mean sea level (mamsl), it becomes clear that the carbonatite diatreme has the highest water levels, and this aquifer system feeds into the lower-lying systems. The highly weathered karstic carbonatite aquifer stores abundant groundwater and releases to / recharges the adjacent systems at lower elevations.

The CHM in Figure 4-34 shows a geological section through the Project area provided by Pensana and intercepts as many of the exploration boreholes as practically possible, including the new boreholes drilled at the proposed TSF localities. Groundwater levels in these boreholes were measured both during the hydrocensus and later by members of the Pensana geology team on-site.

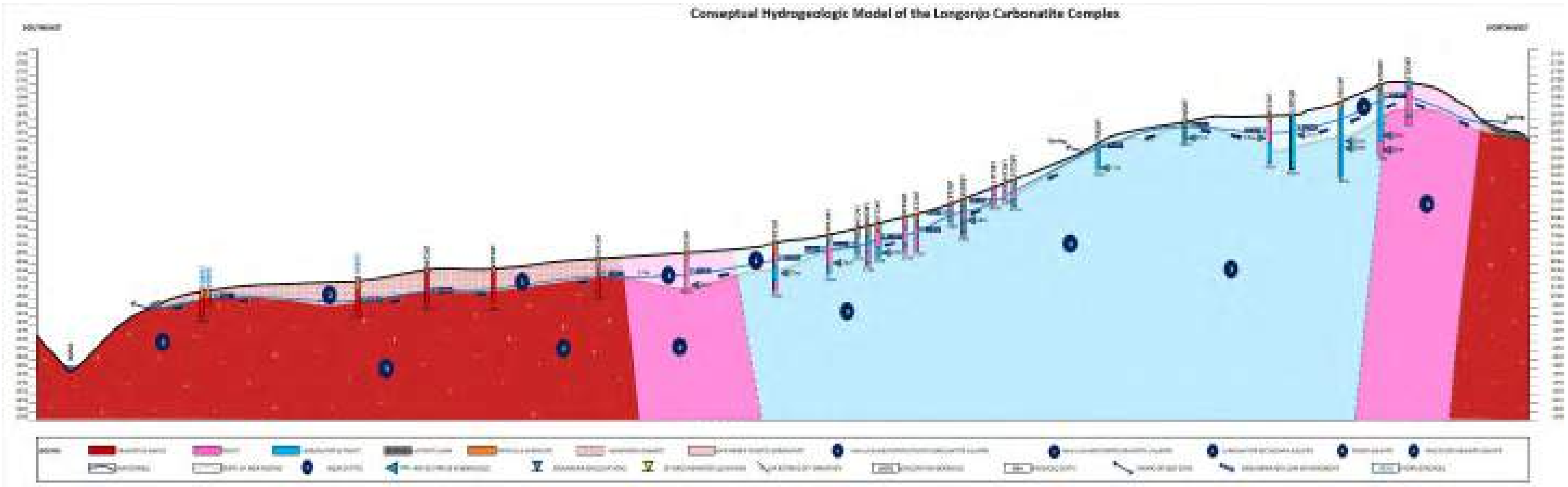


Figure 4-34: Conceptual Hydrogeologic Model of the Longonjo Carbonatite Complex

The baseline data analysed and compiled into a conceptual model is simplified and summarised below as there are 2 aquifers in the area:

- Upper weathered material that can extend to a maximum depth of about 30 meters; and
- the underlying competent and fractured rock, mostly crystalline granite.

The upper aquifer forms due to the vertical infiltration of recharging rainfall through the weathered material being retarded by the lower permeability of the underlying competent rock. This aquifer is generally more productive and transmissive than the fractured hardrock aquifer and stores slightly more saline water at a higher pH. Groundwater collecting within the weathered aquifer interface with the hardrock, migrates down gradient along the contact to lower lying areas. In places where the contact is near surface the groundwater can daylight on surface as springs or seepage into the surface streams. Where significant springs or seepage areas are found, a laterite or ferricrete build-up is often associated with these locations. This is a reflection of long-term water flow and the deposition of iron and other minerals as they oxidize from the groundwater near surface.

Groundwater flows in the lower aquifer are associated with secondary fracturing in the competent rock and as such will be found along discrete pathways associated with the fractures. Faults and fractures can be a significant source of groundwater depending on whether the fractures have been filled with secondary mineralisation or are open in nature.

In general this deeper aquifer system stores less water and is less productive than the upper weathered system. It also contains groundwater that is slightly less saline (better quality) with a lower pH. This is mostly due to the fact that the water is associated with hard crystalline granite that has less dissolved salts available and has also percolated though the upper weathered aquifer indicated by a slight drop in pH.

Airlift testing conducted on the 13 monitoring boreholes (LMB01-13) drilled around the 2 proposed TSF footprints yielded highly variable transmissivities for the local aquifers. Transmissivities for the upper weathered aquifer range from 0.18 to 0.001 m^2/day. These values are low, but consideration needs to be given to the fact that the testing only included a 3m screen interval situated just below the water table. Therefore, relatively higher transmissivities appear to be representative of the upper weathered aquifer.

The lower fractured secondary granitic aquifer had slightly lower transmissivities ranging from 0.15 to 0.001 m^2/day. Again the airlift testing only included the 3m screened off section of the borehole and may have been enhanced by a leaky relationship with the upper weathered aquifer. Consideration also needs to be given to the fact that sophisticated geophysics was used to site these boreholes and as such they are likely to have been sited within highly transmissive fracture systems. As a result, the deeper boreholes may represent the higher end of the transmissivity values and not be representative of the entire aquifer system.

The updated CHM (Figure 4-34) tentatively ranks the aquifer systems from the most productive to that considered least productive as follows:

(1) Shallow weathered carbonatite and fenite aquifer systems
(2) Shallow weathered saprolitic granite system
(3) Deeper fractured and karstic carbonatite aquifer
(4) Deeper fractured fenite aquifer
(5) Deeper fractured granite aquifer system

The deeper granitic aquifer system is certainly the least productive and transmissive and, in some instances, may even be impermeable where it is not fractured and more massive in nature. This is why there is a system of springs and seepage zones related at the point where the granite outcrops at surface or is found close to the surface.

Groundwater flow patterns are considered to generally follow topography, with flows occurring from the higher lying areas towards the lower lying areas and rivers. The mean annual precipitation (MAP) in the study area is about 1200 mm per annum, with the rate of groundwater recharge estimated to be around 3 to 4% of MAP.

4.8 Noise

The Project site noise profile is that of a typical rural setting with no noise sources from commercial / industrial development. Baseline noise monitoring was conducted in June 2019. Noise measurements were taken to define existing ambient noise levels at the Project area, specifically at selected identified sensitive receptors. Noise levels were measured using a Type 1 Brüel & Kjær / 2250 / 3024363 / 404033 Class 1 Sound Level Meter, equipped with a Brüel & Kjær / 4189 / 3147663 microphone and Brüel & Kjær / ZC0032 / 27362 pre-amplifier. The equipment has a measurement uncertainty based on ISO 1996-2: 2007, which yields a combined standard uncertainty value of 1.8dB and expanded measurement uncertainty of +/- 3.6dB. Monitoring was conductedfollowing guidance from the monitoring methodology detailed in "*Guia Prático para Medições de Ruído Ambiente*" (Practical Guide to Environmental Noise Measurements), which is based on the Portuguese Norm NP ISO 1996, and with the requirements of the IFC Environmental, Health, and Safety (EHS) Guidelines General Environmental Health Standards Guidelines: Environmental Noise Management, 2007.

Noise monitoring points are shown in Figure 4-35.

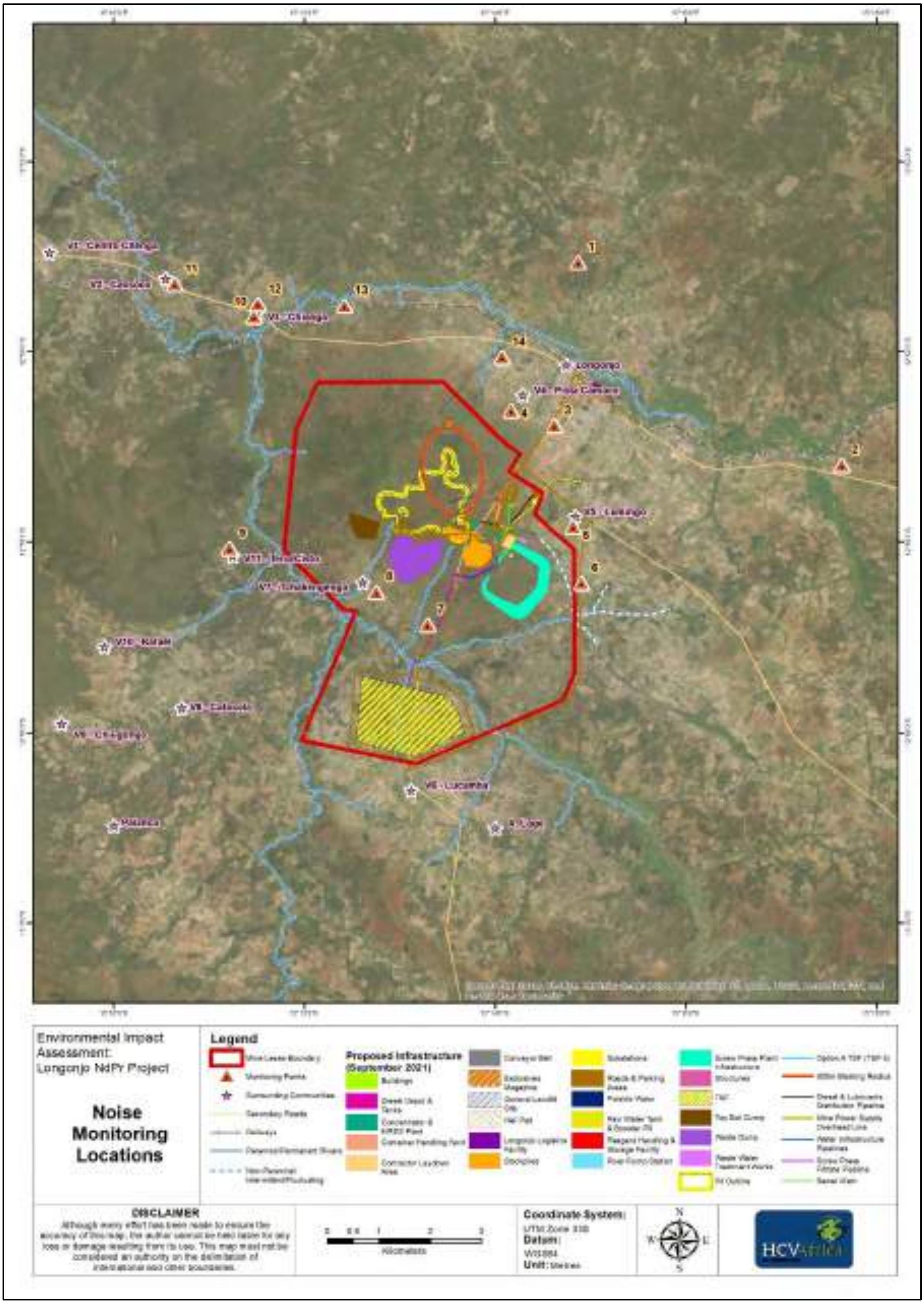


Figure 4-35: Noise monitoring localities

Noise levels were higher in the vicinity of the roads and lowered in the vicinity of the villages as there were fewer noise sources increasing ambient noise levels. The distance between the point and linear noise sources will determine the level of the environmental noise source. The results of the noise survey are illustrated in Table 4-27 (daytime - 1st period), Table 4-28 (daytime - 2nd period) and Table 4-29 (night-time period) (The "remarks column" contextualises instances with elevated noise readings). The L_{90} value is a statistical value that indicates the ambient noise level.

Table 4-27: Measured environmental noise levels - day time (1st period)

Measuring point	L_{Aeq}	L_{Amax}	L_{Amin}	L_{90}	Remarks
1	52.0	75.0	33.2	38.0	Domestic with motorcycles (18) and domestic animals in the vicinity of the main road.
2	54.7	75.5	36.3	38.6	Along the feeder road with motor vehicles (42), heavy duty vehicles (8), motorcycles (28) and a generator.
3	39.5	54.8	33.1	36.4	Domestic noise with motor vehicles (2) and motorcycles (7).
4	45.8	69.0	36.4	41.5	Domestic with amplified music, children playing and football match at a distance.
5	44.7	71.0	33.2	37.4	Outskirts of the village with domestic noises such as chickens, cows and goats.
6	41.0	69.2	24.0	29.6	Rural area along gravel road with 1 motorcycle and wind noise.
7	40.0	66.7	27.2	31.2	Along feeder road with motor-vehicles (7), motorcycles (5) and wind noise.
8	40.1	61.3	19.9	24.5	Outskirts of Village V7 with motorcycles (8).
9	46.4	59.7	33.5	43.5	Outskirts of Village V11 with distant barking of dogs.
10	42.3	63.8	27.2	32.5	At village V3 with motor vehicle (19), heavy vehicles (8) and motorcycles (3) at a distance.
11	41.0	72.4	25.5	28.2	Village V2 next to feeder road - 110m with motor vehicles (17), heavy vehicles (6), motorcycles (3) noises and domestic animals.
12	38.6	61.1	25.3	29.4	Village V3 next to feeder road - 180m with motor vehicles (18), heavy vehicles (8) noises and domestic animals.
13	33.7	57.8	24.8	27.0	No Train activities and distant intermittent traffic noise.
14	39.8	58.9	29.5	33.3	Western side of the village (V4) close to the main feeder road (280m) with motor vehicles (14), heavy vehicles (8) and 2 motorcycle noises.

Table 4-28: Measured environmental noise levels - day time (2nd period)

Measuring point	L_{Aeq}	L_{Amax}	L_{Amin}	L_{90}	Remarks
1	48.6	69.8	34.8	39.7	Traffic along the main road.
2	54.2	71.0	40.7	44.9	Along the feeder road with motor vehicles (24), heavy and motorcycles (19) and a generator.
3	48.1	65.1	32.2	38.1	Domestic noise with motor vehicles (2) and motorcycles (5).
4	36.4	71.0	27.9	29.9	Domestic noises and a generator at a distance.
5	51.2	75.7	31.6	38.4	Outskirts of the village with domestic noises such as goats, motorcycle (1) and a church bell.
6	38.5	67.1	18.5	21.5	Rural area along gravel road with 1 motorcycle and cow noises.
7	30.9	56.3	23.5	25.3	Along feeder road with motor vehicle (4)
8	40.7	71.3	24.1	26.3	Outskirts of Village V7 with motorcycles (1) and distant domestic animals.
9	No noise reading done due to logistical problems				
10	46.6	74.3	25.7	31.7	At village V3 with motor vehicle (26), heavy vehicles (8) and motorcycles (10) at a distance. Increased motor vehicles due to a funeral.
11	42.5	58.7	27.3	30.3	Village V2 next to feeder road - 110m with motor vehicles (11), heavy vehicles (6), motorcycles (5) noises and domestic animals.

12	40.0	65.2	23.2	27.4	Village V3 next to feeder road - 180m with motor vehicles (16), heavy vehicles (3) noises and domestic animals.
13	30.5	58.6	22.4	23.9	No Train activities and distant Intermittent traffic noise.
14	48.9	75.8	22.2	25.3	Western side of the village (V4) 280 m from the main road with distant traffic noise.

Table 4-29: Measured environmental noise levels – night-time

Measuring point	L_{Aeq}	L_{AMax}	L_{AMin}	L90	Remarks
1	31.1	52.3	20.8	23.0	Traffic along the main road with noise from motor vehicles (7) and construction vehicles (4).
2	50.4	76.6	31.0	34.0	Along the feeder road with noise from motor vehicles (4), heavy (5).
3	33.3	56.9	23.0	27.7	Noise from motor vehicles (1) and motorcycles (4).
4	28.4	57.2	17.8	19.1	Domestic noises.
5	30.9	65.3	17.0	18.2	Domestic animal noises.
6	21.6	48.1	17.4	17.9	Domestic animal noises.
7	23.7	57.4	16.9	17.3	Domestic animal noises.
8	25.6	61.3	17.8	19.0	Domestic animal noises.
9	40.2	63.0	19.5	22.5	Domestic animal noises.
10	33.8	57.8	19.8	22.9	At village V10 motor vehicle (8) and distant amplified music.
11	41.7	67.5	20.5	24.6	Village V2 next to feeder road - 110m with motor vehicles (2) noise.
12	33.7	55.9	18.0	19.6	Village V3 next to feeder road - 180m with motor vehicles (11) noises.
13	31.2	48.0	19.1	21.0	No Train activities and distant Intermittent traffic noise.
14	35.9	61.3	19.3	22.4	Western side of the village (V4) 280 m from the main road with motor vehicle (6) and construction vehicles (3) distant traffic noise.

4.8.1 Elevation profiles

The topography of an area under development will play a significant role in how sound from a source will be propagated. Topographical features such as hills, valleys and elevation levels may create natural barriers between the different mining activities (noise sources) and the abutting residential areas. The elevation profiles are illustrated in Figure 4-36 and Figure 4-40. The elevation profiles appear somewhat exaggerated due to the scale, and the landscape is undulating with a protrusion (mountain) where the mining will take place.

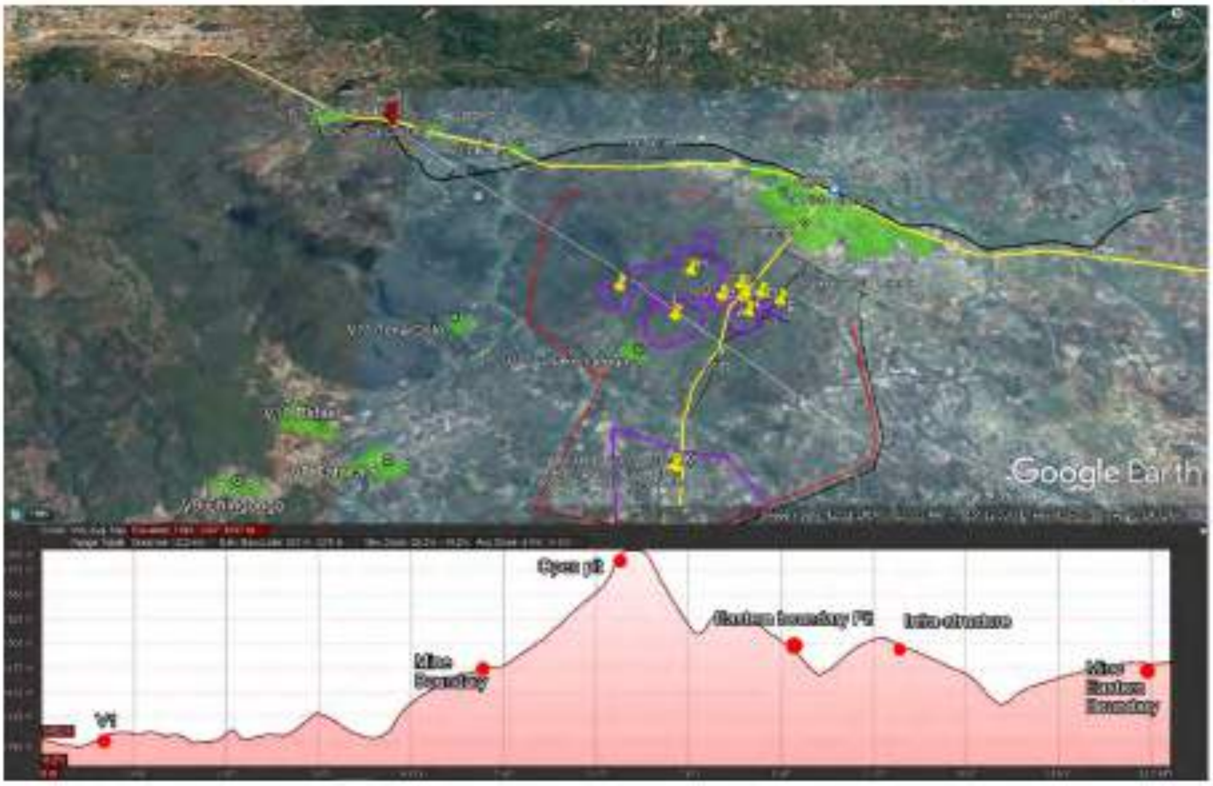


Figure 4-36: Elevation profile between V8, V9, V10 and north-eastern side of the Project Area

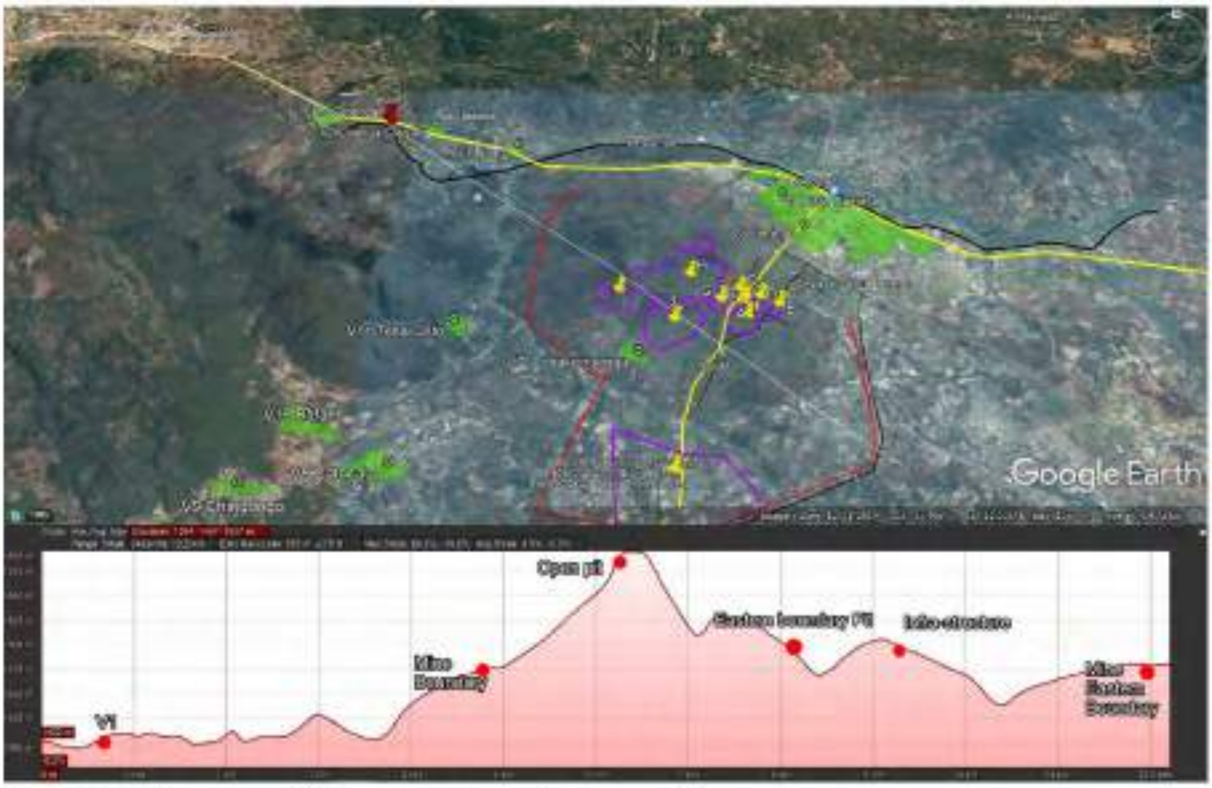


Figure 4-37: Elevation profile between V1 to south-eastern side

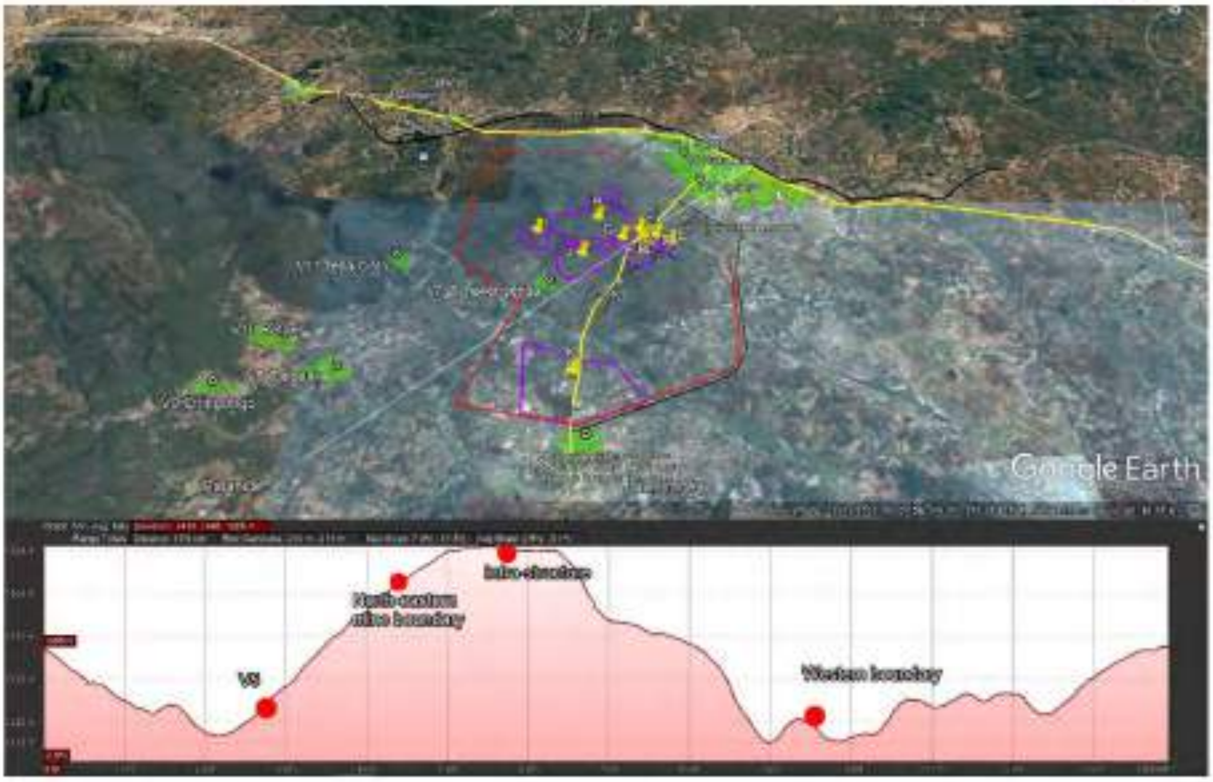


Figure 4-38: Elevation profile between V4 and V5 to the southwestern side

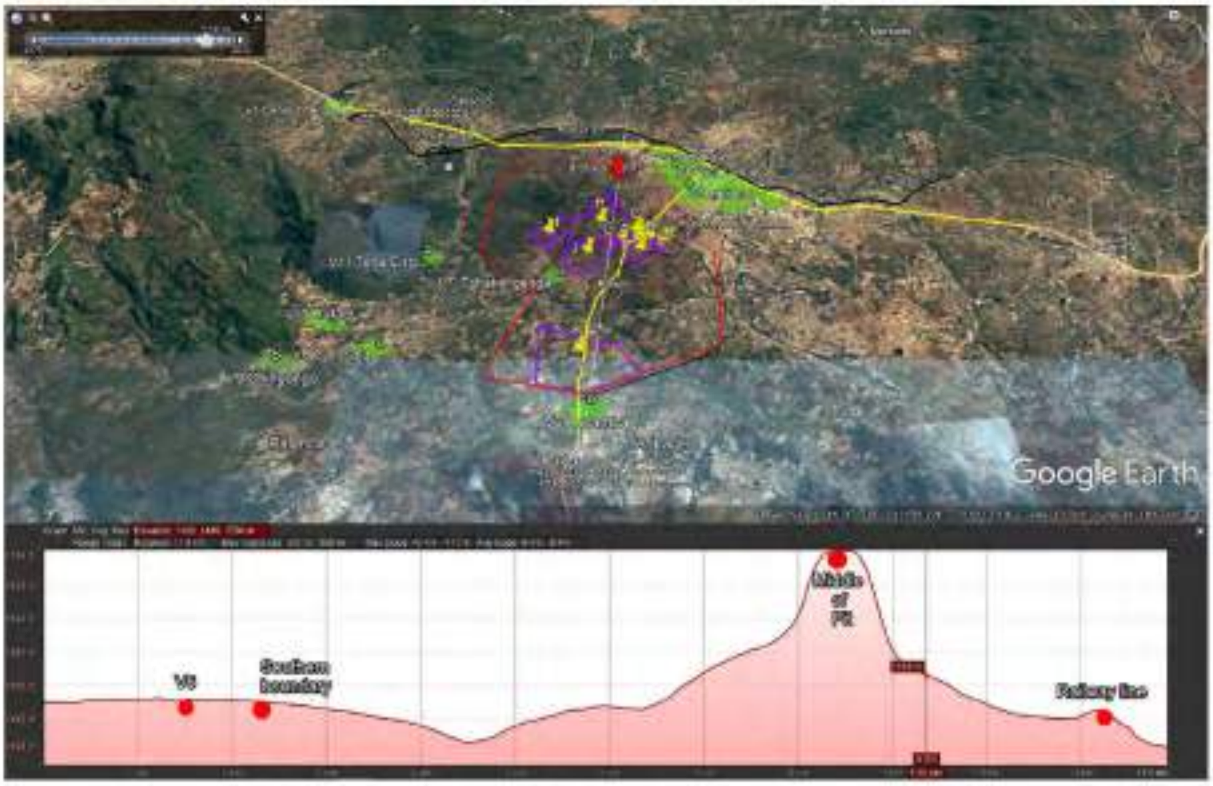


Figure 4-39: Elevation profile between V6 and the railway line

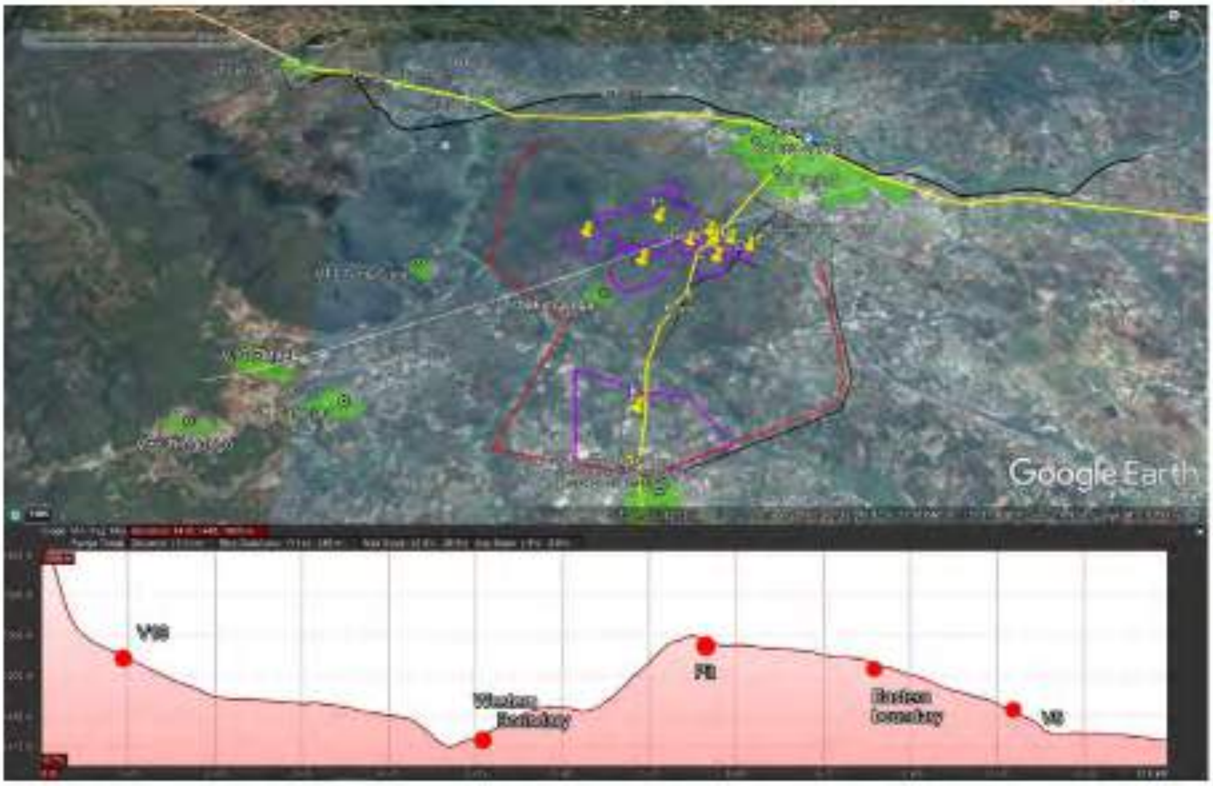


Figure 4-40: Elevation profile between V10 to V11 and north-eastern side of the Project Area

4.9 Soils

According to standard methods and techniques, a soil survey was undertaken in 2019 and 2021 on a flexible grid. Soil survey observation points are shown in Figure 4-41 and Figure 4-42. The soil survey field data is summarized in the Soils Specialist Study (Appendix G). Soil sampling localities are shown in Figure 4-43 (2019) and Figure 4-44 (2021).

As the Project progressed from the pre-feasibility phase to the IFS stage, several adjustments to the mine layout took place, especially regarding the placement of the tailings storage facilities (TSFs). Based on soil survey data and other ESIA Specialist Studies (e.g. vegetation distribution as presented in the Botany Specialist Study), extrapolation methods based on our understanding of the Project site was applied to extend the soil maps into the un-surveyed areas.

Figure 4-45 shows the distribution of the different soil types on the Project area (Taxonomical classification system):

- Avalon.
- Bainsvlei.
- Brandvlei.
- Clovelly.
- Hutton.
- Mispah.
- Plooysberg.

Hutton is the dominant soil type according to the latest version of the *South African Taxonomical Soil Classification System.*

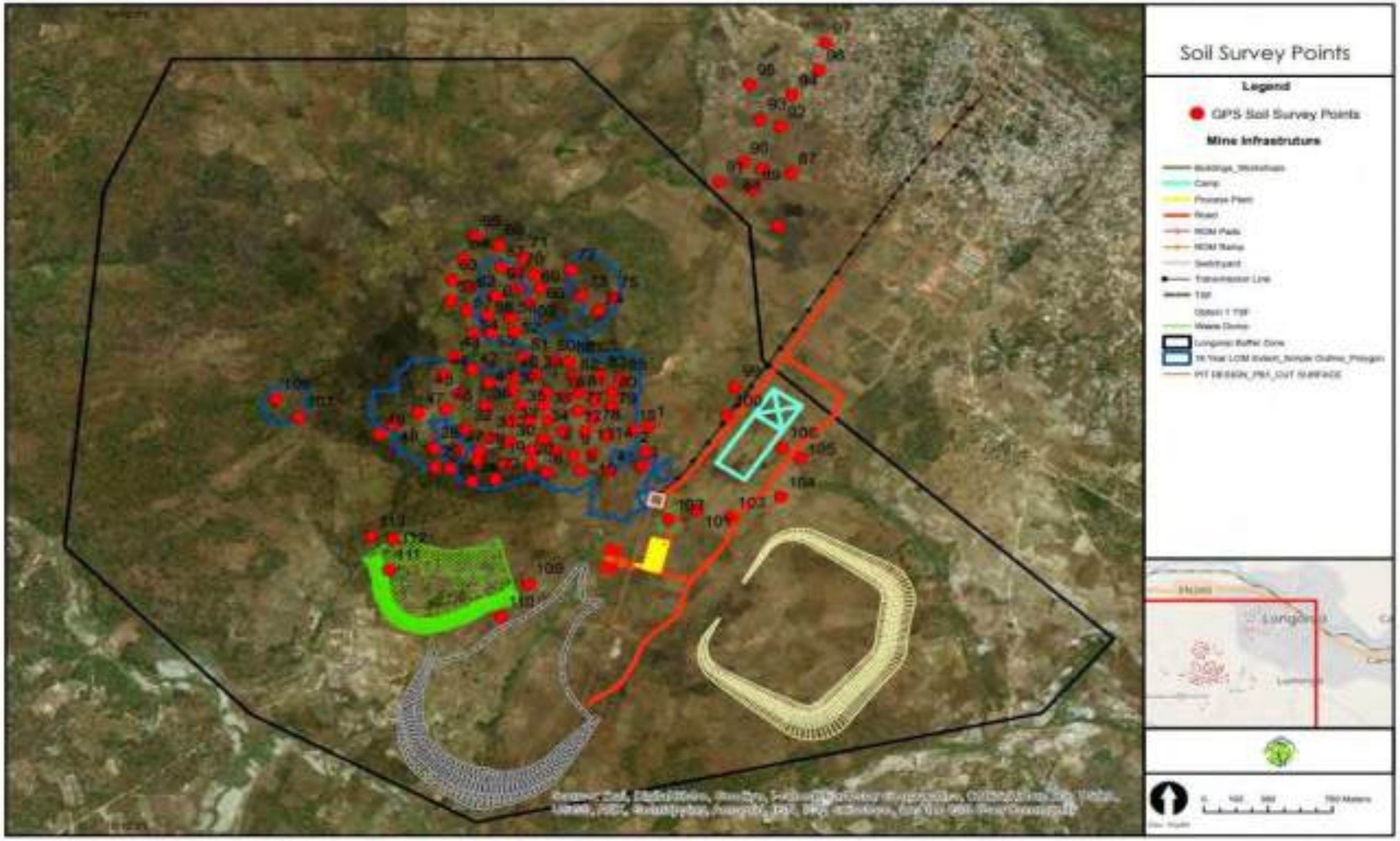


Figure 4-41: Soil Survey Observation Points (June 2019)

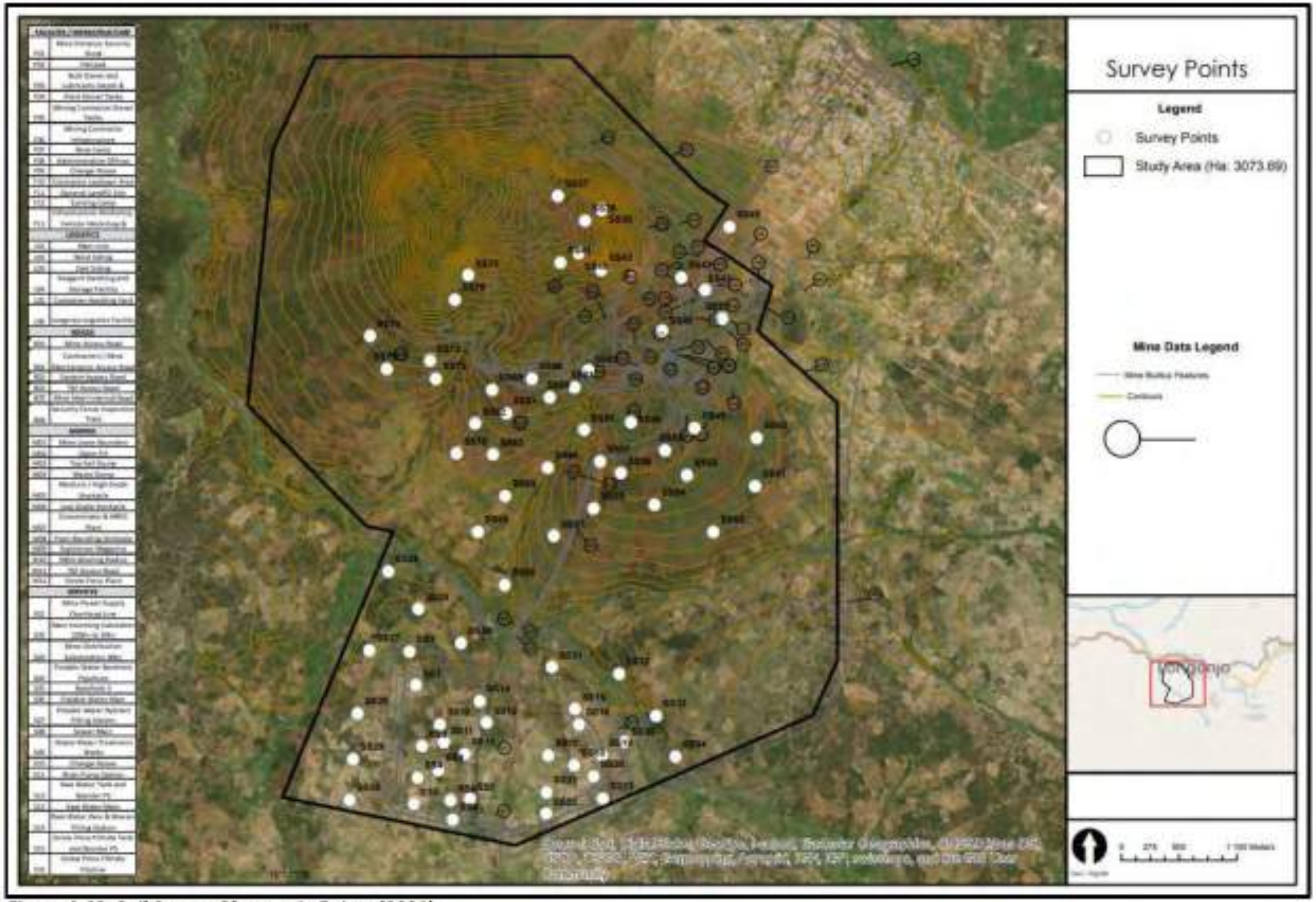


Figure 4-42: Soil Survey Observatio Points (2021)

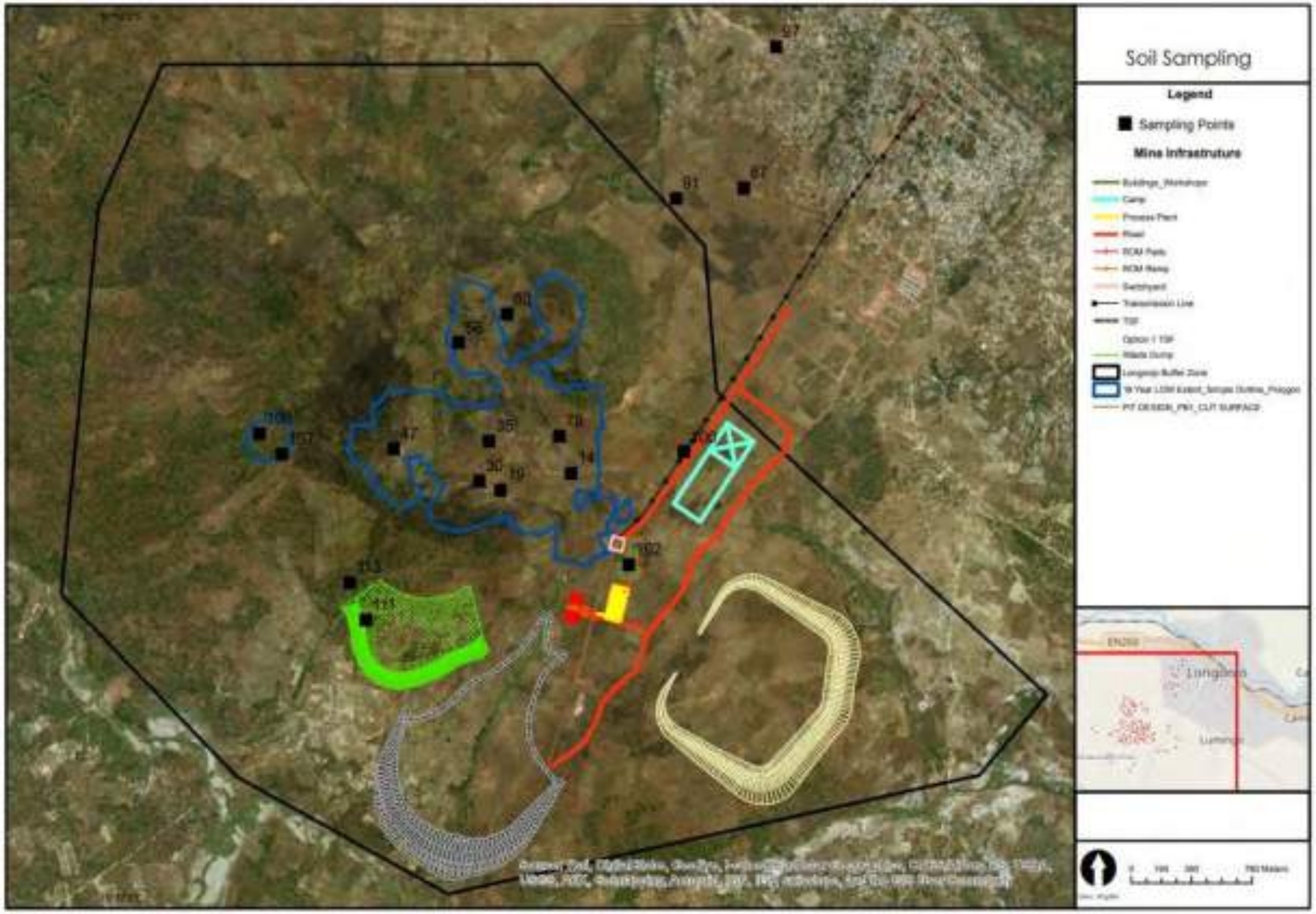


Figure 4-43: Soil Sampling Points (2019)

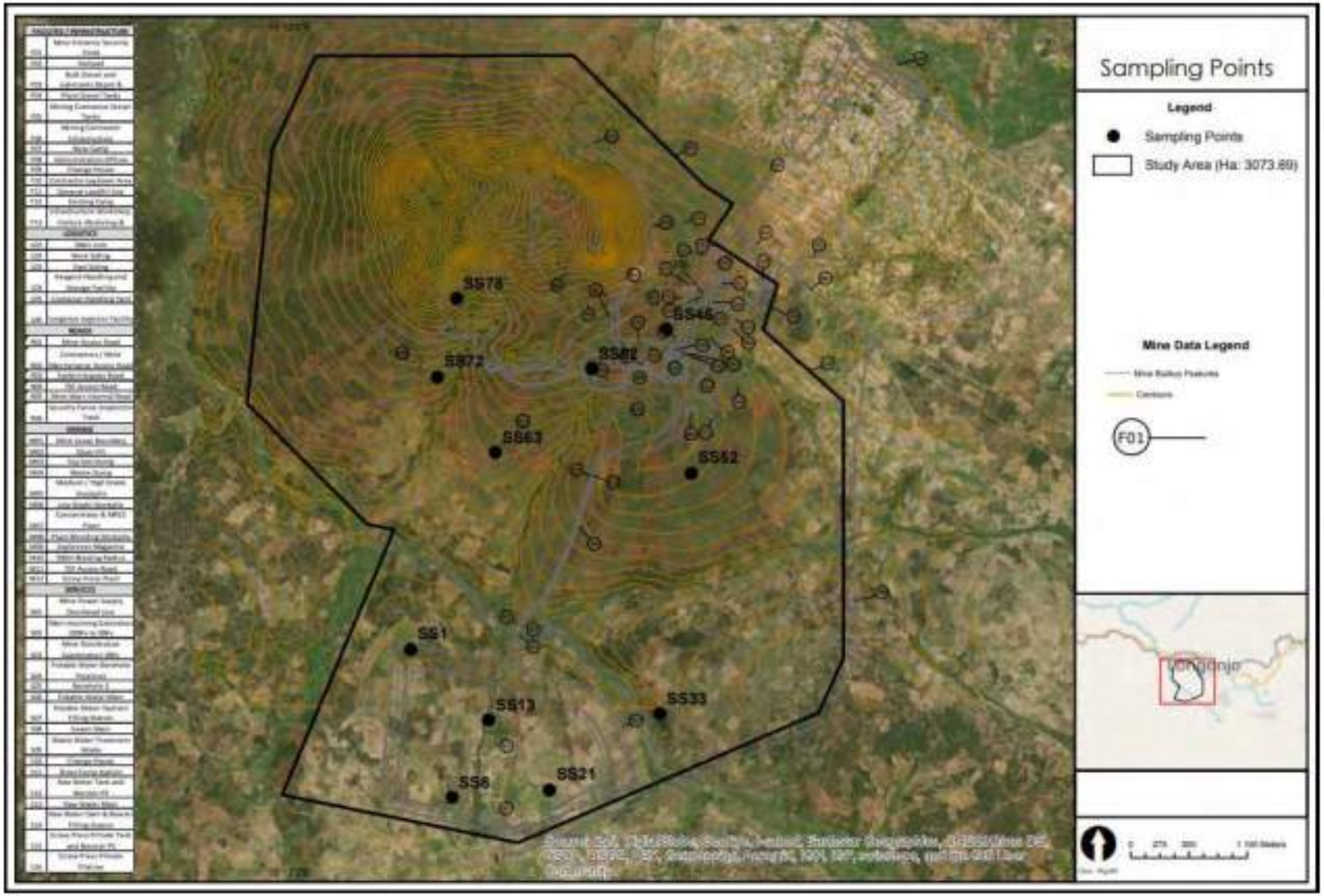


Figure 4-44: Soil Sampling Points (2021)

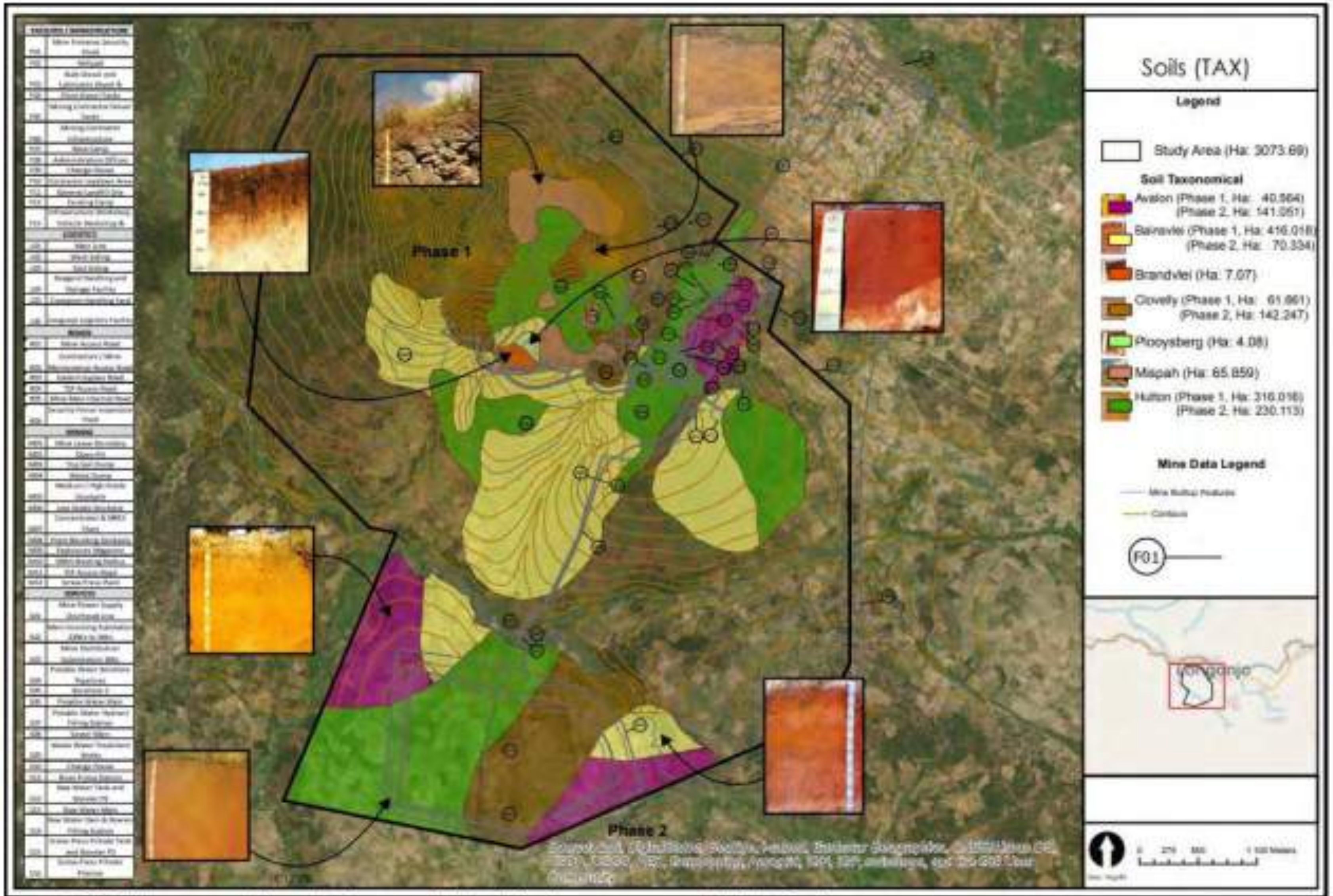


Figure 4-45: Soil types according to the Taxonomical classification system recorded in the Project area

The different soil types recorded in the Project area are shown in Figure 4-46.

Figure 4-46: Avalon, Bainsvlei, Brandvlei, Clovelly, (Top), Hutton, Mispah and Plooysberg (Bottom) (accoding to the Taxonomical system)

The characteristics of the soils in the Project area, are summarised in Table 4-30.

Table 4-30: Soil Types according to the Taxonomical system

Soil Type	Diagnostic Horizons	Effective Depth (mm)	Ha
Avalon	Orthic A/Yellow Brown Apedalic B/Soft Plinthic B-Horizon	>300	181.61
Bainsvlei	Orthic A/Red Apedalic B/Soft Plinthic B-Horizon	>300	486.35
Brandvlei	Orthic A/Soft Carbonate B-Horizon	>300	7.07
Clovelly	Orthic A/Yellow Brown B/Unspecified Horizon	>300	203.90
Hutton	Orthic A/Red Apedalic B/Unspecified Horizon	>300	522.129
Mispah	Orthic A/Hard Rock	<300	65.859
Plooysberg	Orthic A/Red Apedalic B/Hardbank Carbonate Horizon	>300	4.08

The diagnostic horizons in Table 4-30 are described below:

- **Orthic A–Horizon**: is a surface horizon containing an abundance of organic material darkened by organic matter, occurring over virtually the full range of soil-forming conditions encountered in Southern Africa, including Angola. The horizon excludes the properties of organic, humic, vertic or melanic topsoil horizons.
- **Red/Yellow Apedalic B–Horizon**: Characterised by 1:1 clay minerals, *i.e.* kaolinite and oxides of iron and manganese. The clay percentage ranges between 10 and 20% (hydrometer method), and due to the low clay content, there is a lack of structure. In some instances, 2:1 clay minerals are present due to the influx and drainage of 2:1 clays. The Fe and Mn concretions indicate oxidation and reduction conditions due to a fluctuating water table. The main difference between the Yellow and Red Apedalic horizon is that Fe is present in the oxidised (red) and reduced (yellow) states. From a contamination perspective, if the of the soil solution's pH would go below 5,3 the Fe and Mn would go into solution together with all other heavy metals present in the soil matrix. Therefore, the plinthic layer should not be mixed with other soil layers during topsoil stripping.

- **Soft Plinthic B-Horizon**: This horizon is characterized by oxidation and reduction conditions induced by a fluctuating water table, causing Fe and Mn concretions to form.
- **Hard Rock-Horizon**: This horizon would be a function of the geology.
- **Hard/Soft Carbonate-Horizon**: This horizon will primarily be constituted of carbonates in a combination of Ca, Mg and / or Ca-Mg as a function of the weathered geology and/or soil-forming processes. The consistency thereof might vary from soft to hard.

The soils were initially classified according to the Taxonomical Soil Classification System. It is a more precise and diverse classification system than both the FAO and USDA soil classification systems and will be used during the rehabilitation and closure quantum. The soils were furthermore classified according to the FAO classification system.

Figure 4-47 shows the distribution of the different soil types (FAO):

- Cambisol
- Ferralsol
- Fluvisol
- Lithosol

The Fluvisol soil covers 60.7% (738ha) of the 3,073ha study area.

Figure 4-47: Cambisol, Ferralsol, Fluvisol and Lithosol accoding to the FAO system

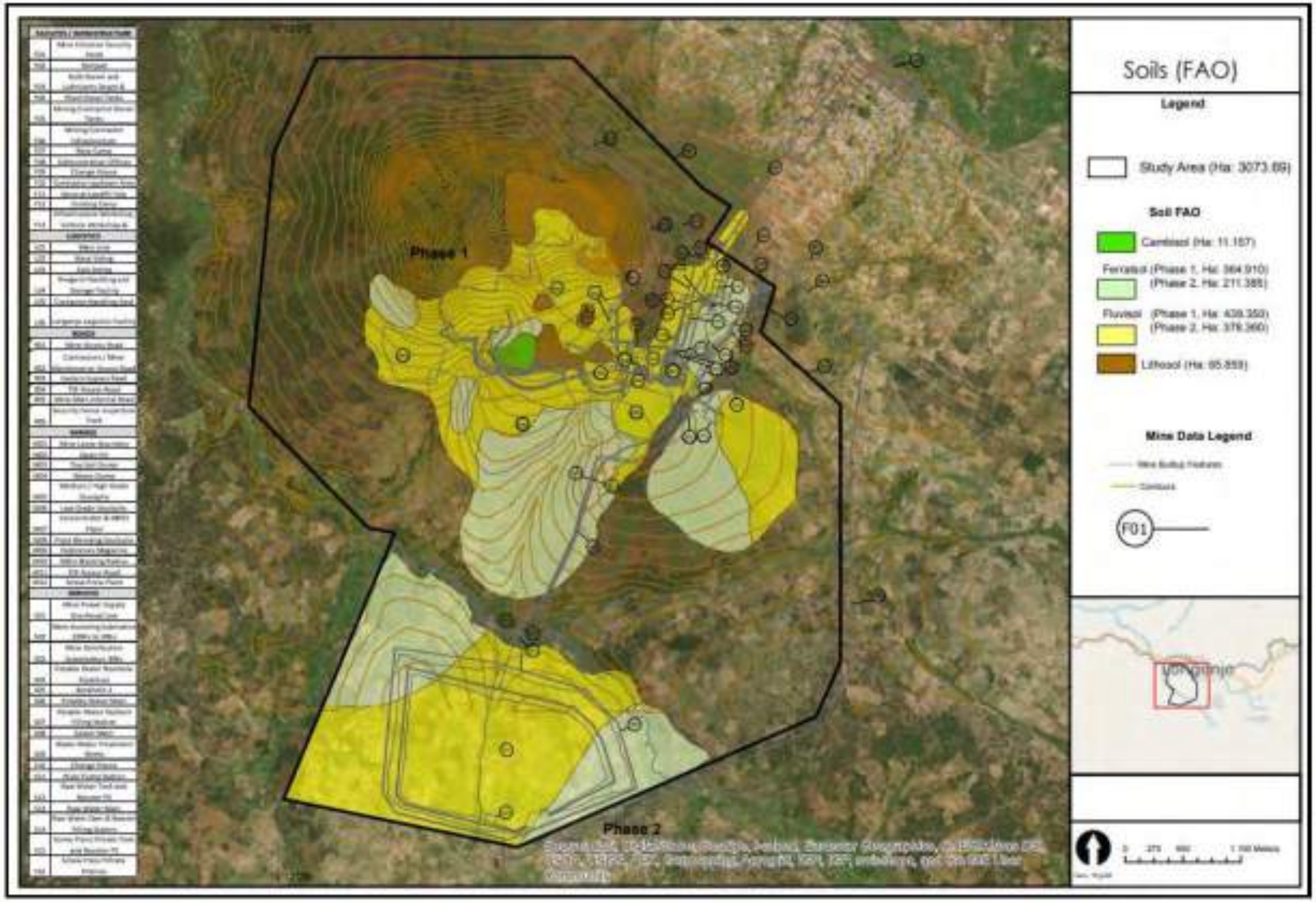


Figure 4-48: Soil Types according to the FAO classification system recording in the Project area

The different soil types according to the FAO classification system (Figure 4-47) stated in the context of the Project, are summarised in Table 4-31.

Table 4-31: Soil Types in the Project area according to the FAO system

Soil Type	Diagnostic Horizons	Effective Depth (mm)	Ha
Cambisol	Cambic B, no other diagnostic horizon except Ochric or Umbric or Calcic of Gypsic-Horizon	>300	11.157
Ferralsol	Oxic B-Horizon	>300	576.295
Fluvisol	Ochric, Umbric or Histic H-Horizon	>300	817.710
Lithosol	Shallow soils with hard rock in 100mm of soil surface	<300	65.859

- **Cambic**: A subsurface horizon that does not qualify as argillic, natric or spodic. It lacks the dark colours, organic material or structure of a histic, mollic or umbric horizon and is not cemented or hardened. It is characterised by the alteration and / or removal of mineral material as indicated by mottling or grey colours, removal of carbonates or development of structure.
- **Ochric**: Horizon too light in colour, too high in chroma, too low in organic matter, too thin in quality as mollic or umbric or both.
- **Umbric**: Same characteristics as the mollic epipedon concerning depth, organic material and phosphorus content, colour, structure and consistence. Base saturation is less than 50%.
- Calcic: Accumulation of secondary calcium carbonate (calcium carbonate equivalent >15%) with al least 5% more calcium than the underlying C horizon.
- **Gypsic**: Enrichment of secondary calcium sulphate with at least 5% more gypsum than underlying C horizon.
- **Oxic**: At least 300mm thick with more than 15% clay, little or no weatherable primary aluminosilicates or 2:1 clay minerals and no water-dispersible clay. Typical properties are the presence of 1:1 clays, hydrated oxides of iron and aluminium, a low CEC (<16cmol+/kg @ pH7) and <10cmol+/kg exchangeable cations kg-1 clay.

4.9.1 Agricultural and Rehabilitation Potential of Soils

The agricultural and rehabilitation potential of soils in the mining context is important to establish as it assists in quantifying project-related impacts and planning for rehabilitation post-closure.

The Fluvisol (>300mm), Cambisol (>300mm), and Ferralsol (>300mm) soils have high and medium agricultural and rehabilitation potential under dryland and irrigation conditions. Production under 30,000 plants/ha dryland conditions with an average rainfall of 650mm/year could be sustainable. However, during the summer period with extreme heat units growth could be lowered. Production under irrigation conditions would require 6,100m^3/ha/year of water for 100,000 plants/ha, equivalent to 30,000l/ha 24hours, 7 days per week. The Lithosol have low agricultural and rehabilitation potential due to the effective depth being shallower than 300mm. The soils will not facilitate good root development and store enough plant available water between 33 and 1,500kPa.

Table 4-32: Agricultural Rehabilitation Potential of Soils

Soil Types	Agricultural Potential		Rehabilitation Potential
	Dryland	Irrigation	
Fluvisol	High	High	High
Lithosol	Low	Low	Low
Cambisol	Medium	High	Medium
Ferralsol	High	High	High

4.9.2 Land Use and Land Capability

Land use can be defined as the arrangements, activities and inputs people undertake in a particular land cover type to produce, change or maintain, *i.e.* the human use of land. Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as dams, infrastructure, natural veld, pans, ploughed land, settlements, wetlands, pastures, and managed woods. Land capability classification shows the suitability of soils for most field crops and is vital to establish pre-mining to understand the baseline conditions fully. A summary of land capability criteria is given in Table 4-33. Crops that require unique management are excluded. Next, the soils are grouped according to their limitations for field crops, the risk of damage if used for crops, and how they respond to management.

The current land use includes 477.34ha natural veld, and 993.68ha ploughed land.

Table 4-33: Criteria Land Capability (Chamber of Mines of South Africa, 1981)

Wetlands, Pans, Drainage Lines	Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined.
Arable (>600mm)	Land that does not qualify as a wetland. Soil is readily permeable toa depth of 750mm. Soil has a pH value between 4 and 8.4. Soil has low salinity and SAR. Soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm. It has a slope (%) and erodibility factor (k) such that their product is <2.0. Occurs under a climate of crop yields that are at least equal to the current national average for these crops.
Grazing (250 – 600mm)	Land which does not qualify as wetland or arable land. Has soil, or soil-like material, permeable to roots of native plants, that is more than 250mm thick and contains less than 50% by volume of rocks or pedocrete fragments larger than 100mm. Supports, or is capable of supporting a stand of native or introduced grass species or other forage plants used by domesticated livestock or game animals on a commercial basis.
Wilderness (<250mm)	Land which does not qualify as wetland, arable or grazing land.

Table 4-34 summarises the current land use as percentage of the total Project area. Also see Figure 4-49 for a visual illustration of land use in the Project context.

Table 4-34: Land Use in the Project area

Land Use	Surface Area (ha)
Natural Veld	477.34
Ploughed Land	993.68

The current land capability includes 1,359ha arable, 17ha grazing and 93ha wilderness.

Table 4-35 summarises the current land use as percentage of the total area. Also see Figure 4-50 for land capability pre-mining as relevant to the Project area.

Table 4-35: Land capability in the Project area as percentage of total area

Land Use	Surface Area (ha)
Arable	1,359.88
Grazing	17.395
Wilderness	93.742

4.9.3 Chemical Analyses Results

None of the soil samples from the different soil types indicated excess sodium >15% of the cation exchange capacity rendering the soils free of any dispersion anomalies that could induce soil erosion. The soils are characterised by neutral pH and low electrical conductivity values, indicative of an uncontaminated soil regime in the Project area. Details are presented in the Soils Specialist Study (Appendix G).

4.9.4 Available Topsoil

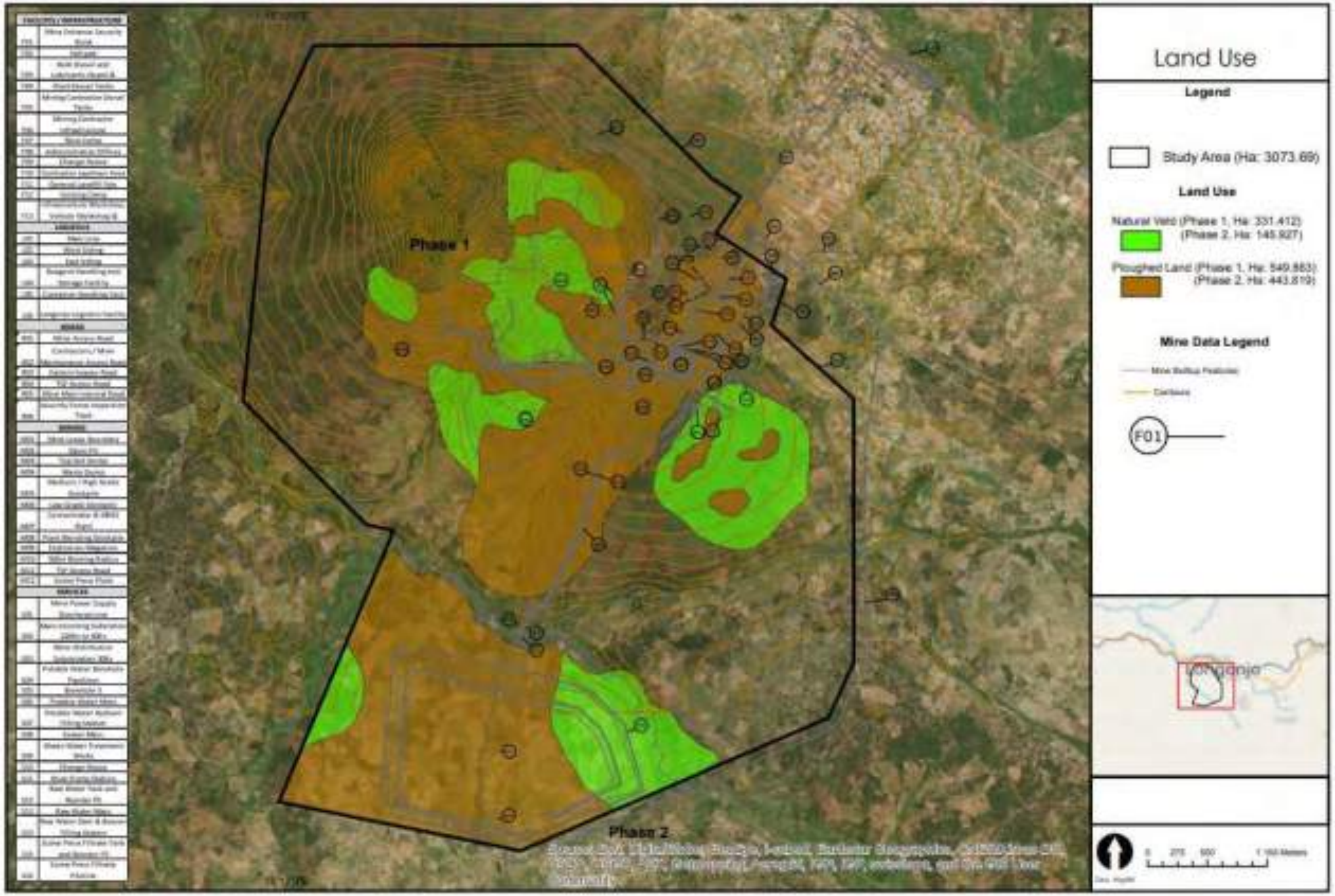
A conservative estimate of available topsoil to be stripped for rehabilitation purposes is summarized in Table 4-36.

Table 4-36: Available topsoil for rehabilitation

Soil Type and Effective Depth	Size (ha)	Volume (m^3)
Cambisol (1.2m)	217	2,483,800
Ferralsol (1.2m)	530	7,821,200
Fluvisol (1.2m)	455	6,993,600
Lithosol (1.2m)	219	1,984,800
Total		19,283,400m^3 @ BD 1,275kg/m^3

4.9.5 Stripping and Stockpiling

According to the FAO soil classification system, there are 4 soil types in the study area, i.e. *Fluvisol, Lithosol, Cambisol and Ferralsol*. The Taxonomical soil classification system classified 7 soil types with more diagnostic horizons differentiation, *i.e. Hutton, Clovelly, Mispah, Plooysberg, Brandvlei, Bainsvlei* and *Avalon*. It is recommended to strip soil carefully according to horizon differentiation and stockpile accordingly, and implement measures to prevent soil loss due to erosion and contamination. During rehabilitation, it aims to reconstruct the soil profiles as before mining. This will make sure that successful rehabilitation to as close as possible to its original state and legally agreed on final land use. End land use targets shall be pragmatic and achievable, i.e. end land use of 'wilderness' is often the best and easiest responsible option.



<u>**Figure 4-49: Land Use as relevant to the Project area**</u>

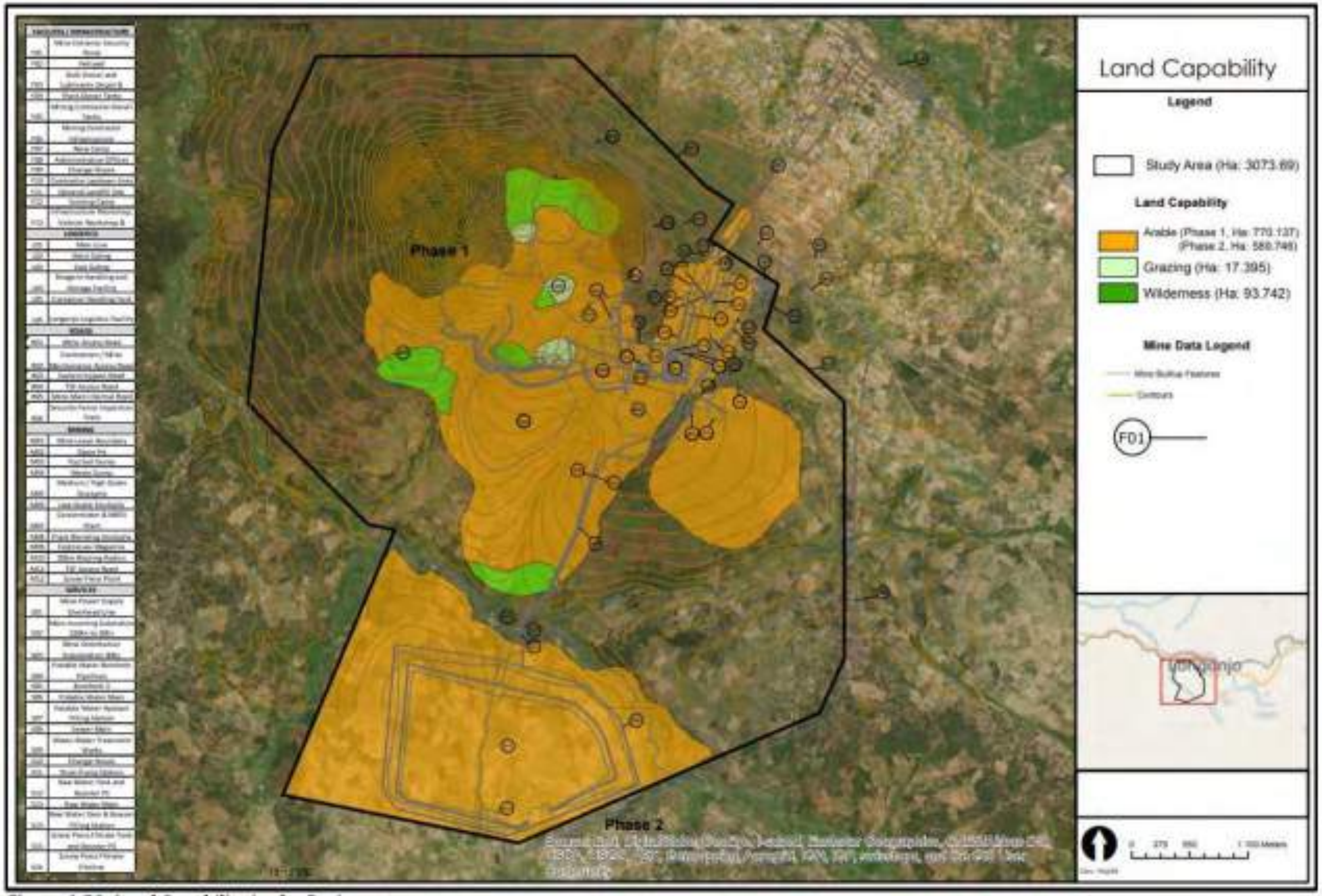


Figure 4-50: Land Capability in the Project area

4.10 Visual aspects

4.10.1 Landscape character

The Visual Impact Assessment Report is presented in Appendix H. The generalized land cover of the region (Figure 4-52) suggests that little of the natural vegetation remains in the lower-lying plains and have mostly been replaced by subsistence agriculture. Little grassland patches can be found in-between agricultural fields, while woodland vegetation is more restricted to mountainous/hilly terrain, lower-lying valleys and drainage lines. Numerous communities are associated with agricultural practices. The photographs in the figures below were taken from various vantage points, and represent the landscape character of the area. Figure 4-51 shows the open character of the area, with the Longonjo Carbonatite outcrop (Mount Chimbilundo) in the background.

Figure 4-51: Open landscape character, Longonjo Carbonatite outcrop in background (7 km, northwest)

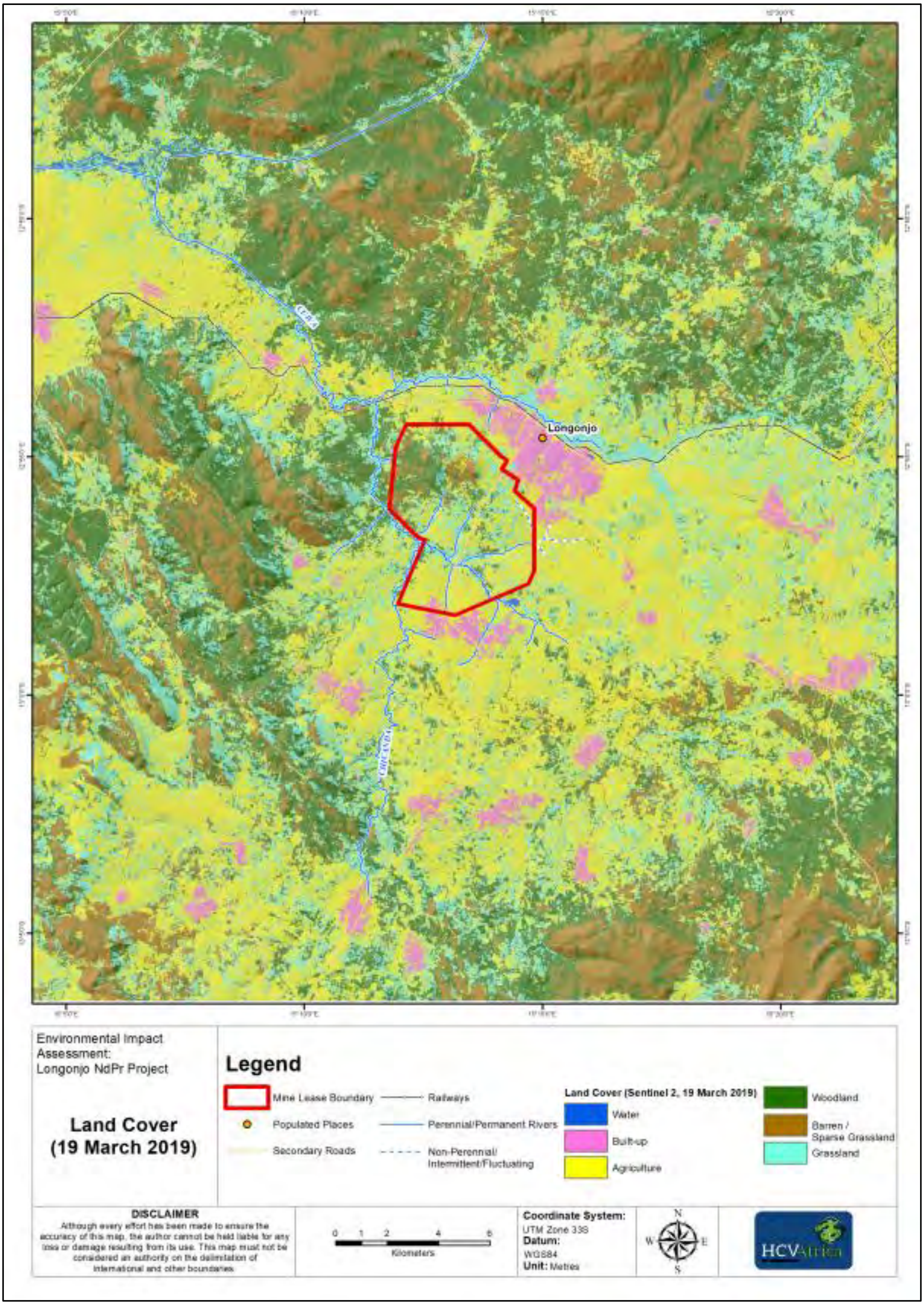


Figure 4-52: Land Cover of the Region

Figure 4-53: Grasslands and woodland with Longonjo Carbonatite outcrop in background (2.8 km, north)

Figure 4-54: Fallow agricultural fields with patches of trees, Longonjo Carbonatite outcrop in background (1.2 km, northeast)

Isolated trees are prevalent but have a minimal masking potential. This land cover regime is illustrated in Figure 4-55, taken from the top of the Longonjo Carbonatite outcrop. It shows large patches of agricultural fields interspersed with impacted grasslands and isolated tree patches.

Figure 4-55: View from Longonjo Carbonatite outcrop (on-site)

Natural vegetation will occasionally form higher-growing "hedges" along roads. These hedges will play an essential visual screening role since the roads are visual corridors and may carry significant traffic.

4.10.2 Potential receptors and visual corridors

The term ‘receptor’ can be defined as “*an element or assemblage of elements that would directly or indirectly affected by the proposed development*”. These elements can include landscape and visual receptors where the latter is described as “*particular groups of people who are likely to be affected*” (Dacorum Borouh Council, 2018).

According to Oberholzer (2005), different receptor types will display varying degrees of sensitivity to visual impact from a project. For example, nature reserves and visitors are regarded as receptors with high sensitivity, while mining areas are regarded as low sensitivity. Therefore, it is important to identify potential receptors and assess their sensitivity.

Naturally, viewers' perceptions will differ notably given their cultural backgrounds, state of mind, regularity of sighting, and if they are residents or visitors to the area. However, again, this demonstrates the subjectivity of visual impacts. As a result, this complex subject is approached with a certain degree of generalisation and it is beyond the scope of the ESIA to attempt a detailed breakdown of viewers’ perceptions.

The potential receptors identified in the vicinity of the Project area are shown in Figure 4-56 and are summarized as follow:

- **Small Communities** – Several communities exist in the vicinity of the Project, with Longonjo, Centro Chenga, Chianga, and Lucamba considered to be the most prominent; and

- **Roads** - Roads with high traffic loads would imply higher number of potential receptors that other roads. Roads act as visual corridors and can therefore exacerbate a negative visual impact.

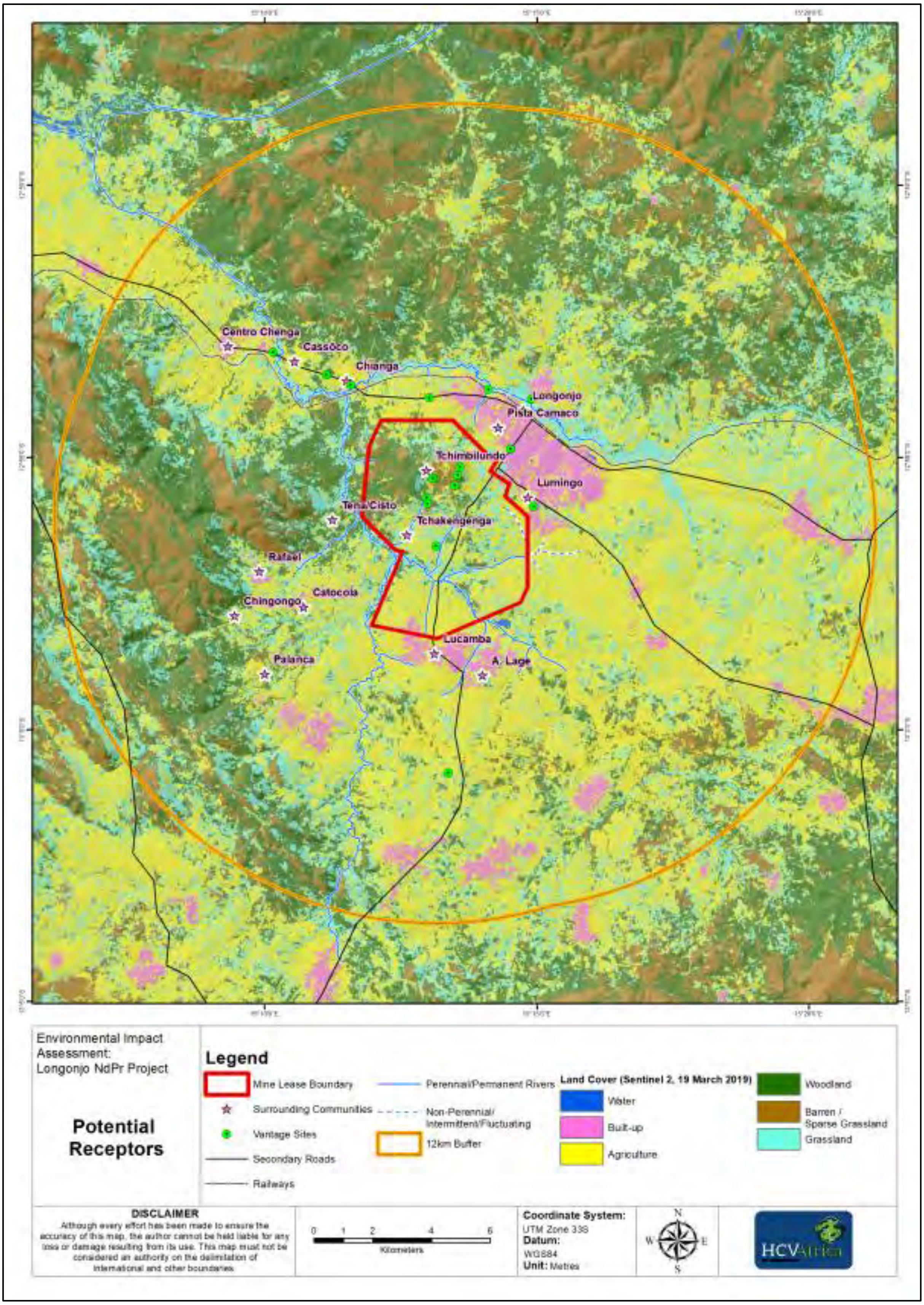


Figure 4-56: Potential visual receptors in the vicinity of the Project

BIOLOGICAL SETTING

HCV Africa specialists undertook three field surveys: the first were in April/May 2019 (wet season), the second in August 2019 (dry season), followed by another wet season survey during May 2021. The HCV Africa specialist team took all photos presented in the respective sections during these field surveys..

The respective field methodologies of each biodiversity specialist discipline are available in each specialist study as appended to this ESIA.

Background context

Angola is one of the most biologically diverse countries globally, mainly due to the species diversity and endemism of the vegetation. The major natural systems of the country have been classified in terms of the biome concept, based on dominant plant life forms, correlated with climatic variations. Angola's position along an ecotone between the Namib Desert to the south and the Congo Basin rainforests to the north, together with a complex topography and impressive variety of habitats, affords the country an exceptional and unique biodiversity diversity. Biomes found in Angola include desert, succulent, tropical rainforest, grassland, savanna, miombo woodland, montane forest, and wetland vegetation. Due to its relatively high altitude, the Project area is within the Angolan miombo woodland biome and contains extensive wetlands with associated grassland species.

Approximately 7% of Angola's land surface area is formally conserved through national and provincial protected conservation areas. The protected area network is skewed towards specific biomes such as forest and savanna, leaving grasslands and forest under-conserved (5th National Report on Biodiversity in Angola 2007-2012). Many of these under-conserved areas overlap with high population density, high agricultural potential, mineral deposits and scenic beauty (important for tourism). With particular reference to the Longonjo Project, there are no recognised or registered protected areas adjacent to the proposed mining area.

Summary of available studies / literature

HCV Africa conducted a literature review to identify areas of ecological importance and understand the Project area. The literature review also aimed to determine the flora and fauna communities and species previously recorded in or adjacent to the Project. The primary sources for the review included, but were not limited to, the following:

- Aerial imagery to determine the state of the vegetation and to identify points of interest prior to carrying out fieldwork (e.g., changes in vegetation and riparian areas);
- Conservation plans and other national planning tools to gauge the conservation importance of the area;
- Lists of floral and faunal species that were likely to occur within the area were compiled; and
- Lists of species of special concern (SSCs) for both flora and fauna were compiled, focussing on Red Data Species[35].

[35] The following parameters were used to determine the Probability of Occurrence of each Red Data species:

- Habitat requirements (HR) – Most Red Data animals have very specific habitat requirements and the presence of these habitat characteristics in the Project area was evaluated;
- Habitat status (HS) – The status or ecological condition of available habitat in the area is assessed. Often a high level of habitat degradation prevalent in a specific habitat will negate the potential presence of Red Data species (this is especially evident in wetland habitats); and
- Habitat linkage (HL) – Movement between areas for breeding and feeding forms an essential part of the existence of many species. Connectivity of the Project area to surrounding habitat and the adequacy of these linkages are evaluated for the ecological functioning of Red Data species habitat within the Project area.

Probability of occurrence is presented in four categories, namely:

- Low (will not occur);
- Medium (could possibly occur);

4.11 Aquatic ecology

Also, refer to sections 4.6.1 and 4.6.2 for info on geomorphology and land use in the context of hydrology. Also refer to Figure 4-27for the locations of aquatic biomonitoring localities.

4.11.1 Aquatic habitats

The field surveys indicated similarities between the Chicanda and Luluvila Rivers, where shallow runs dominated river morphology with sandy substrates (Figure 4-57 and Figure 4-58). These runs were typically devoid of submerged cobbles but contained intermittent areas with exposed bedrock and boulders. No instream aquatic vegetation was noted in the Luluvila or Chicanda Rivers. Marginal vegetation consisted of dense stands of *Phragmites australis* with limited woody cover interspersed with *Persicaria* sp. As noted above, the river habitats largely conformed to uniform conditions and therefore were classified as shallow-deep run-pool complexes. Downstream of the confluence between the Chicanda, Luluvila and Cuiva Rivers, the watercourse increases in size and velocity. However, habitat types remain largely similar, shifting between meandering shallow runs and deeper pools. Approximately 4km downstream of the confluence between the Cuiva and Chicanda Rivers, the Cuiva cascades occur (Figure 4-60). The habitat type in this location changes to bedrock, boulders and cobbles with associated bedrock pools and waterfalls (Figure 4-61). Instream aquatic macrophytes, including *Hydrostachys cf. polymorpha,* were also observed at the Cuiva cascades (Figure 4-62). It is anticipated that the waterfalls observed would serve as a migration barrier for instream fauna.

Figure 4-57: Typical habitat in the Project Area showing the confluence between the Upper Cuiva and Luluvila River at L1B (July 2019)

Figure 4-58: Habitat types in the Chicanda River showing similarities to the Luluvila River (July 2019)

- High (most likely could occur); or
- Recorded (does occur on-site).

The IUCN Red Data categories are used for the status identification of mammals, birds, reptiles and amphibians globally.

Figure 4-59: Typical riparian habitat showing *Persicaria* (top) and *Phragmites* sp (bottom) in the Chicanda and Luluvila Rivers (July 2019)

Figure 4-60: The bedrock structures and waterfalls on the Cuiva River (July 2019)

Figure 4-61: A waterfall at the Cuiva Cascades (July 2019)

Figure 4-62: Aquatic macrophytes (Hydrostachys polymorpha) in the Cuiva River (July 2019)

The morphology of the perennial systems directly associated with the Project was noted to vary, with a wetland shallow gradient system located in the east of the Project Area (ET1) and steep channelised drainages in the remaining tributaries. The channel morphology of the watercourses was deep (+-1.5m) and narrow (+-1m) with woody miombo vegetation and crops in the channel. Intermittent areas of bedrock and eroded cobbled substrates were also noted in these systems. However, overall, the systems were dominated by sandy and bedrock substrates.

Figure 4-63: Typical morphology of the perennial systems draining the Project Area (July 2019)

Refer to the hydrology section and photos for more information on geomorphology. Anthropogenic impacts are also illustrated in the hydrology section. Considering the degree of catchment modification in the study area, it is anticipated that riverine habitat integrity will be compromised.

The morphology of the perennial systems directly associated with the project was noted to vary, with a wetland shallow gradient system located in the east of the project area (ET1) and steep channelised drainages in the remaining tributaries. The channel morphology of the watercourses was deep (+-1.5m) and narrow (+-1m) with woody miombo vegetation and crops in the channel. Intermittent areas of bedrock and eroded cobbled substrates were also noted in these systems. However, the systems were dominated by sandy and bedrock substrates (Figure 4-64). As observed in the images, the riparian cover of these systems was almost entire, and therefore these habitat types would provide suitable conditions for specialized Odonata.

Figure 4-64: Typical morphology of the perennial systems draining the proposed mining area (May 2021)

4.11.2 Invertebrate Assemblage and Indices

The results of the aquatic macroinvertebrate assessment are presented in Table 4-37. The results of the macroinvertebrate analysis for the May 2021 survey are presented in Table 4-38, while the results of the statistical analysis of data are provided in Table 4-39.

Table 4-37: Aquatic Invertebrate results for the study area (April and July 2019)

April 2019								
Site	LU1	LU2A	LU2B	CH1	CH2	CUV1	SET2	NT2
Diversity/Sensitivity Score	73	N/A	128	80	58	N/A	117	60
Taxa	11	N/A	16	14	12	N/A	20	11
ASPT*	6.6	N/A	8.0	5.7	4.8	N/A	5.9	5.5
July 2019								
Diversity/Sensitivity Score	102	59	105	42	46	74	N/A	N/A
Taxa	17	14	19	10	10	15	N/A	N/A
ASPT	6.0	4.2	5.5	4.2	4.6	4.9	N/A	N/A
EPT%	29	7	26	10	10	26	N/A	N/A

Table 4-38: Aquatic invertebrate results for the study area (May 2021)

Site	LU1US	LU1	LU1BUS	C1	LU1B	LU2B	CUV1	SET1	ET1	LT1
Diversity/Sensitivity Score	47	76	88	115	85	125	115	59	30	57
Taxa	10	16	15	21	15	20	19	14	7	13
ASPT*	4.7	4.75	5.36	5.4	5.6	6.25	6.0	4.2	4.2	4.3
EPT%	10	13	27	19	27	35	32	7	42	15

Table 4-39: Statistical analysis of macroinvertebrate results (April 2019 - May 2021)

River	Sensitivity Score	ASPT	EPT
Chicanda (n=4)	56±8.5	4.8±0.3	10±0.0
Luluvila (n=5)	77±9.1	5.4±0.4	19±4.8
Cuiva (n=8)	100±8.9	5.7±0.4	24±3.4
Minor Tributaries (n=4)	66±18	4.9±0.4	24±17

The results of the invertebrate assessment indicate a vast absence of taxa. Due to the limit in the extent of the stones in current habitats, invertebrates adapted to the biotope were not frequently observed across the AoI. As depicted in the biotope assessment, vegetation biotopes consisted of instream *Phragmites*, and this is where invertebrates with flow sensitivity were observed and sampled. Overall invertebrate diversity was considered low because of the sedimentation observed. Fine sediment, as a resultant impact of the erosion in the catchment, with notably high turbidity levels of, would further reduce aquatic macroinvertebrate diversity in the watercourse. In addition, the loss of the riparian habitats, which provides critical allochthonous materials and bank top cover to the water column, have been altered, which has further exacerbated the existing extensive sedimentation.

Despite modification to the condition of the watercourses, sensitive macroinvertebrates were noted to be present. The ASPT values observed at the sites were largely similar between the sample points at 5.7±0.4 in the Cuiva River, 5.4±0.4 in the Luluvila and 5.8±0.3 in the Chicanda River, indicating an overlap in Mean and Standard Error Mean (SEM) values. This corroborates the water quality assessment in that minor differences in water quality exist between the catchments, and that primary impacts may be attributed to habitat condition degradation rather than water quality modification. Sensitive macroinvertebrates observed included Oligoneuridae and Perlidae (Figure 4-65) in the Cuiva River. Important indicator species included the observation of Heptageniidae in the Luluvila River downstream of the proposed abstraction point. The EPT% derived from the samples indicated a variation between 10% in the Chicanda River to 24% in the Cuiva and minor tributaries. The EPT% result indicates some degradation of condition in the Chicanda River which confirms the ASPT results. Diverse assemblages of predacious Hemiptera and Coleoptera invertebrates were observed to be associated with the marginal vegetation (Figure 4-66). All expected Hemiptera were observed in the AoI.

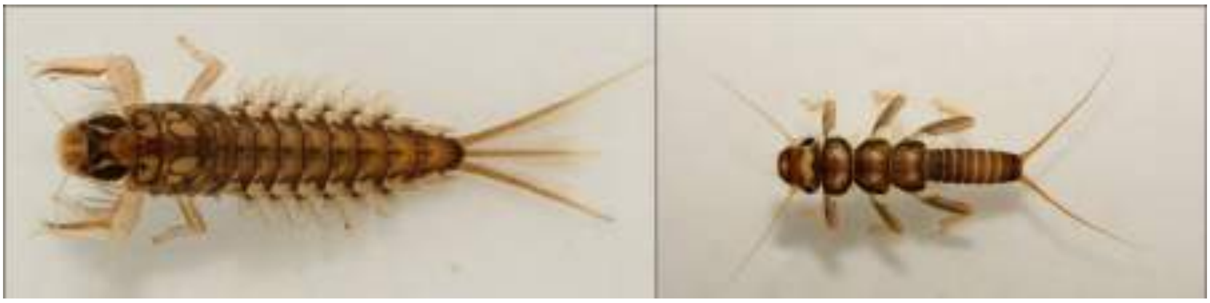


Figure 4-65: Common invertebrates in the lower reaches of the Cuiva River. Left: Oligoneuridae; Right: Perlidae (May 2021)

Figure 4-66: Common invertebrates in lower order reaches, minor tributaries and dense stands of marginal vegetation. Left: Dytiscidae; Right: Nepidae (May 2021)

4.11.3 Odonata (Dragonflies)

Given the sensitivity of Odonata (dragonflies and damselflies) to both water quality and the condition of the local habitat, the diversity of Odonata can serve as an effective mechanism for the monitoring of cumulative impacts and environmental degradation. In addition, Odonate diversity can also be an effective endpoint for assessing the diversity of aquatic macroinvertebrate taxa in a given river reach.

The dragonflies of Angola have not been extensively surveyed, with most work being completed after 2000. According to Kipping et al. 2017, a total of 236 dragonfly species are known to occur in Angola, with approximately 120-160 expected species for the study area. In addition, several near-endemic dragonflies are known to occur in proximity to the Project Area, with one of the species confirmed present in the study area (

Table 4-40). Headwater river systems typically contain the highest diversity of dragonflies. Odonata diversity is typically associated with habitat biotope factors such as flow rates, macrophyte and reed cover (Clark and Samways, 1996).

A total of 36 species were observed of the anticipated 94 expected taxa. The low number of species observed could be attributed to seasonal conditions during the surveys, typical of winter conditions. It is expected that the full component of Odonata will be present in the summer period, a season whereby standard riverine sampling is, however, tricky. The most important findings from the survey were the confirmation of the poor understanding of the AoI in terms of Odonata distribution. In addition, three species were observed in the survey, which did not conform to the data on existing species in the region. This included the endemic *Pseudagrion estesi* (LC), and *Onychogomphus rossii (DD)* and *Umma electa (LC).*

Odonata communities observed during the assessment ranged from flow associated species such as *Zygonyx torridus* to wetland habitats specialist species such as *Palpopleura portia, P. lucia* and *P. jucunda*. Limited cover specialist taxa were identified during the survey, with dominant taxa observed as tolerant taxa such as *Pseudagrion salisburyense* and *Pseudagrion kersteni*.

The observed Odonata included the listed Near Threatened (NT) species *Chlorocypha bamptoni (NT)*. This species is sensitive to changes in flow and therefore forms an important indicator species for the proposed impoundment. In addition, the observation of endemic *Pseudagrion estesi* (LC) and *Onychogomphus rossii* (DD) represent essential findings to the study and will inform the monitoring conditions.

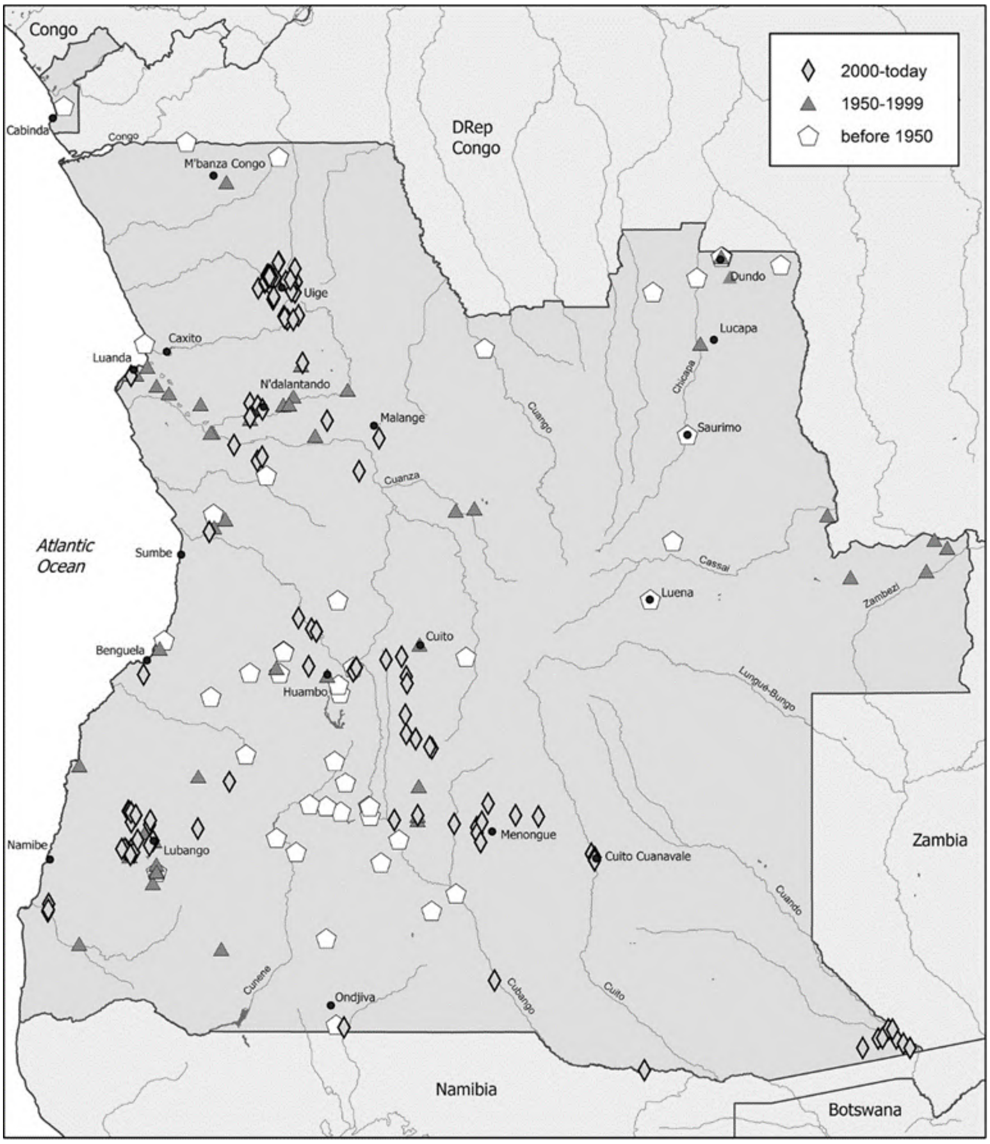


Figure 4-67: An illustration Depicting Odonata Surveys in Angola from historical records until 2017 (Kipping et al. 2017)

Table 4-40: Adult Odonata observed in the Project Area (July 2019 and May 2021)

Species	Photograph
Chlorocypha bamptoni.	
Chlorocypha angolensis	
Pseudagrion salisburyense	
Pseudagrion estesi.	

Species	Photograph
Pseudagrion kersteni	
Ellatoneura glauca	
Umma electa	
Trithemis arteriosa	

Species	Photograph
Trithemis cf. furva	
Trithemis pluvialis	
Trithemis sticta	
Crocothemis erythraea	

Species	Photograph
Crocothemis sanguinolenta	
Acisoma inflatum	
Zygonyx torridus	
Orthetrum trinacria	

Species	Photograph
Orthetrum caffrum	
Orthetrum cf. chrysostigma	
Palpopleura portia	
Palpopleura lucia	

Species	Photograph
Palpopleura jucunda	

4.11.4 Fish

The Project area is located in the headwaters of the Cuanza Freshwater Ecoregion (Figure 4-68). This region is in the Cuanza (Atlantic coastal) Ichthyological province, which has a mixture of Zambezian and Congolese fish species due to river captures in the past (Darwell *et al.* 2009). This fish ecoregion is considered to have vulnerable conservation status, and the expected species richness of the area is poor, with 0-10 expected taxa (Figure 4-68). Expected fish species are listed in the Aquatic Ecology Specialist Study (Appendix I).

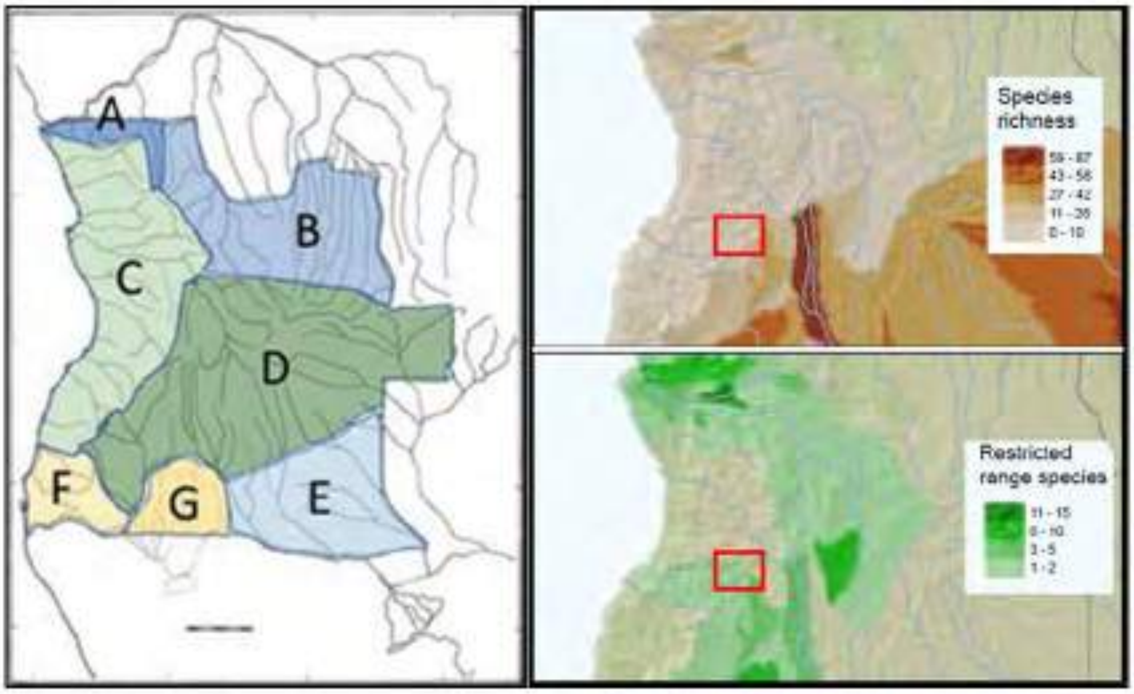


Figure 4-68: Left: Aquatic ecoregions in Angola. A – Lower Congo, B – Cassai, C – Cuanza, D – Zambezian headwaters, E – Okavango and Upper Zambezian floodplains, F – Namib coastal, G – Etosha. (Skelton, 2019); Right: Aquatic Biodiversity Richness and Range of Restricted Species (Darwall et al. 2008). Red Square Represents Project Area

4.11.4.1 Fish Habitat and Sampling Effort

The Habitat Cover Rating assessment results are presented in Figure 4-69. The habitat types observed in the survey area were dominated by slow, shallow velocity depth classes with intermittent areas of slow deep. Rare values for fast shallow or fast deep were observed and were restricted mainly to the Cuiva cascades reach where the most diverse habitats were observed (Figure 4-70). Overall, fish habitat was determined to be limited in diversity and, as a result, limited fish diversity.

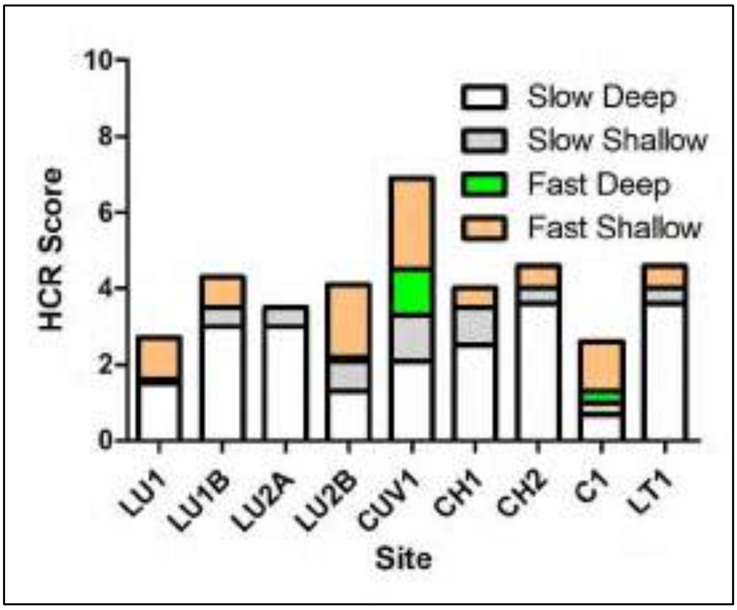


Figure 4-69: Habitat Cover Rating for the various sampling points (July 2019 and May 2021)

Figure 4-70: Diverse habitat in the Cuiva River at CUV1 (July 2019)

4.11.4.2 Qualitative Fish Results

The results of the qualitative fish assessment are provided in

Table 4-41.

Table 4-41: Qualitative fish assessment results (April 2019, July 2019 and May 2021)

Species	Photograph	Sites	FROC%
Kneria cf. polli		LU1, LU1B, LU2A, LU2B, CH2	71
Enteromius cf. welmanni		LU1A LU1B, LU2A, LU2B	57
Enteromius cf. breviceps		LU1, LU1B, LU2A, LU2B, CH1, CH2	85
Enteromius cf. dorslineatus		LU1, LU1B, LU2B, CUV1, LT1	57
Enteromius Sp1.		LU1B	14
Enteromius sp2.		LU1, LU1B, LU2B, CUV1, CH2, C1	71

Species	Photograph	Sites	FROC%
Enteromius sp3.		CUV1	14
Labeobarbus sp1.		CUV1, LU2B	14
Labeo cf. cylindricus "elongate"		CUV1, LU2B	28
Chiloglanis sp1. "large"		CUV1, LU2B	28
Chiloglanis sp2.		CH1	14
Chiloglanis Sp4. "small"		LU1, LU1B, LU2A, CH1	57

Species	Photograph	Sites	FROC%
Chiloglanis Sp5. "stout"		CUV1, LU2B	28
Clarias cf. liocephalus		CUV1, LU1, LU1B, LU2A, LU2B, CH2,C1	85

The results of the qualitative fish assessment indicated 14 different fish species in the associated water bodies. Almost none of the expected species were sampled during the survey, with all species presented representing new distributions. It is noted that no additional species were observed in the June 2021 survey, indicating that April and July 2019 were comprehensive. Three fish families were observed during the survey: Cyprinidae, Mochockidae and Clariidae. Cyprinidae was the most abundant fish family observed during the survey, represented by 9 species. This is an expected result in the Cuanza ecoregion, which is known for the high diversity of Cyprinidae. Overall, fish diversity was low as a result of poor habitat cover. However further assessment of the deeper pools with overnight nets is required in the region as no studies are available for comparison.

The Frequency of Occurrence (FROC) for each species was determined for the study area, and *Enteromius cf. breviceps* and *Clarias cf. liocephalus* were the most observed taxa in the study area. These species were typically observed in the margins of the watercourse in between the *Phragmites* sp. or under the *Persecaria* sp. stands. Flowing water between the *Phragmites* sp. was the habitat of the *Kneria cf. polli, E. welmanni* and *E. dorsolineatus* species, which were derived from having similar FROC.

In addition, flowing water over depressions in the sandy substrate yielded an *Enteromius* species, which bears a similarity to *Enteromius mattozi*. These taxa were found to be adapted to the flowing water in the middle of the channels. Similarly, the *Enteromius* sp3. and *Labeobarbus* sp1. were only found between the flowing waters over the boulders at the Cuiva cascades sampling point. Other species sampled in the stone's substrate habitat included *Labeo cf. cylindricus "elongate"* which were abundant in the rocky habitats (Figure 4-71). This *Labeo and Labeobarbus* species are expected to be undescribed.

The various *Chiloglanis* species found were either associated with the sandy habitat and submerged logs, such as *Chiloglanis* sp2., the marginal vegetation in flow such as *Chiloglanis* sp4 *"small"*, and the species adapted to stones substrates such as the large species *Chiloglanis* sp1 *"large" and Chiloglanis* sp5. *"stout"*. It is noted that the *Chiloglanis* species observed in this study are highly likely to be undescribed taxa.

Figure 4-71: *Labeo* sp. feeding marks on rocks at CUV1 (July 2019)

Although diversity was low, several undescribed and sensitive specimens were likely obtained during the survey. This is presently being confirmed through Professor Paul Skelton at the Southern African Institute for Aquatic Biodiversity (SAIAB). Based on the assessment, the following taxa were notably sensitive to changes.

Labeo cf. cylindricus "elongate was determined to be sensitive to changes in flow and sedimentation given its preference for rocky habitats. *Kneria cf. polli* was sensitive to modification of the slow and fast shallow velocity depth classes with marginal vegetation. The various *Chiloglanis* species observed have been recorded in other regions in Southern Africa to be sensitive to water quality modification. The *Chiloglanis* taxa are therefore regarded as sensitive to water quality and flow.

The conservation status of the observed fish species is largely data deficient or not evaluated given their novel descriptions. Considering this, the taxa observed throughout the study area would be considered as being Species of Conservation Concern (SCC). In addition, the Cuiva cascades were noted to be migration barriers; therefore, the taxa located upstream of this barrier are likely to contain unique genetic compositions that further increase the SCC's stature.

During the May 2021 survey, concerted efforts were placed to capture cryptic species using overnight nets and investigate the fish community downstream of the Cuiva cascades. As a result, no additional species were added during the survey, and the survey further confirmed the absence of Cichlidae from the AoI, an interesting finding considering that almost all African rivers contain cichlids.

Based on the fish community assessment outcomes, the study of different sampling points in the region needs to be considered. The additional assessments will aim to define the distribution ranges of the undescribed fishes. This will provide critical information to inform the conservation status of the fish species observed in this study.

4.11.5 Delineation of Sensitive Aquatic Habitats

A 200m buffer zone[36] around the delineated riverine habitats was constructed using the vector buffer tool in ARCGIS 10.5. The delineated sensitive habitats with the proposed infrastructure layout are provided in Figure 4-72.

[36] See Section 2.29.3

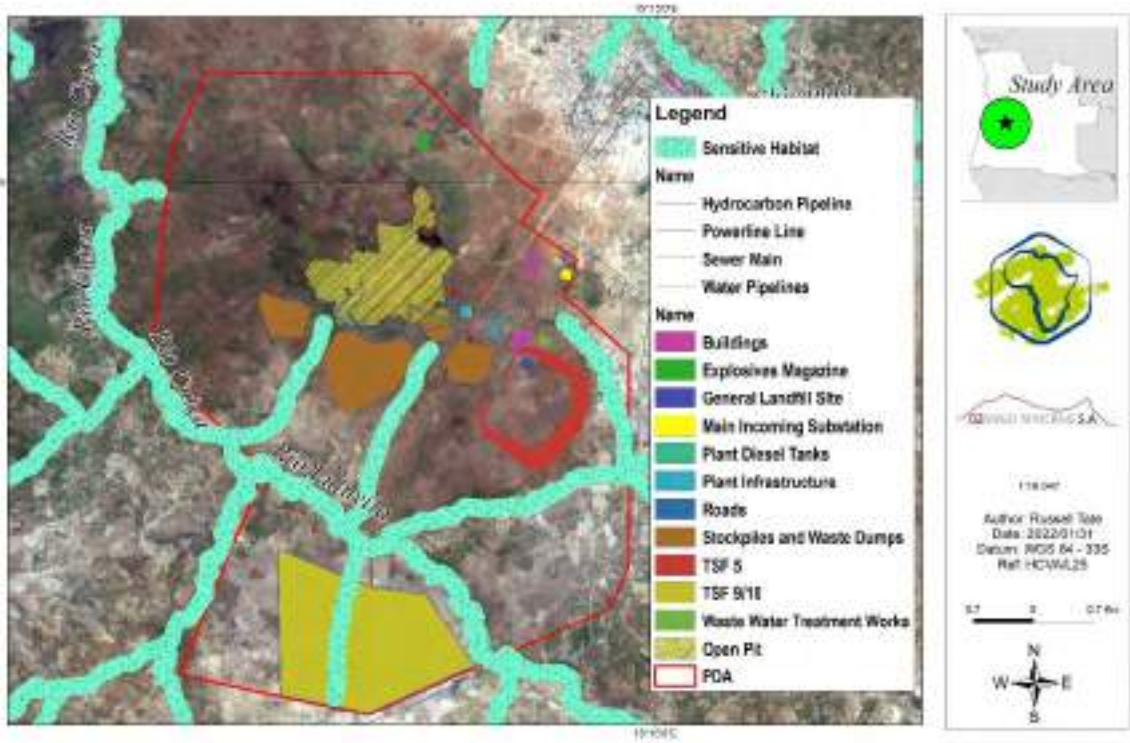


Figure 4-72: Sensitive aquatic habitats in the Project area

4.11.6 Critical Habitat Assessment

Aquatic habitats in the Project area were compared against the criteria for identifying critical habitat as established in IFC PS6. An intermediate level Critical Habitat Assessment (CHA) for the aquatic habitats was therefore conducted against the five established criteria as provided below:

- Criterion 1: Critically Endangered and Endangered Species;
- Criterion 2: Endemic/Restricted Range Species;
- Criterion 3: Migratory/Congregatory Species
- Criterion 4: Highly threatened and/or unique ecosystems; and
- Criterion 5: Key Evolutionary Process.

4.11.6.1 Critical Habitat Assessment: Criteria 1-3

The river reaches within the AoI assessed in this study were modified from natural conditions. Through extensive agricultural activities, large-scale modification has resulted in significant flow, bed and channel modification. The extent of the transformation has resulted in altering natural biological (ichthyological and macroinvertebrate) communities. No critically endangered or endangered species of aquatic biota were observed or expected, thus not qualifying the AoI as critical habitat under criterion 1. Despite the extent of the modification, in the remaining limited extents of impacted river reaches endemic, novel and migratory biota were observed, thus triggering Criterion 2 and Criterion 3. When the study AoI and its ecological compositions were compared against the thresholds for Criterion 2 Tier 1 and Tier 2, both thresholds were not met, in that the habitat assessed does not subjectively contain >1% of their global populations of the endemic and threatened species. However, this will need to be confirmed through additional studies in the Catumbela River Basin. Therefore, when the habitat in the AoI was compared to the thresholds for Criterion 3 species, none of the thresholds was met for this AoI, indicating that Criterion 3 was not triggered.

4.11.6.2 Critical Habitat Assessment: Criterion 4 -5

Limited information about the ecological category of the various water bodies in Angola is available. However, considering the expansive areas within the study area that are not yet developed, the freshwater ecology in this specific AoI cannot be constituted as Criterion 4 habitat.

The presence of the Cuiva cascades has likely created some degree of genetic isolation and therefore may support genetically unique subpopulations of various species. However, given the degree of modification within the DMU the watercourse reaches considered in this assessment cannot be classified under Criterion 5.

4.11.6.3 Critical Habitat Assessment: Conclusion

The riverine habitats were determined to be modified habitat in line with the definition below:

- 'areas that may contain a large proportion of plant and / or animal species of non-native origin, and / or where human activity has substantially modified an area's primary ecological functions and species composition'.

In addition, none of the 5 Critical Habitat criteria thresholds was triggered for the AoI of this assessment. Therefore, it is recommended that additional studies on the ichthyofauna be completed to derive the relative distributions and descriptions of fish observed in this study area.

4.12 Avifauna

4.12.1 National and Regional Perspective

Angola's position along an ecotone between the Namib Desert to the south and the Congo Basin rainforests to the north, together with a complex topography and impressive variety of habitats, affords the country an exceptional and unique bird diversity with over 940 species and 17 endemics placing it as the sixth most diverse in Africa (Mills and Melo 2013). Additionally, the country supports 221 biomes restricted species in its five major floristic biomes, namely the Guinea–Congo Forests biome, Afrotropical Highlands biome, Zambezian biome, Kalahari–Highveld biome and Namib–Karoo biome. (Fishpool and Evans 2001; Parker, 2001). The country also supports 23 Important Bird Areas (IBAs). Despite this, the country's rich birdlife remains poorly studied, and many areas await exploration due to the country's history of the Civil War, which ended less than 20 years ago, and the omnipresent risk associated with forgotten land mines. Since then, ornithological interest has slowly started to gain traction, with articles such as: "*Angola Opportunities for Exploration* " (Mills, 2014) sparking renewed interest. In recent years the country has taken some significant steps towards better understanding ad conserving its birdlife by publishing a national checklist (Mills and Melo, 2013) and other necessary research.

The closest IBA to the Project area is Mount Moco (AO019), situated 20 km south-east, which provides a relatively accurate portrayal of the reference state habitat and species assemblages for the Longonjo area.

4.12.2 Local Context

A total of 479 species of birds has the potential to occur in the greater region, as defined as a 50 km radius surrounding the Project area. However, this inventory includes the highly diverse and unique avifaunal assemblage associated with Mount Moco and other larger hills on the area which support more contiguous forest. As such, the number of species likely to occur in the Project area is probably lower, given that many of the strictly forest restricted species are expected to be absent.

A total of 137 species have been recorded in the Project area to date, based on pooled observations (point counts and incidental records) from the 2019 wet (79 spp.), 2019 dry (86 spp.), and 2021 wet season (97 spp.) surveys. The Avifauna and Mammals Specialist Study (Appendix J) provides species lists of the general / common species observed, while Figure 4-73 presents examples of some bird species observed. Noteworthy bird observations recorded from Mount Chimbilundo in the Project area, wooded ravines and miombo hillslope woodlands included:

- Two national endemics, namely Angola Cave Chat (*Xenocopsychus ansorgei*), a rare habitat specialist, and Huambo Cisticola (*Cisticola bailunduensis*), a recently described species restricted to wooded slopes in the Huambo region;
- Five near Angolan endemics, namely Angola Lark (*Mirafra angolensis*), Oustalet's Sunbird (*Cinnyris oustaleti*), Black-and-rufous Swallow (*Hirundo nigrorufa*), Bocage's Sunbird (*Nectarinia bocagii*), Bocage's Weaver (*Ploceus temporalis*);
- Three Near Threatened species namely Bateleur (*Terathopius ecaudatus*), Pallid Harrier (*Circus macrourus*) and Monteiro's Bushshrike (*Malaconotus monteiri*) a poorly known, rare and range restricted species;
- Thirteen biome restricted species including the aforementioned endemics as well as Dusky Twinspot (*Euschistospiza cinereovinacea*), Thick-billed Seedeater (*Crithagra burtoni*), Broad-tailed Paradise Whydah (*Vidua obtusa*), Black-and-rufous Swallow (*Hirundo nigrorufa*), Bocage's Sunbird (*Nectarinia bocagii*), Oustalet's Sunbird (*Cinnyris oustaleti*), Bocage's Weaver (*Ploceus temporalis*), Fülleborn's Longclaw (*Macronyx fuelleborni*), Monteiro's Bushshrike (*Malaconotus monteiri*) and Miombo Rock Thrush (*Monticola angolensis*);
- A significantly out of range observation of European Nightjar (*Caprimulgus europaeus*) which together with the 2021 wet season observation suggests that it was not a vagrant sighting; and
- African Cuckoo-Hawk (*Aviceda cuculoides*) a scarce raptor that is a reptile hunting specialist.

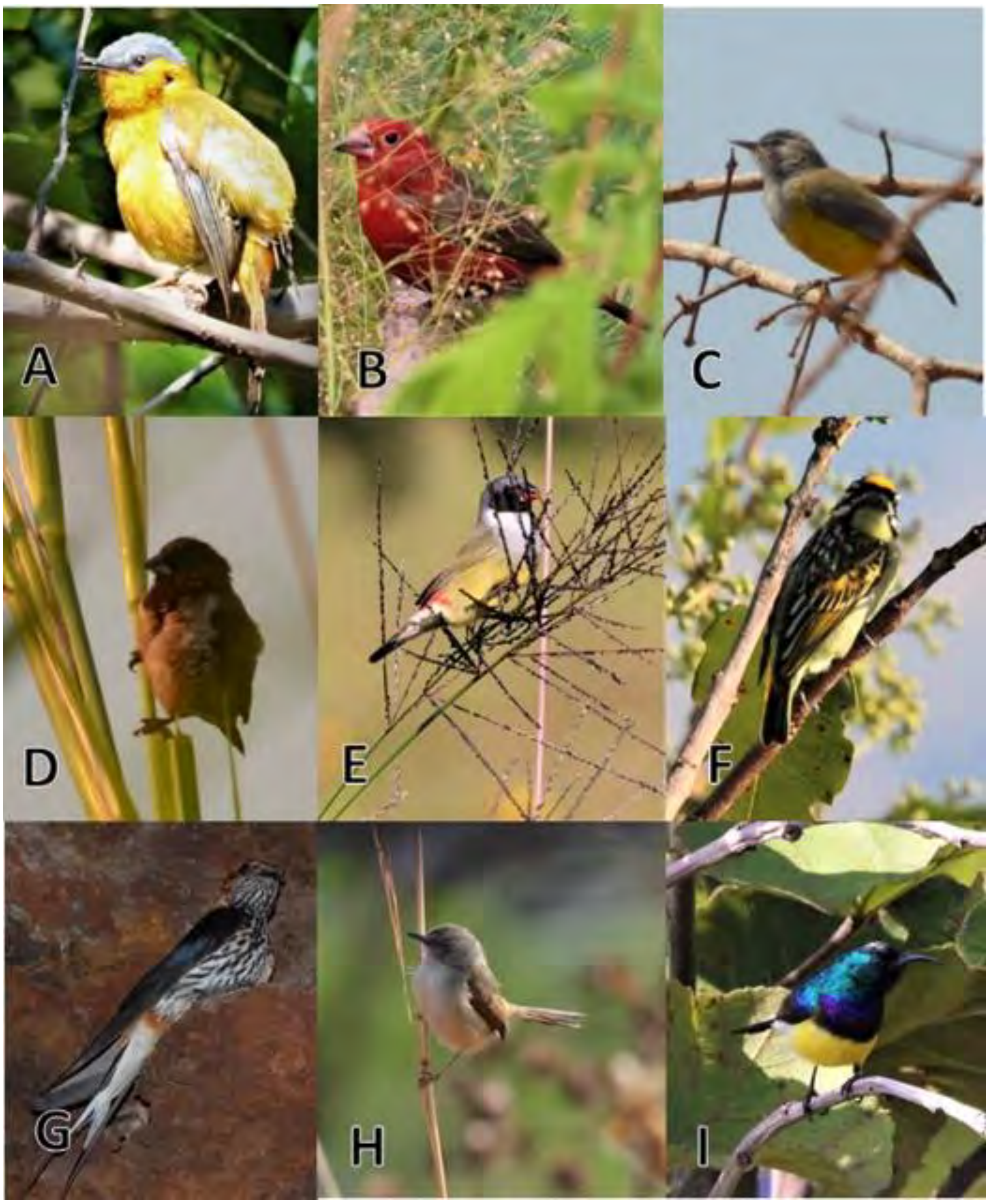


Figure 4-73: Plate 1 - Examples of some of the bird species observed during the field survey; A) Bocage's Akalat (*Sheppardia bocagei*), B) Red-billed Firefinch (*Lagonosticta senegala*), C) Salvadori's Eremomela (*Eremomela salvadorii*), D) Bronze Mannikin (*Lonchura cucullata*), E) Angolan Waxbill (*Coccopygia bocagei*), F) Yellow-fronted Tinkerbird (*Pogoniulus chrysoconus*), G) Lesser Striped Swallow (*Cecropis abyssinica*), H) Tawny-flanked Prinia (*Prinia subflava*), I) and Variable Sunbird (*Cinnyris venustus*)

Figure 4-74: Plate 2 – Examples of birds observed in the Project area; A) European Nightjar (*Caprimulgus europaeus*), B) Lilac-breasted Roller (*Coracias caudatus*), C) Swallow-tailed Bee-eater (*Merops hirundineus*), D) Fiery-necked Nightjar (*Caprimulgus pectoralis*), E) Sooty Chat (*Myrmecocichla nigra*), F) Fork-tailed Drongo (*Dicrurus adsimilis*) and G) White-fronted Bee-eater (*Merops bullockoides*)

4.12.3 Habitat Assemblages

Six broad avifaunal habitat types were identified in the Project area: Carbonatite Outcrops, Riparian and Wetlands, Grassland, Wooded Ravines, Woodland, and Transformed Areas (Figure 4-75).

4.12.3.1 Carbonatite Outcrops

This area of highly dissected broken and somewhat karstic terrain is associated with the carbonatite outcrop situated on the crest of the tallest hill in the Project area. This habitat supports cliff, boulder scree and cave habitat, interspersed with dense, taller, almost scarp-like (although relatively dry and open) broadleaf woodland. The bird community associated with this habitat was diverse and unique.

4.12.3.2 Grasslands (inclusive of wetlands and riparian areas)

This habitat occurs within the higher elevation areas on-site. Although some grassland remains natural, much of it has been degraded by burning and past cultivation practices. Species typically associated with this habitat included Angola Lark (*Mirafra angolensis*), Flappet Lark (*Mirafra rufocinnamomea),* Sooty Chat (*Myrmecocichla nigra*), Fülleborn's Longclaw (*Macronyx fuelleborni*), Yellow-fronted Canary (*Crithagra mozambica*) and Cinnamon-breasted Bunting (*Emberiza tahapisi*).

4.12.3.3 Wooded Ravines

The deep, narrow, densely wooded ravines in the Project area support a relatively high diversity of species, including some of the region's forest associated species such as Bocages Akalat and Dusky Twinspot. These ravines show signs of erosion that has taken place in recent history (likely within the last 20 years) but have since re-established themselves with a complement of medium-sized broadleaf tree species.

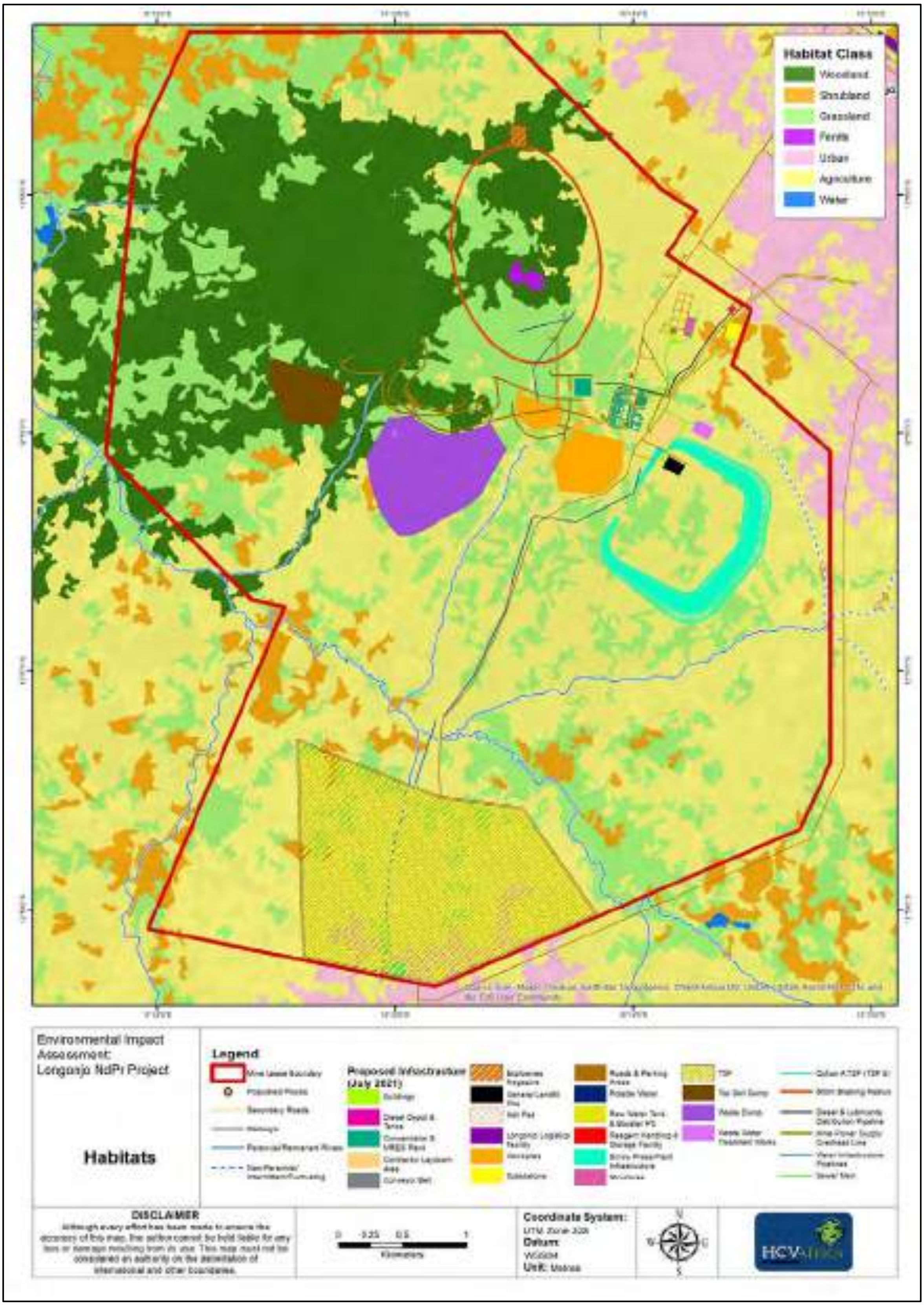


Figure 4-75: Avifaunal habitats delineated for the project

4.12.3.4 Woodland (Miombo) Habitat

This habitat includes miombo woodland on both hillslope and flatland areas. Large portions of these woodlands remain relatively intact and retain some fairly large trees, although wood harvesting is prolific, and all larger specimens have been felled. Nevertheless, this habitat is likely to support several of the region's biome-restricted endemics such as Red-backed Mousebird (*Colius castanotus*), Miombo Pied Barbet (*Tricholaema frontata*), Miombo Tit (*Parus griseiventris*), Miombo Wren-Warbler (*Calamonastes undosus*), Sharp-tailed Starling (*Lamprotornis acuticaudus*), Miombo Scrub Robin (*Erythropygia barbata*), Miombo Rock Thrush (Monticola angolensis) and potentially Gabela Helmetshrike (*Prionops gabela*) and Gabela Akalat (*Sheppardia gabela*). Although this habitat was found to provide important foraging and roosting habitat for diurnal and nocturnal raptors, no large raptor nests were observed, nor did there appear to be suitably tall trees (> 5 m) to support them.

4.12.3.5 Transformed Habitat

This habitat represents land that has been completely transformed through anthropogenic land-use practices (e.g. settlements, croplands, infrastructure and a soccer field). As a result, common, adaptable and commensal species characterize the avifaunal assemblage associated with it. Species that occurred in particularly high abundances in this habitat included Red-billed Quelea (*Quelea quelea*) Fork-tailed Drongo (*Dicrurus adsimilis*), Pied Crow (*Corvus albus*) and Black-throated Canary (*Crithagra atrogularis*).

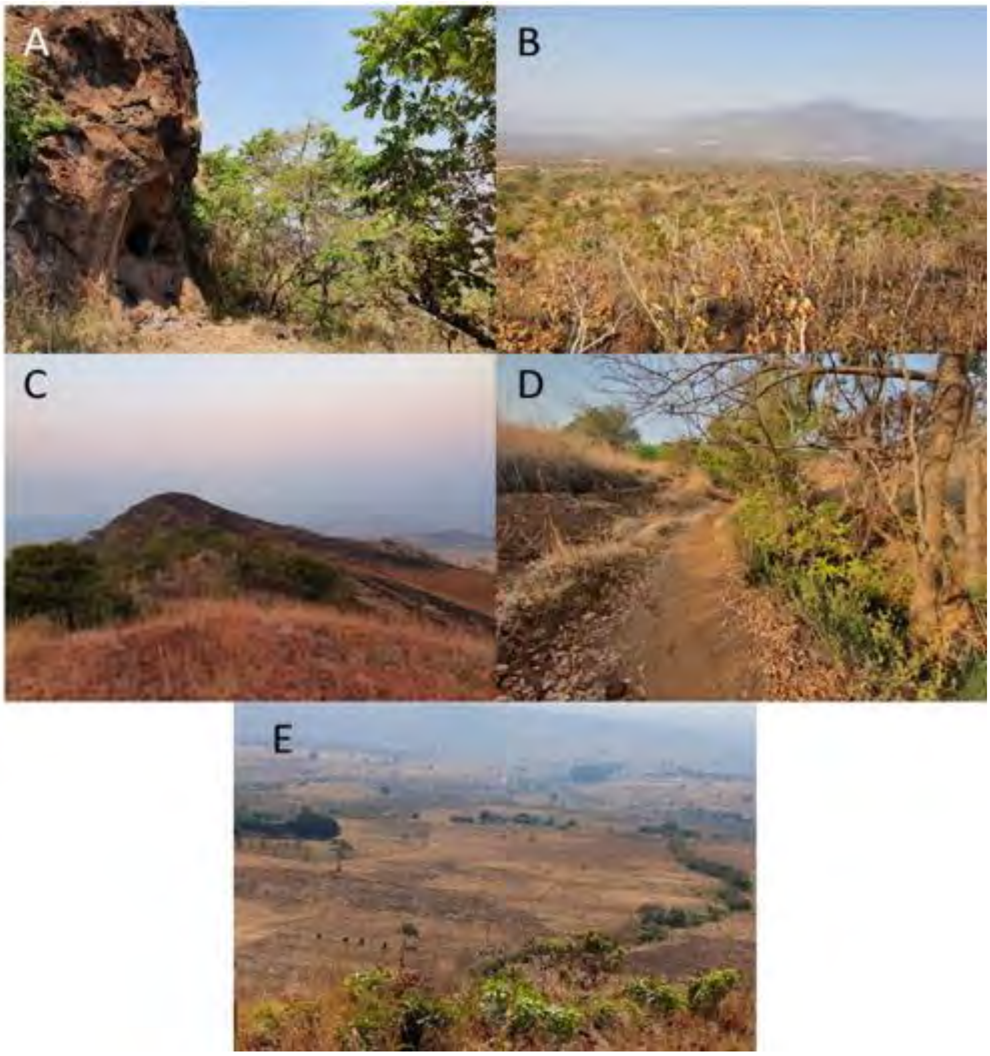


Figure 4-76: Examples of the five avifaunal habitats identified in the project area A)Carbonatite Outcrops, B) Woodland, C) Grassland, D)Ravines / Riparian / Drainage lines and E) Transformed (includes croplands and infrastructure)

4.12.4 Species of Conservation Concern

This section provides an overview of the Project area's potential to support species of conservation concern (SCC), a term which is extended to include red-listed species (Globally or locally Threatened or Near-threatened species), endemic and biome-restricted species and other species deemed to be of conservation importance.

4.12.4.1 Red-Listed Species

A total of 16 IUCN Red-listed species have the potential to occur in the greater Huambo region (50 km radius around the Project area). However, this includes five species that may be restricted to the region's larger, less impacted hilltops. Based on the availability of suitable habitat the Project area has the potential to support 12 Red-listed species representing 75% of the regional Red-listed diversity (). Field surveys revealed the presence of three Red-listed species in the Project area, namely Monteiro's Bushshrike (*Malaconotus monteiri*), Bateleur (*Terathopius ecaudatus*) and Pallid Harrier (*Circus macrourus*). Only the Monteiro's Bushshrike is likely to be a breeding resident as no suitably tall trees exist on-site for nesting by Bateleur, and Pallid Harrier is a non-breeding migrant. Monteiro's Bushshrike is a rare, highly range-restricted and poorly known species thought to be in decline. Present and potentially occurring Category A listed bird species (listed as Endangered) according to Angola's national Red List (Minesterio Do Ambiente, 2018) include Angola Cave Chat (*Xenocopsychus ansorgei*) Cinderella Waxbill (*Estrilda thomensis*). The former was detected on-site.

Some of the wetlands in and surrounding the Project area may support Great Snipe (*Gallinago media*). Given the proximity of the site, the Gabela Mountains and the availability of similar wooded ravines and miombo hillslopes, the site may support Gabela Helmetshrike (*Prionops gabela*) and Gabela Akalat (*Sheppardia gabela*). Although the higher altitude grasslands may be visited by Denham's Bustard (*Neotis denhami*) and Secretarybird (*Sagittarius serpentarius*), breeding is unlikely due to the high levels of human activity in the Project area. Similarly, although the Project area may be visited by red-listed raptor species such as Tawny Eagle (*Aquila rapax*), Hooded Vulture (*Necrosyrtes monachus*), White-backed Vulture (*Gyps africanus*), Martial Eagle (*Polemaetus bellicosus*), breeding on-site is considered unlikely. Due to wood harvesting, no suitably tall trees (> 5m) remain on-site capable of supporting breeding by any of these large-bodied raptors. This, together with the relatively high disturbance levels and lack of suitable nesting, suggests the presence of very large-bodied raptors in the Project area is likely to be transitory at best. No red-listed raptor nests were detected in the Project area. A noteworthy yet concerning observation is that no vulture species were detected during the wet or dry season surveys suggesting local extirpation. Regarding the smaller-bodied Sooty Falcon, the project area is likely to be utilized only from a foraging perspective as the species is a non-breeding summer visitor.

The regionally occurring Grimwood's Longclaw (*Macronyx grimwoodi*), Gabela Bushshrike (*Laniarius amboimensis*) and Swierstras Francolin (*Pternistis swierstrai*) are considered unlikely to occur based on the lack of high altitude forest and associated grassland. At the same time, the Southern Ground Hornbill (*Bucorvus leadbeateri*) is likely precluded by a lack of large trees with suitably large nesting holes, whereas Slaty Egret (*Egretta vinaceigula*) is precluded by a lack of suitable wetland habitat.

Table 4-42: Present and potentially occurring conservation important avifauna

Species	English Common Name	Portuguese Common Name	LO
Critically Endangered			
Necrosyrtes monachus	Hooded Vulture	Abutre-de-capuz	3
Gyps africanus	White-backed Vulture	Grifo-de-dorso-branco	3
Endangered			
Prionops gabela	Gabela Helmetshrike	Atacador-preto da Gabela	3
Sheppardia gabela	Gabela Akalat	Pisco da Gabela	3
Vulnerable			
Sagittarius serpentarius	Secretarybird	Secretário	3
Aquila rapax	Tawny Eagle	Águia-fulva	2
Polemaetus bellicosus	Martial Eagle	Águia-marcial	3
Bucorvus leadbeateri	Southern Ground Hornbill	Calau-gigante	3
Near Threatened			
Terathopius ecaudatus	Bateleur	Águia-bailarina	1
Circus macrourus	Pallid Harrier	Tartaranhão-pálido	1
Neotis denhami	Denham's Bustard	Abetarda-real	2
Gallinago media	Great Snipe	Narceja-real	3
Malaconotus monteiri	Monteiro's Bushshrike	Picanço de Monteiro	1

4.12.4.2 Endemic species

The forested ravines and miombo woodland habitats associated with the hilltops in the greater Huambo region support a large proportion (13 species) of Angola's (17 species) endemic bird species. Based on habitat suitability the project area can support seven national endemics and six near-endemics. Field surveys conducted during the wet and dry season has revealed the presence of two national endemics, namely Angola Cave Chat (*Xenocopsychus ansorgei*), Huambo Cisticola (*Cisticola bailunduensis*) as well as five near-endemics namely Angola Lark (*Mirafra angolensis*), Black-and-rufous Swallow (*Hirundo nigrorufa*), Bocage's Sunbird (*Nectarinia bocagii*), Oustalet's Sunbird (*Cinnyris oustaleti*) and Bocage's Weaver (*Ploceus temporalis*). In addition, a pair of Angola Cave Chats were found occupying a cave in carbonatite towards the top of the hill during the dry season survey. This unique habitat type likely represents an important breeding site for this habitat specialist.

4.12.4.3 Biome restricted species

The region supports 62 (28%) of the country's 221 biome restricted species. Of these, 30 species are highly likely to occur in the Project area based on habitat suitability. These include 21 Zambezian biome, four Afrotropical Highlands biome, three Guinea–Congo Forests biome and two Kalahari-Highveld biome restricted species. 13 biome restricted species were recorded in the Project area over both survey periods. These species are listed in

Table 4-43 (indicated by a 1 in the LO column) along with the habitats from which they were recorded. Photographs taken on-site of some of these species are shown in Figure 4-77.

Table 4-43: Present and potentially occurring biome restricted avifauna

Species	Common Name	LO	Survey		Global Status	Endemicity
			Wet	Dry		
Afrotropical Highlands (A07)						
Xenocopsychus ansorgei	Angola Cave Chat	1		x	LC (S)	End
Euschistospiza cinereovinacea	Dusky Twinspot	1	x		LC (S)	
Crithagra burtoni	Thick-billed Seedeater	1		x	LC (S)	
Pseudoalcippe abyssinica	African Hill Babbler	2			LC (D)	
Dioptrornis brunneus	Angola Slaty Flycatcher	3			LC (D)	End
Guinea–Congo Forests (A05)						
Vidua obtusa	Broad-tailed Paradise Whydah	1	x		LC (S)	
Malaconotus monteiri	Monteiro's Bushshrike	1		x	NT (D)	
Scleroptila finschi	Finsch's Francolin	2			LC (U)	
Prionops gabela	Gabela Helmetshrike	3			EN (D)	End
Sheppardia gabela	Gabela Akalat	3			EN (D)	End
Cisticola bulliens	Bubbling Cisticol	3			LC (S)	
Kalahari–Highveld (A11)						
Estrilda thomensis	Cinderella Waxbill	2			LC (D)	
Erythropygia paena	Kalahari Scrub Robin	2			LC (S)	
Lanioturdus torquatus	White-tailed Shrike	3			LC (I)	
Pternistis hartlaubi	Hartlaub's Spurfowl	3			LC (S)	
Tockus monteiri	Monteiro's Hornbill	3			LC (S)	
Zambezian (A10)						
Mirafra angolensis	Angola Lark	1		x	LC (D)	N-end
Hirundo nigrorufa	Black-and-rufous Swallow	1		x	LC (S)	N-end
Nectarinia bocagii	Bocage's Sunbird	1	x	x	LC (S)	N-end
Cinnyris oustaleti	Oustalet's Sunbird	1	x	x	LC (S)	N-end
Ploceus temporalis	Bocage's Weaver	1	x		LC (S)	N-end
Macronyx fuelleborni	Fülleborn's Longclaw	1	x		LC (S)	
Cisticola bailunduensis	Huambo Cisticola	1		x	LC(U)	End
Lanius souzae	Souza's Shrike	2			LC (D)	
Pentholaea arnotti	Arnot's Chat	2			LC (D)	
Muscicapa boehmi	Böhm's Flycatcher	2			LC (D)	
Petrochelidon rufigula	Red-throated Cliff Swallow	2			LC (I)	
Colius castanotus	Red-backed Mousebird	2			LC (S)	End
Tricholaema frontata	Miombo Pied Barbet	2			LC (S)	
Lybius minor	Black-backed Barbet	2			LC (S)	
Parus rufiventris	Rufous-bellied Tit	2			LC (S)	
Parus griseiventris	Miombo Tit	2			LC (S)	
Sylvietta ruficapilla	Red-capped Crombec	2			LC (S)	
Calamonastes undosus	Miombo Wren-Warbler	2			LC (S)	
Lamprotornis acuticaudus	Sharp-tailed Starling	2			LC (S)	
Erythropygia barbata	Miombo Scrub Robin	2			LC (S)	
Monticola angolensis	Miombo Rock Thrush	1			LC (S)	
Turdus libonyana	Kurrichane Thrush	2			LC (U)	
Tauraco erythrolophus	Red-crested Turaco	3			LC (D)	End
Coracias spatulatus	Racket-tailed Roller	3			LC (D)	
Tockus bradfieldi	Bradfield's Hornbill	3			LC (D)	
Stactolaema anchietae	Anchieta's Barbet	3			LC (S)	
Centropus cupreicaudus	Coppery-tailed Coucal	3			LC (S)	
Tockus pallidirostris	Pale-billed Hornbill	3			LC (S)	
Batis margaritae	Margaret's Batis	3			LC (S)	
Euplectes aureus	Golden-backed Bishop	3			LC (S)	
Lagonosticta nitidula	Brown Firefinch	3			LC (S)	

Key: IUCN (2019) global status, letters in parentheses indicate population trend, D= Decreasing, S = Stable, U = Uncertain. Endemicity; End = Endemic, N-end = Near Endemic.

Figure 4-77: Examples of biome-restricted bird species detected in the Project area; A) Angola Cave Chat (*Xenocopsychus ansorgei*), B) Huambo Cisticola (*Cisticola bailunduensis*), C) Monteiro's Bushshrike (*Malaconotus monteiri*), D) Angola Lark (*Mirafra angolensis*), E) Dusky Twinspot (*Euschistospiza cinereovinacea*), F) Black-and-rufous Swallow (*Hirundo nigrorufa*), G) Miombo Rock Thrush (*Monticola angolensis*)

4.12.4.4 Other Conservation Important Species

Raptor species, in general, are conservation important not only due to their long-lived, k-selected biology but also because they are apex predators whose populations are widely considered to be in a general decline. The Project area supports a diversity and abundance of raptors which bodes well for the integrity and functionality of the ecosystem. In total, 11 raptor species were observed during the site visits, which included African Cuckoo-Hawk (*Aviceda cuculoides*), a generally rare species, Bateleur (*Terathopius ecaudatus*), Pallid Harrier (*Circus* *macrourus*), Lizard Buzzard (*Kaupifalco monogrammicus*), Augur Buzzard (*Buteo augur*), Wahlberg's Eagle (*Hieraaetus wahlbergi*), Long-crested Eagle (*Lophaetus occipitalis*), Grey Kestrel (*Falco ardosiaceus*), Rock Kestrel (*Falco rupicolus*) and Spotted Eagle-owl (*Bubo africanus*). Some examples of these species are shown in Figure 4-78. The observation of a juvenile Lanner Falcon on the crest of the hill suggests that the breeding is likely taking place nearby. Although listed as Least Concern on a global scale, Lanner Falcons are considered Vulnerable in Europe and South Africa and are nowhere common. Rock Kestrel (*Falco rupicolus*) were frequently observed on-site during both surveys suggesting that the birds are resident and breeding on the carbonatite outcrop.

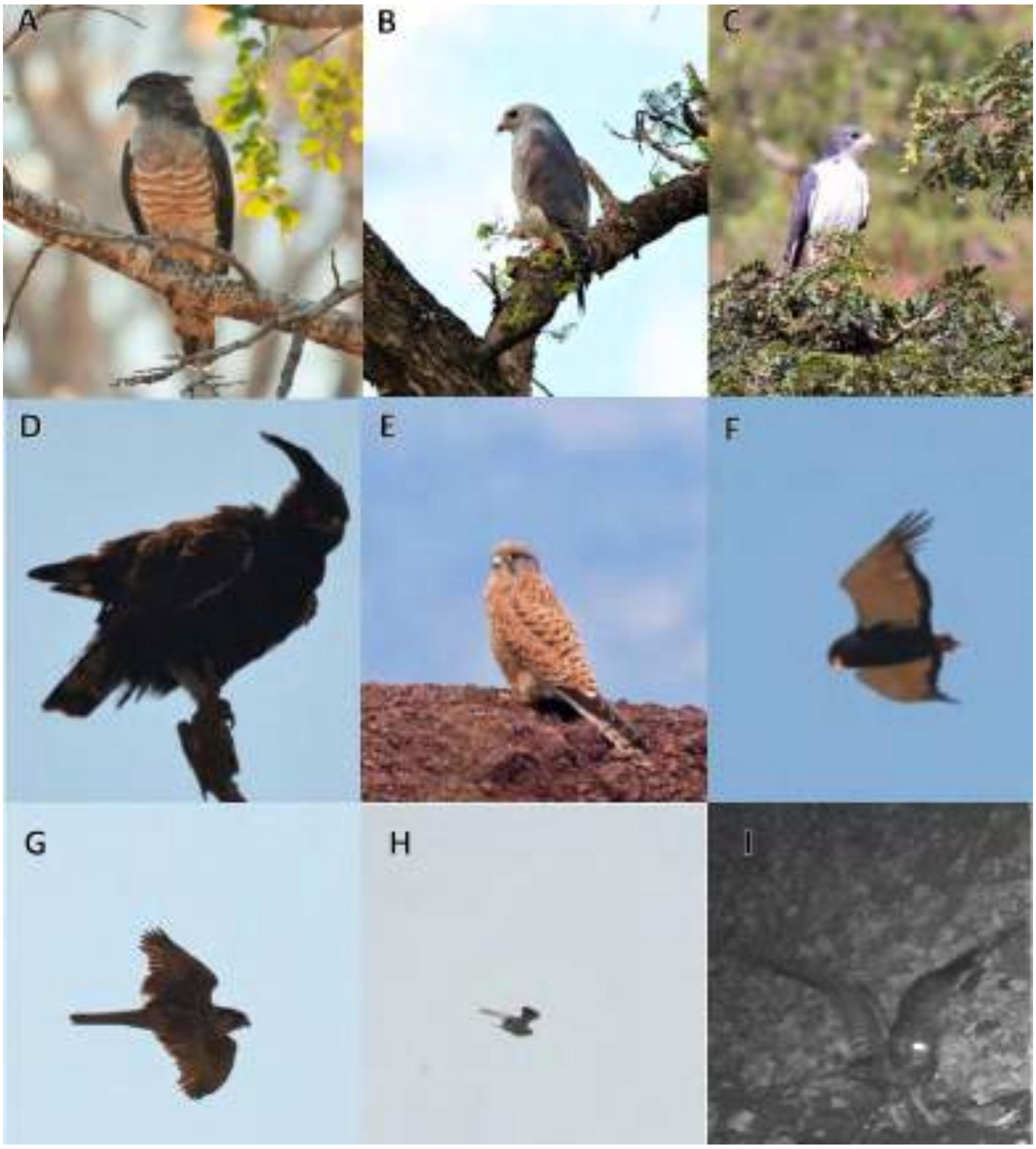


Figure 4-78: Examples of raptor species detected in the Project area: A) African Cuckoo-Hawk (*Aviceda cuculoides*), B) Lizard Buzzard (*Kaupifalco monogrammicus*), C) Augur Buzzard (*Buteo augur*), D) Long-crested Eagle (*Lophaetus occipitalis*), E) Rock Kestrel (*Falco rupicolus*), F) Bateleur (*Terathopius ecaudatus*), G) Lanner Falcon (*Falco biarmicus*), H) Black-winged Kite (*Elanus caeruleus*), I) Spotted Eagle-Owl (*Bubo africanus*)

4.12.5 Habitat sensitivity / Critical habitat

Results of this avifaunal survey highlight the Carbonatite Outcrop as supporting a unique and essential avifaunal assemblage and is of High importance and sensitivity. Although the deep ravines, higher altitude grasslands and miombo woodland habitats associated with the hill also support rare, SCC, and endemic species, these habitats are more widespread and occur in relatively large expanses in the hills to the north-west of the project area and as such are considered to be of Moderate importance and sensitivity. All of the other habitats (proposed TSF areas, croplands, infrastructure and other degraded areas) are of low importance / sensitivity and are of little value to local mammal and birdlife and are assigned a Low sensitivity.

Following an update to the mine design, specifically the pit layout, the Carbonatite Outcrop has effectively been excluded from the mining footprint.

4.13 Botany

The Botany Specialist Study is presented in Appendix K.

4.13.1 Regional context

According to Sayre, et al. (2013), the Project area forms part of three macro ecosystems, namely the Wet Miombo, Dry Miombo, and Gabono-Congolian Mesic Woodland & Grassland ecosystems. Each of these macro ecosystems are briefly described below and taken verbatim from Sayre et al. (2013).

The wet miombo macrogroup-

"*Miombo woodland is the most widespread vegetation type of the Central African Plateau in an elevational range typically between 800 and 1200 m. It is dominated by three related genera of the Caesalpinioideae: Brachystegia, Isoberlinia, and Julbernardia. The wet miombo is distinguished from the dry by having >1000 mm (up to 1400 mm) mean annual precipitation; the dry season lasts from 5 to 7 months. Fires are part of the functional ecology of these woodlands. Woodland trees are usually 15 to 20 m tall, with a broadleaf shrub and continuous grass understory beneath*."

The dry miombo macrogroup

"*Dry miombo is similar to the wetter miombo but with 600 to 800 mm mean annual precipitation and therefore less vegetation structure and diversity. It lies mostly to the south and east of the wet miombo. Like the wet miombo, it occupies part of the Central African Plateau and its escarpments, though the dry miombo reaches further in the lowlands with extensive areas between 200-800 m elevation in Mozambique. Besides the dominant Brachystegia spiciformis and Julbernardia globiflora, other common tree species include Uapaca kirkiana, Brachystegia boehmii, Monotes glaber, Faurea saligna, Faurea speciosa, Combretum molle, Albizia antunesiana, Strychnos spinosa, Strychnos cocculoides, Flacourtia indica, and Vangueria infausta*."

The Gabono-Congolian Mesic Woodland & Grassland Macrogroup

"The macrogroup represents moist-climate savannas that occur west and south of the Congo Basin due to climatic fluctuations in Central Africa that over the past several thousand years have caused a succession of transitions from forest to savanna and back to forest, leaving in the process a number of fragments of savanna intermingled with humid forest. Some of these savannas might also be caused by human transformation of the forest. The climate has two wet and two dry seasons, and the mean annual rainfall varies from 1500-1800 mm with a mean temperature of 23-25 degrees C. There are different types of savanna that are grouped in this class: treed savannas to more open savannas; some of the latter are dembos (wet meadows). Characteristic of the treed savannas is Hymenocardia acida. In more open types, Jardinea gabonensis which is joined by Setaria anceps in the flooded savanna (dambos)."

Terrestrial ecoregions of the world

According to Olson (2001), the Project area forms part of the Angolan montane forest-grassland mosaic ecoregion. This ecoregion has been assigned Critical/Endangered status by the WWF. According to Olson (2001) taken verbatim:

> *"This ecoregion comprises a number of small montane forest patches surrounded by grasslands and Protea savanna in the west-central highlands of Angola. The forest patches are restricted to the deep ravines or remote valleys of the highest mountains in the Huambo and Cuanza Sul provinces and an area of Afromontane forest mosaic further south, on the Serra da Chela in Huíla province. The ecoregion represents a small fragment of White's (1983) Afromontane archipelago-like center of endemism, which consists of widely scattered "islands" of forest on mountain systems in southern, eastern, and western Africa (Werger 1978). The characteristic elements of the ecoregion's fauna and flora are more closely related to other such Afromontane areas than to the surrounding Angolan biomes (Huntley 1974a, Dean 2000). Pockets of forest survive mainly in deep, humid ravines and on isolated peaks higher than 1,800 m (Huntley and Matos 1994).*
>
> *The forest patches range from 1 to 20 ha in size and reach a canopy height of 8 m to 15 m. The dominant forest tree species is the yellowwood Podocarpus latifolius. Other common tree species include Polyscias fulva, Apodytes dimidiata, Pittosporum viridiflorum, Syzygium guineense afromontanum, Halleria lucida, Olea spp., and Ilex mitis. Hardly any grass grows in these shady forests, and they are less heavily overgrown with epiphytes than similar forests elsewhere in Africa (Huntley and Matos 1994). The canopy tends to be very irregular because of the steep and rocky slopes on which the forest patches are found. Open grasslands with widely scattered trees and shrubs cover large areas of the highland plateau above 1,600 m and make up most of the ecoregion's area. In well-drained areas, this vegetation is generally fire-prone and includes shrub species such as Philippia benguelensis, Erica spp., Protea trichophylla, Stoebe vulgaris, and Cliffortia sp. and grasses Themeda triandra, Tristachya inamoena, T. bequertii, Hyparrhenia andogensis, H. quarrei, Festuca spp., and Monocymbium ceresiiforme. On waterlogged plateaus, representative plants include Parinari capensis, Myrsine africana, Protea welwitschii, Dissotis canescens, Cyathea spp., Loudetia spp., Fimbristylis spp., and Xyris spp. (Huntley and Matos 1994).*
>
> *The grasslands in the ecoregion are partly of edaphic origin and partly maintained by fire, much of this from anthropogenic origin. Though the forest vegetation is not very flammable, fires can intrude into the forest in hot, dry periods or when forests have been thinned through logging and grass has been able to grow. The abrupt boundaries of the forest fragments and their remaining distribution in ravines and moist south-facing slopes demonstrate that the extent of forests is largely determined by fire. This is also the case in other Afromontane areas in Africa, e.g. South Africa, where Afromontane forest has been highly fragmented for a very long time as a result of fire (Midgley et al. 1997). It has also been shown that the smaller the forest fragments are, the greater the potential impact of fire."*

4.13.2 Local context

Seven key habitat types were identified through GIS analysis (Figure 4-79) namely, four natural habitat types and three modified/transformed habitat types(Figure 4-80).

Natural habitat types

- Rocky hillslope grassland;
- Woodland;
- Ravine community; and
- Cliffs and caves.

Modified habitat types

- Agricultural fields
- Bare soil

Transformed habitat types

- Transformed

Selected photographs of conspicuous plant species associated with the natural habitats are shown in Figure 4-81 and Figure 4-82. Only natural habitat types are briefly discussed below.

Rocky hillslope grassland

This habitat type is dynamic and predominantly in a fire maintained secondary successional state. Due mainly to anthropogenic fires, an unstructured mosaic of open shrubland / grassland savanna with remnant patches of fire-tolerant small trees and / or shrubs incorporates both woodland and grassland elements into this habitat unit. The frequency of burning is likely the predominant determining factor in the ratio between grass-shrub-tree cover dominance.

Woodland

This habitat type extends the typical habitat associated with the region. Woodland habitats in the Project area are characterised by short to tall sparse to closed vegetation canopies on moderate to steep slopes. The canopy cover ranges between 15% in disturbed (e.g. due to wood harvesting or clearing for shifting agriculture) and 50% in less disturbed areas. The dominant life forms are tree species over 2m tall.

Ravine community

The Ravine community differs from the valley bottom rivers and wetlands in the surrounding landscape in that they are associated with distinct geomorphological and erosional landforms. According to Bates and Jackson (1984), "A ravine is defined as a small, narrow, deep depression smaller than a valley but larger than a gully." This habitat was likely formed over decades through head cutting actions within artificial drainage channels constructed to drain/channel water in the landscape for agriculture. They are characterised by areas with largely tall closed vegetation canopies on very steep slopes across symmetrical opposing hillsides associated with deep and narrow channelled depressions in the Project area.

Cliffs and caves

This habitat type is limited to the steep rocky cliffs along the mountain's southern slope. Vegetation cover within this habitat is limited to the outer rock surfaces and consist of sparsely covered herbaceous vegetation on small ledges and within rock crevices.

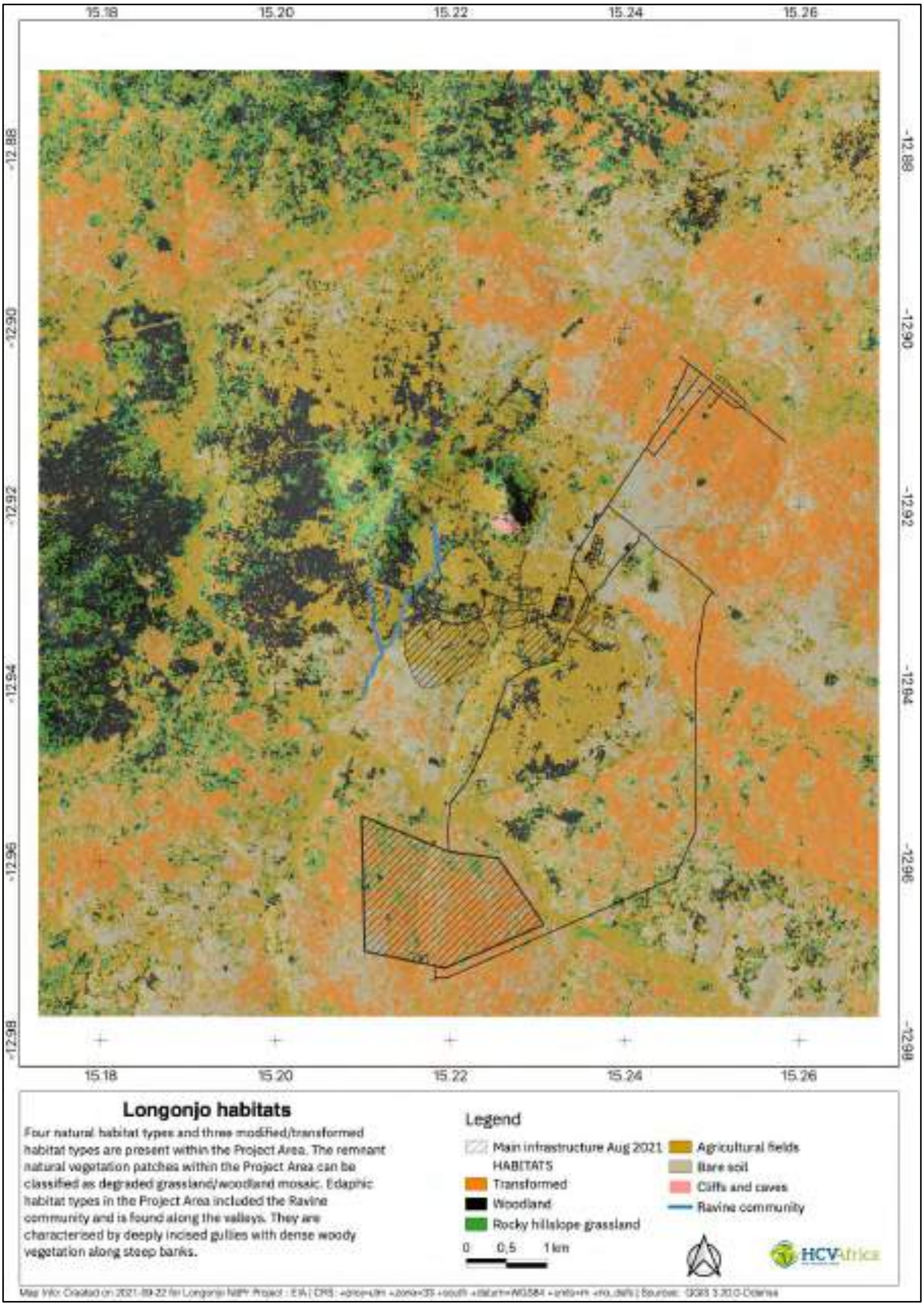


Figure 4-79: Habitat types recorded in the Project area

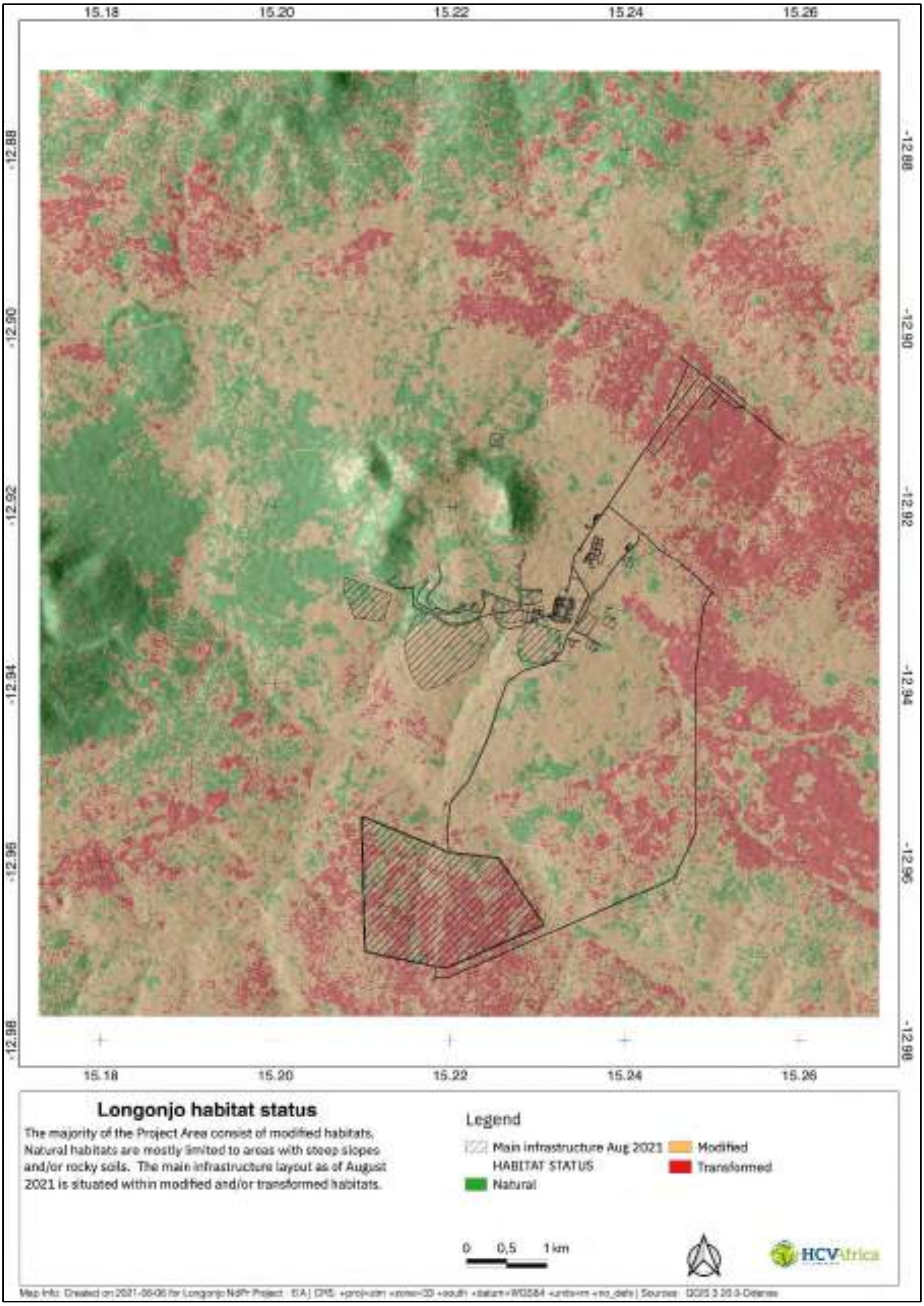


Figure 4-80: Map differentiating between natural and modified habitats in the Project area

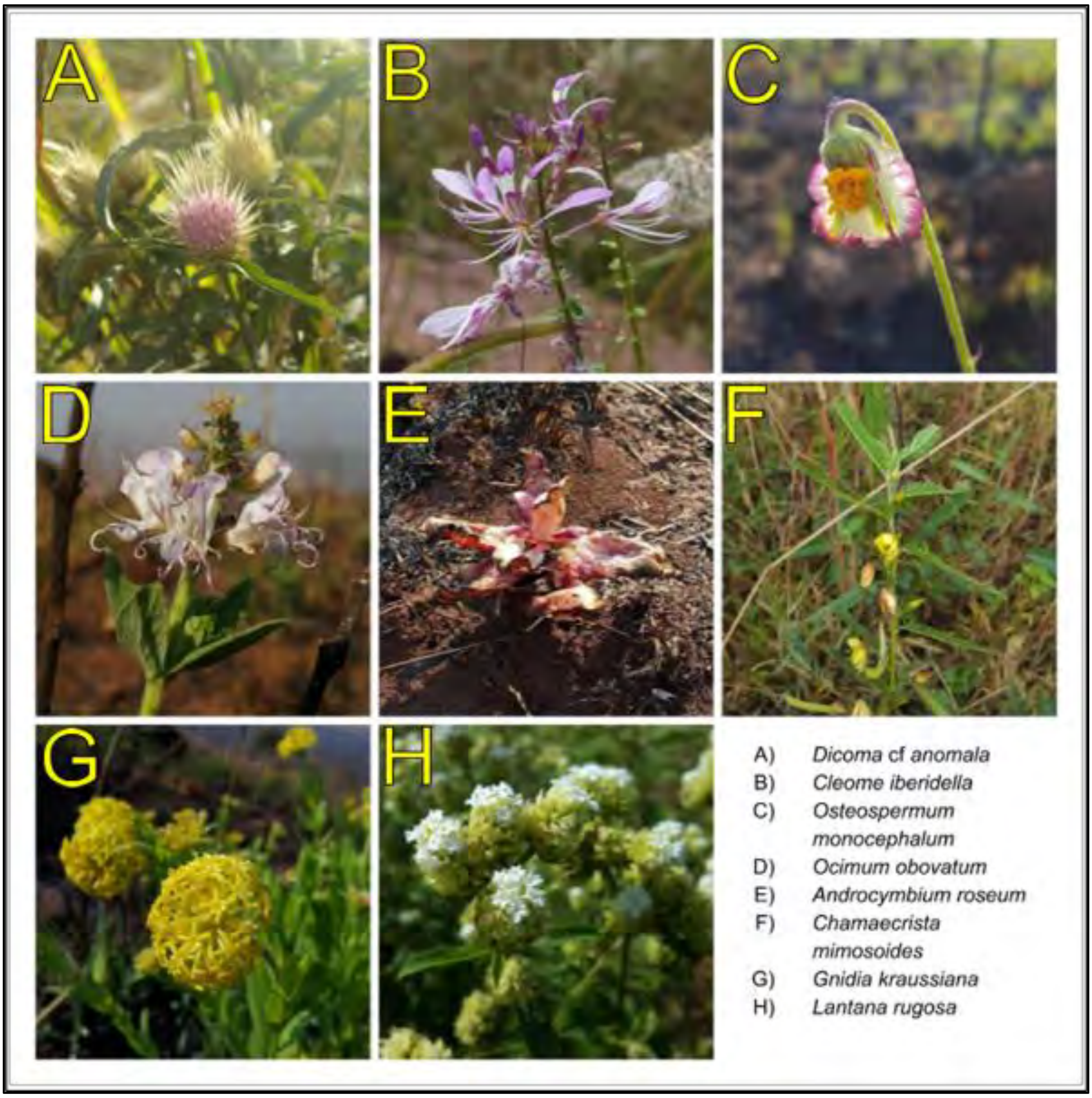


Figure 4-81: Conspicuous wildflowers observed within the natural habitats of the Project area

Figure 4-82: Conspicuous tree species observed within the natural habitats of the Project area

4.13.2.1 Species richness

Approximately 170 plant species were recorded during the dual season survey (data from timed meanders as well as opportunistic observations). Based on the species accumulation calculated using the timed meander data, preliminary analysis suggests that the woodland habitats contain the most plant species. The grassland habitat surveyed during the timed meander was homogeneous and species-poor. However, this is likely due to seasonal limitations and under-sampling using timed meanders within this habitat type.

4.13.3 Species of conservation concern

Three species of conservation concern were recorded within the Project area during the dual season surveys. However, based on the habitats observed, eight additional SCC are expected to occur (with a medium to a high probability of occurrence (POO)) within the Project area (Table 4-44).

Table 4-44: Species of conservation concern recorded and with a medium to high POO

Scientific name	IUCN Category	Angola Red List	Habitat	POO
Pterocarpus angolensis	Data Deficient	Vulnerable		Recorded
Psorospermum febrifugum	Lower Risk-Near threatened			Recorded
Rotala fontinalis	Vulnerable		Small herb growing in water of granite cracks in woody savanna.	Medium
Aeschynomene angolensis	Data Deficient		*A. angolensis* is a perennial shrub which grows in dry grassland. Plants have been found growing in large groups from a woody root (Faulkner #49).	Medium
Crotalaria bakeriana	Data Deficient		*C. bakeriana* is a well branched herb up to 1 m tall, with very slender subglabrous branches which has been collected in plateau grassland (Hundt #470).	Medium
Eriosema benguellense	Data Deficient		*E. benguellense* is a perennial shrub up to 1 m high, which occurs in grasslands, open bush and Acacia< forests (African Plant Database version 3.3).	Medium
Ansellia africana	Vulnerable			High
Disa katangensis	Data Deficient			Medium
Disa verdickii	Data Deficient			Medium
Disa celata	Data Deficient			Medium

4.13.4 Alien and/or invasive plant species

A total of 14 alien and / or invasive plant (AIP) species were recorded in the Project area. The majority of these were recorded in the "Agricultural fields" and "Transformed" habitat types. A list of all the AIP's recorded within the Project area is given in Table 4-45.

Table 4-45: Alien and/or invasive plant species recorded within the Project area

Plant species name	Invasive	Location
Achyranthes aspera	No	-12.9228269,15.2183068
Agave sisalana	No	-12.9310451,15.2294015
Ageratum conyzoides	Yes	-12.9168168,15.2183755
Amaranthus hybridus	Yes	-12.9228127,15.2182616
Bidens pilosa	Yes	-12.9168993,15.2182621
Conyza albida	Yes	-12.9227028,15.2281578
Cosmos sulphureus	Yes	-12.8998678,15.2478062, -12.9546442,15.219917
Ipomoea cf pileata	Yes	-12.9229337,15.2182118

Manihot esculenta	No	-12.9224191,15.2181334
Mimosa cf pigra	Yes	-12.8998605,15.2478163
Musa	No	-12.9226108,15.2184202
Psidium guineense	Yes	-12.9228411,15.2182658, -12.954439,15.2197654
Ricinus communis	Yes	-26.0728834,27.9384849, -12.9247445,15.2175965
Tithonia diversifolia	Yes	-12.9166924,15.2185518, -12.9293869,15.2168145

4.13.5 Current impacts

Several current impacts in the Project area were observed during the dual season survey. These impacts negatively affect plant species, especially in combination with each other.

4.13.5.1 Exploitive activities affecting the botanical baseline

- Farming
  - Cultivation – large areas within the Project area are consistently cleared for shifting / subsistence agriculture.
  - Grazing - extensive livestock grazing was observed across the Project Area.
- Harvesting
  - Honey – harvesting honey from natural and artificial beehives.
  - Timber harvesting – wood harvesting for fuel or charcoal production is one of the main impacts associated with the loss of woodland habitats within the Project area.
- Mineral extraction
  - Quarrying – a non-Project related borrow pit is located in the Project area.

4.13.5.2 Inappropriate management affecting the botanical baseline

- Inappropriate fire regimes
  - Inappropriate frequency and timing of burning significantly affect the successional stages of natural habitats within the region.
- Inappropriate water regimes
  - Damming – artificial impounding of water within a ravine was observed.
  - Drainage – artificial drainage channels within agricultural fields have significantly altered the natural hydrology of the Project area

4.13.5.3 Mass movement of material in/out of habitat

- Mass movement of material from habitats
  - Soil – the Project area is primarily characterised by soils with high erosive properties, and extensive areas of erosion were observed within drainage lines and along roads.

4.13.5.4 Pest and problem species

- Plants

- Competition – alien and / or invasive weeds and trees are scattered throughout the Project area and rapidly invade / colonise disturbed areas (e.g. fallow lands).

4.13.6 Botanical sensitivity assessment

The layout of the sensitive botanical habitat areas in relation to the infrastructure of the Project Area is provided in Figure 4-83. The figure shows a limited overlap of infrastructure with habitats of high to very high sensitivity.

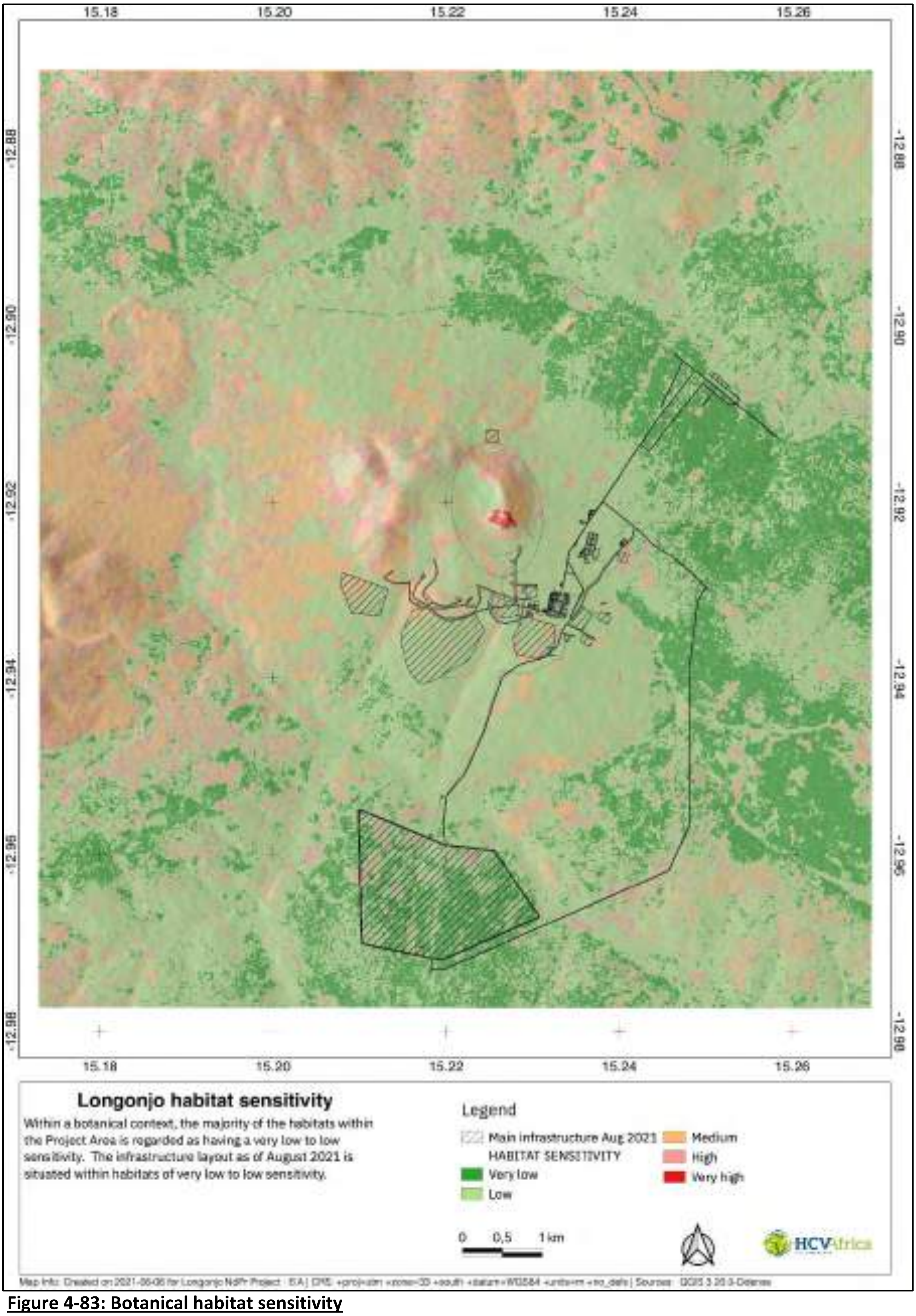


Figure 4-83: Botanical habitat sensitivity

4.14 Herpetology

4.14.1 Regional context

Due to the large country size and high habitat diversity, Angola has very rich herpetofauna. A total of 117 amphibians and 278 reptiles have been recorded for the country (Marques *et al*., 2018). However, despite this impressive diversity, relatively few sample locations have been recorded across the country, mostly due to the near 30-year series of civil and colonial wars, the resultant lack of adequate road infrastructure, and high densities of landmines, all of which limit accessibility. Reproduction of all herpetofauna sample localities across Angola (Marques *et al*. 2018) in relation to the location of the current Project Area shows that while some sampling has been performed around the city of Huambo itself, there is a complete lack of sampling for amphibians southwest of Huambo in the area surrounding the current Project area, and only limited samples sites for reptiles in this region, mostly confined to the mountainous areas to the west of the Project area (Figure 4-84). Consequently, predicting species likely to occur in the Project area relied on understanding the habitat requirements for each species and extrapolation from known surrounding localities. Species with even a small probability of occurring in the Project area have been included as a precautionary measure.

A vital consequence resulting from the lack of herpetological work performed in Angola due to the aforementioned, is that the taxonomic certainty for most species is in question. This is because most of the collected specimen descriptions originate from times before colour photography was possible, and in particular, the more recent development of genetic analyses to delineate species boundaries are almost entirely absent from the Angolan herpetofauna. Consequently, nearly all species descriptions presented in Marques *et al*. (2018) call for additional studies and the application of molecular techniques to try to eliminate this widespread uncertainty. Other essential reference works used to assist with identification were the reptile database (Uetz *et al*. 2019), Amphibiaweb (2019), Frost (2019), Branch (1998), Branch (2008), Schiøtz (1999), Channing (2001), Channing *et al*. (2012) and Channing & Rödel (2019). Therefore, herpetofauna species identifications presented in this report are subject to change and represent the best understanding possible at the time of publication, given these limitations.

Reptiles **Amphibians**

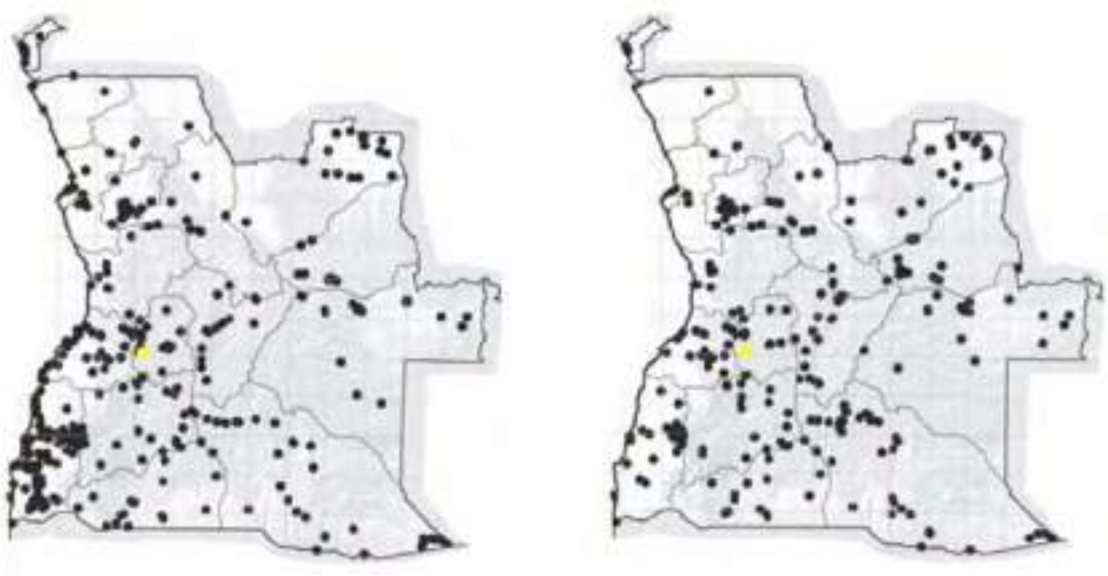


Figure 4-84: Herpetofauna sampling localities across Angola (Marques et al. 2018) in relation to the current Project area (yellow dot).

4.14.2 Local context

Predictive analysis indicates that 34 amphibians and 83 reptile species could occur in the Project area. These species, and their probability of occurrence in the Project area are available in the Herpetology Specialist Study (Appendix M and L). The same habitat classification as per Figure 4-79, applies to herpetofauna. The herpetofauna field surveys recorded eight amphibian and eighteen reptile species present in the Project area, representing 24% and 22% of the expected species, respectively. Photographic evidence of the observed amphibian and reptile species is provided in Figure 4-85 and Figure 4-86, respectively.

This relatively low amphibian species diversity observed during the fieldwork survey (of the diatreme in particular) is a combination of the relatively low levels of activity due to the timing of the surveys (late wet season and dry season) but also the rather specialised and specific habitat in the Project area. For example, no depression wetlands and marshy areas are present in the Project area, limiting the amphibian community to stream and river habitats. Similarly, although a good representation of the expected diversity, the reptile diversity was expected to be higher due to the rocky habitats of the diatreme. However, a total absence of geckos and lack of other expected rupiculous species indicates that this habitat is not suitable, probably due to how the fenite rock erodes, which is not conducive to forming ideal refugia.

A semi-standardised manner of quantifying the level of herpetofauna activity during a survey is to observe and enumerate roadkill specimens (amphibians and snakes are particularly susceptible). The road was continuously scanned for herpetofauna roadkill during all driving and, specifically, the three-night drives performed (wet season survey). Only a single roadkill specimen was observed, indicating very low levels of herpetofauna activity at a regional scale.

All species observed in the Project area are considered to be widespread habitat generalists (except for the rupicolous habitat specificity of the Western Rock Skink [*Trachylepis sulcata ansorgii*] and Schack's Rock Agama [*Agama schacki*]). Unfortunately, insufficient data were obtained during the survey to delineate species assemblages per habitat type accurately.

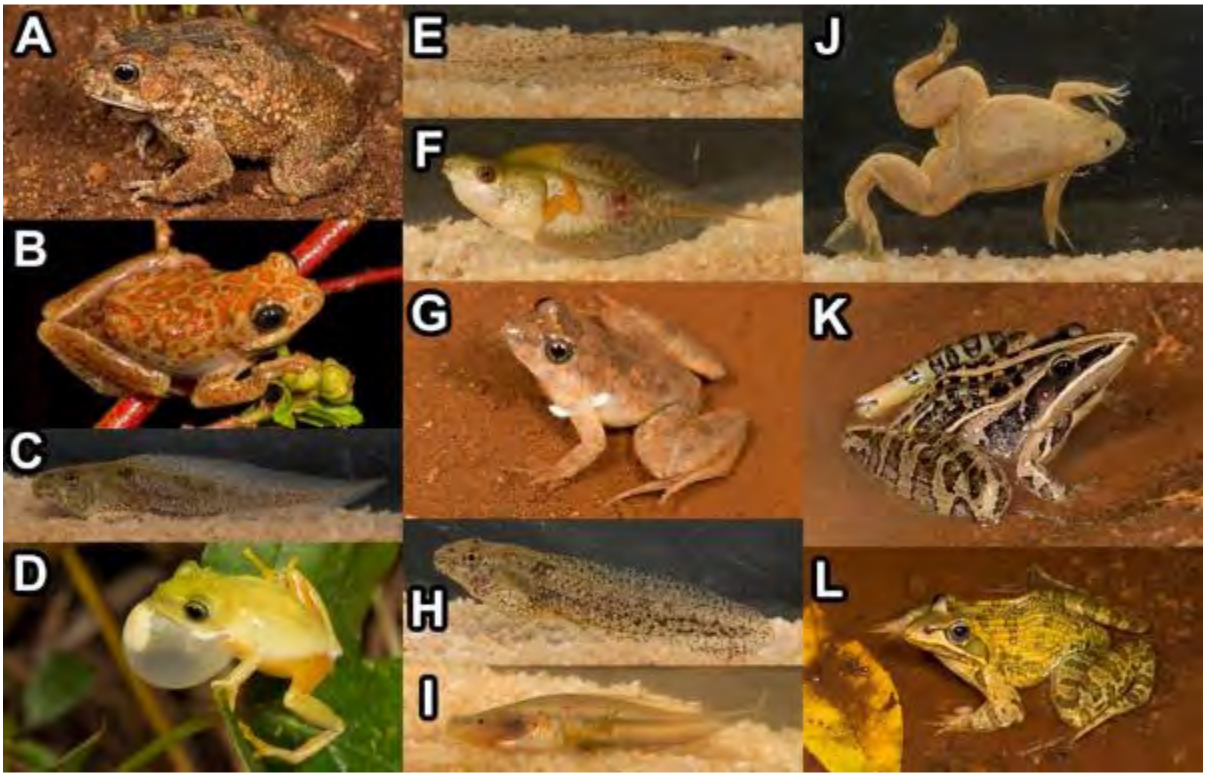


Figure 4-85: A selection of amphibian species observed and photographed during the 2019 surveys A) *Sclerophrys pusilla* B) *Hyperolius angolensis* C) Tadpole of *Hyperolius angolensis* D) *Hyperolius cinereus* E) Tadpole of *Hyperolius cinereus* F) Tadpole of *Kassina kuvangensis* G) *Phrynobatrachus natalensis* H) Tadpole

of *Phrynobatrachus natalensis* I) Tadpole of *Xenopus petersii* J) *Xenopus petersii* K) *Ptychadena uzungwensis* L) *Amietia angolensis*.

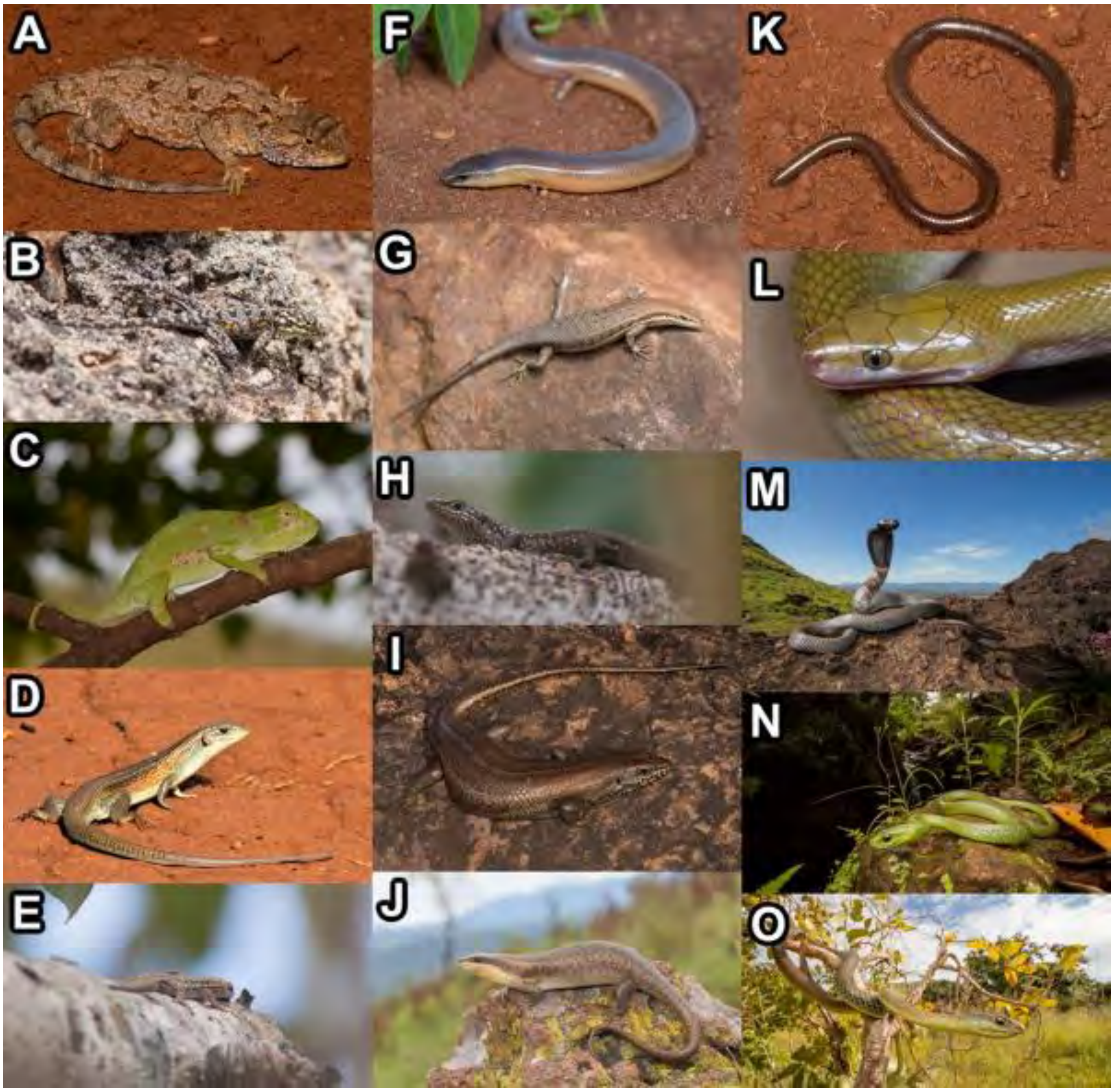


Figure 4-86: A selection of reptile species observed and photographed during the 2019 surveys. A) *Agama aculeata* B) *Agama schacki* C) *Chamaeleo dilepis quilensis* D) *Gerrhosaurus nigrolineatus* E) *Lygodactylus capensis* F) *Sepsina angolensis* G) *Trachylepis albopunctatus* H) *Trachylepis maculilabris* I) *Trachylepis sulcata ansorgii* J) *Trachylepis wahlbergii* K) *Leptotyphlops scutifrons* L) *Boaedon angolensis* M) *Naja nigricollis* N) *Philothamnus angolensis* O) *Psammophis mossambicus*

4.14.3 Amphibian survey results - 2021

During the May 2021 site visit (late wet season), six species of amphibians were recorded in the project area (

Table 4–47 and Figure 4–87). These included Flat-backed Toad (*Sclerophrys pusilla*), Angolan Reed Frog (*Hyperolius angolensis*), Natal Puddle Frog (*Phrynobatrachus natalensis*), Angola River Frog (*Amietia angolensis*), Angola River Frog (*Amietia angolensis*) and Rough Sand Frog (*Tomopterna tuberculosa*). Of these, the latter two represent additional species not recorded in previous (2019) surveys, bringing the total number of amphibian species confirmed in the project area to ten.

Notably, most of these species were recorded at drainage lines in the project area, the quarry at the base of the diatreme hill and dams in the far north-west. Amphibian habitat in the proposed southern TSF area was limited to a narrow watercourse. These areas are terrestrial and comprise of a mix of cropland, grassland and Miombo woodland. These areas distinctly lack perennial or non-perennial watercourses, ravines, dams, depressions, and other wetland types. Consequently, their amphibian assemblages are likely to be limited to a small compliment of widespread and adaptable species capable of persisting either temporarily or permanently in the absence of permanent / seasonal surface water such as toads (*Sclerophrys* spp.), sand frogs (*Tomopterna* spp.), rain frogs (*Breviceps* spp.).

Figure 4–87: A selection of amphibian species observed and photographed during the 2021 survey. Angolan Reed Frog (*Hyperolius angolensis*), Rough Sand Frog (*Tomopterna tuberculosa*), Ansorge's Grass Frog (*Ptychadena ansorgii*) and Angola River Frog (*Amietia angolensis*)

4.14.4 Reptile survey results - 2021

The 2021 site visit yielded eight reptile species. These included Schack's Rock Agama (*Agama schacki*), Flap-neck Chameleon (*Chamaeleo dilepis*), Angolan Variable Skink (*Trachylepis albopunctatus*), Speckled-lip Skink (*Trachylepis maculilabris*), Western Rock Skink (*Trachylepis sulcata ansorgii*), Nile Monitor (*Varanus niloticus*) and Nile Crocodile (*Crocodylus niloticus*). Additionally, the Olive Whip Snake (*Psammophis mossambicus*) was recorded in the vicinity. Evidence of some of these observations is shown in Figure 4–88.

The Olive Whip Snake represents an additional species not previously recorded, bringing the total inventory for the project area to 19 species (Table 4–46). Only the Angolan Variable Skink and the Flap-neck Chameleon were recorded in the new infrastructure areas of the tabulated species. The position of these areas in relatively flat to gently undulating cropland and Miombo woodland (a ubiquitous and extensive habitat type in Angola) significantly limits reptile diversity in these areas. The lack of rocky outcrop habitat precludes the presence of rupicolous species, with which the majority of the regions' reptile diversity is associated. As such, the reptile assemblage likely to inhabit the new infrastructure areas are likely to have a low density, low diversity mix of widespread savannah habitat generalists.

Figure 4–88: A selection of reptile species observed and photographed during the survey: A) Angolan Variable Skink (*Trachylepis albopunctatus*), B) Western Rock Skink (*Trachylepis sulcata ansorgii*), C) Schack's Rock Agama (*Agama schacki*), D) Flap-neck Chameleon (*Chamaeleo dilepis*), E) Olive Whip Snake (*Psammophis mossambicus*) and F) Nile Monitor (*Varanus niloticus*) and Nile Crocodile (*Crocodylus niloticus*)

Table 4–46: Observed reptile species in the Project Area.

Family	Common Name	Scientific Name	2019	2021
Agamidae	Schack's Rock Agama*	*Agama schacki*	x	x
Chamaeleonidae	Quilo Flap-neck Chameleon	*Chamaeleo dilepis*	x	x
Scincidae	Angolan Variable Skink	*Trachylepis albopunctatus*	x	x
Scincidae	Speckled-lip Skink	*Trachylepis maculilabris*	x	x
Scincidae	Western Rock Skink	*Trachylepis sulcata ansorgii*	x	x
Varanidae	Nile Monitor	*Varanus niloticus*	x	x
Crocodylidae	Nile Crocodile	*Crocodylus niloticus*		x
Lamprophiidae	Olive Whip Snake	*Psammophis mossambicus*	x	X
Agamidae	Western Ground Agama	*Agama aculeata*	x	
Colubridae	Angolan Green Snake	*Philothamnus angolensis*	x	
Elapidae	Black-necked Spitting Cobra	*Naja nigricollis*	x	
Gekkonidae	Cape Dwarf Gecko	*Lygodactylus capensis*	x	
Gerrhosauridae	Black-lined Plated Lizard	*Gerrhosaurus nigrolineatus*	x	
Lacertidae	Angolan Rough-scaled Lizard	*Ichnotropis bivittata*	x	
Lamprophiidae	Angolan House Snake	*Boaedon angolensis*	x	
Leptotyphlopidae	Peters' Thread Snake	*Leptotyphlops scutifrons*	x	
Scincidae	Angolan Reduced-limb Skink	*Sepsina angolensis*	x	
Scincidae	Wahlberg's Striped Skink	*Trachylepis wahlbergii*	x	
Testudinidae	Bell's & Speke's Hinge-back Tortoise	*Kinixys belliana & K. spekii*	x	

*Endemic to Angola

4.14.5 Herpetofauna Species of Conservation Concern (SCC)

Three amphibian and seven reptile species are expected in the Project area that is considered national endemic species. Endemic species should be considered as SCC and prioritised for monitoring purposes where possible.

4.14.5.1 Amphibia

Of the three regionally occurring amphibian species of conservation concern (SCC), only two are considered likely to occur in the project area namely Ashy Reed Frog (*Hyperolius cinereus*) and Angola Ornate Frog (*Hildebrandtia ornatissima*). Neither are red-listed, but they are national endemics and therefore of conservation importance. Although the former was recorded in 2019, no SCC amphibians were recorded during the 2021 survey, focusing on the large southern TSF and other new infrastructure areas. These areas are predominantly terrestrial habitats and are unlikely to support amphibian SCC.

Table 4–47: Observed amphibian species in the Project Area.

Family	Common Name	Scientific Name	2019	2021
Bufonidae	Flat-backed Toad	*Sclerophrys pusilla*	x	x
Hyperoliidae	Angolan Reed Frog	*Hyperolius angolensis*	x	x
Phrynobatrachidae	Natal Puddle Frog	*Phrynobatrachus natalensis*	x	x
Pyxicephalidae	Angola River Frog	*Amietia angolensis*	x	x
Pyxicephalidae	Rough Sand Frog	*Tomopterna tuberculosa*		x
Hyperoliidae	Ashy Reed Frog*	*Hyperolius cinereus*	x	
Hyperoliidae	Kuvangu Kassina	*Kassina kuvangensis*	x	
Pipidae	Peter's Platanna	*Xenopus petersii*	x	
Ptychadenidae	Udzungwa Ridged Frog	*Ptychadena uzungwensis*	x	

*Endemic to Angola

4.14.5.2 Reptiles

During the 2021 survey, three reptile SCC were recorded in the project area, namely Schack's Rock Agama (*Agama schacki*), Western Rock Skink (*Trachylepis sulcata ansorgii*) and Nile Crocodile (*Crocodylus niloticus*). However, none of these species was recorded in the new infrastructure areas. Both Schack's Rock Agama and the Western Rock Skink are rupicolous species recorded on the Carbonatite outcrop, while Nile Crocodile was recorded using a footprint found along the Cuiva River banks far south-west of the project area (12°56'59.94"S; 15°12'19.00"E). The Nile Crocodile is listed as a Vulnerable species in Angola according to the *Lista Vermelha de Espécies de Angola* (Ministério do Ambiente, 2018). As most reptile SCC is associated with perennial watercourses and montane rocky outcrops and grassland in the region no reptile SCC is anticipated to occur in the new infrastructure areas.

During the dry season survey of 2019, the poorly known *Bitis heraldica* was targeted by intensively sampling high altitude habitats. However, no specimens were observed. Although it is possible that this species was overlooked due to the rapid survey duration, the lack of cover following the recent fires combined with intensive rock flipping and the non-fossorial nature of dwarf *Bitis* sp. suggests that it is unlikely to occupy the higher-altitude areas in the Project Area. The Vulnerable Bell's Hinge-back Tortoise *Kinixys belliana*, was confirmed in the Project area from photographs taken by staff members.

The only herpetofauna species expected in the Project area that is considered 'Threatened' by the IUCN (2019) is *Kinixys belliana* which is listed as Vulnerable (Rhodin *et al.*, 2017). However, the loss of suitable habitat for this species is expected to be minimal because the Project area's overwhelming proportion is unsuitable since it is either too steep and rocky or has been transformed into agricultural fields. Furthermore, the Project area's overall size is relatively small compared to the wide range of this species. However, Marques *et al.* (2018) caution that the general absence of species of conservation concern in Angola, is due to a severe lack of baseline observation data for Angolan herpetofauna from which to predict geographic distributions and assist in conservation planning. Consequently, many species are listed as "Data Deficient" by the IUCN (2019), which is not considered a threatened category, although many of these species may indeed warrant updated classification to the 'Threatened' category.

Executive Decree No. 252/18 approves the Red List of Species of Angola. Of these listed species, only *Kinixys belliana* (Vulnerable; Rhodin *et al.*, 2017) was expected (and confirmed) in the Project area. However, this report and the accompanying Red List of Angola Species edition 2018-2023 (Ministério do Ambiente, 2018) contains numerous errors regarding species names, red list status, and photographs of herpetofauna. Therefore, more reputable and updated sources were used to identify red list species (Rhodin *et al.*, 2017; IUCN, 2019).

In addition, according to Table 2 of Joint Executive Decree No 201/16, the following herpetofauna species may not be hunted:

- All species of Crocodiles (*Crocodilus*, *Mecistops*, *Osteolaemus*);
- All species of monitor lizard (*Varanus*);
- Sea turtles (*Dermochelys coriacea*, *Caretta caretta*); and
- *Jibóia anchietae* (Boa constrictor). The species name provided in the legislation is incorrect and should be *Python anchietae*.

4.14.6 Habitats of importance for herpetofauna

The majority of the Project area is characterised by subsistence agricultural fields where the soil is rocky or steep. Therefore, only two habitat types in the Project area are considered to be of significance / importance for herpetofauna and categorised as high sensitivity in Figure 4-89:

- *Fenite outcrops and cliffs* – suitable grassland habitat with many rocky patches and cliffs potentially providing refugia for rupicolous and semi-rupicolous reptile species. This landform (diatreme) is not typical in the landscape and represents a suitable habitat for the endemic, although widespread, *Agama schacki*, and possibly *Bitis heraldica* (however, the likelihood of this species presence appears to be low). Nevertheless, this habitat is tentatively categorised as high sensitivity due to its rarity in the landscape and following the precautionary principle that potentially overlooked and specialized species could be expected here. However, it is not considered likely that unknown species of conservation concern would inhabit this diatreme specifically given its small size and connectivity to the surrounding landscape and therefore does not represent a fatal flaw or habitat requiring offset mitigation action for the proposed Project; and
- *Stream and river (aquatic)* - habitats include their associated riparian vegetation, usually a dense strip of trees or tall reeds on either bank. Breeding amphibians, aquatic species such as terrapins and monitor lizards and predacious species (e.g. snakes) which rely on this predictable source of prey occur in these habitats in relatively high densities. Their linear nature promotes connectivity between different habitats throughout the landscape, and the presence of water is crucial for the survival of many species that rely on such surface water. Furthermore, due to this highly connected aquatic nature, these habitats are susceptible to negative impacts which do not remain contained at a particular location but rapidly spread throughout the habitat, causing widespread impact (e.g. a chemical spill).

4.14.6.1 2021 Update

The updated habitat sensitivity retains the Fenite outcrop and all watercourses as being of High sensitivity, other montane grasslands as Moderate sensitivity and all other lower-lying areas (mix of cultivated land, disturbed grassland and Miombo woodland) as being of Low sensitivity for herpetofauna. None of the habitats identified on-site classify meet the IFC PS6 criteria for Critical Habitat from a herpetofauna perspective. The only occurring Threatened species is *Kinixys belliana*. However, the species does not meet Criterion 1a as its conservation status is Vulnerable and not Endangered or Critically Endangered. Although listed as Vulnerable, it still does not meet Criterion 1 B as the majority of habitat in the project area is considered only moderately suitable for the species with low apparent densities meaning that the project will not cause a drop in the global conservation status of the species, nor does it meet the population thresholds as stipulated in GN72(a).

Although the Fenite outcrop is likely to support a small compliment of range restricted, endemic species (e.g. *Bitis heraldica* and *Cordylus angolensis*), it does not qualify as Critical Habitat in the context of herpetofauna under Criterion 2 as it is improbable to regularly hold ≥10% of the global population size or ≥10 of the reproductive units of those species.

None of the herpetofauna in the project area is migratory, and thus Criterion 3 is not applicable. Lastly, none of the habitats in the project area can be regarded as being highly Threatened, unique or essential from an evolutionary perspective for herpetofauna and therefore, do not meet the requirements of Criteria 4 and 5.. However, all areas of High and Moderate sensitivity should be classified as Natural Habitat while all areas of Low sensitivity warrant designation as Natural - Transformed Habitat depending on the presence of villages and croplands.

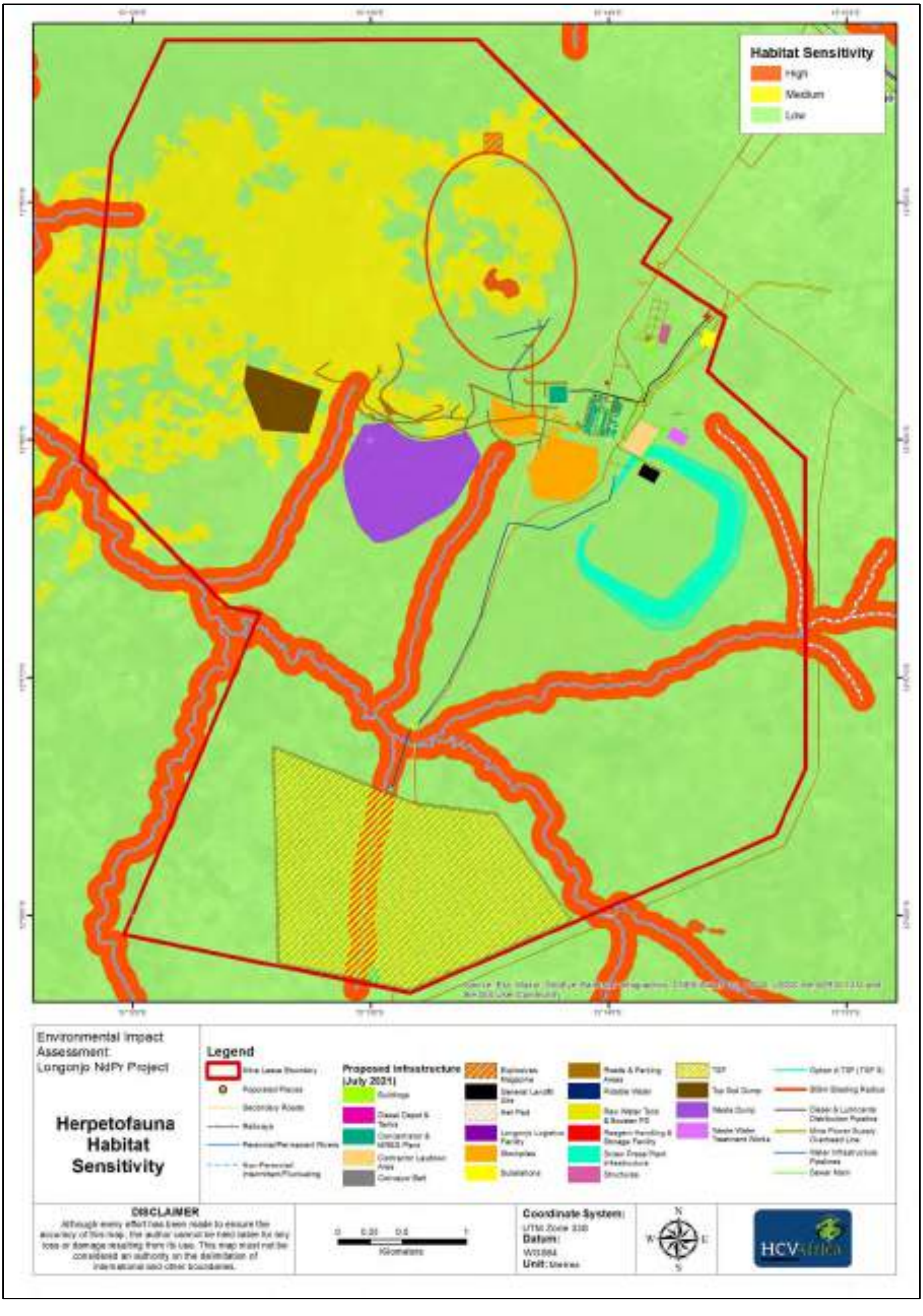


Figure 4-89: Herpetofauna habitat sensitivity in and surrounding the Project area

4.14.7 Current impacts on herpetofauna

Several negative environmental impacts on herpetofauna were evident in the Project area during the fieldwork survey. The majority of these impacts are ongoing in the absence of activities related to the proposed Project (except the drill hole caps) and should therefore be described appropriately to make sure that impacts from the Project can be quantified separately as well as combined for cumulative impact analysis. The Herpetofauna specialist study presents photographic evidence of the current impacts (Appendix M and L). Current impacts are:

- Agriculture (large scale subsistence);
- Alien/invasive vegetation;
- Poor drill hole capping;
- Livestock (cattle and goats);
- Wood felling for charcoal production / firewood / agricultural clearing;
- Erosion;
- Roadkills due to vehicle traffic; and
- Fire.

4.15 Mammals

4.15.1 Regional context

Based on a recent review by Beja *et al*. (2019), Angola supports a moderately high diversity of mammals with 291 confirmed native species. As is the case for avifauna, HCV Africa attributes this diversity to the country's wide range of habitats and contrasting environmental conditions. Many of these species are endemic or near-endemic, most of which are represented by rodents and bats. At present, the country is known to support 2 Critically Endangered, 2 Endangered, 11 Vulnerable, 14 Near-Threatened and 12 data deficient species.

Scientific research on mammals started as early as the mid-nineteenth century which saw the documentation of most of the known species (mainly thanks to José Vicente Barbosa du Bocage), many of, which were new to science. However, scientific progress was stunted by the countries protracted civil war, which lasted from 1975–2002, and today Angola's mammalian fauna is one of the most unexplored and least known in Africa. Very little is known on the Huambo region's mammal diversity ,although it is assumed that most endemics and SCC are likely to be associated with the region's mountain habitats.

4.15.2 Local context

Survey work and available literature on mammals from the Huambo region are scarce, and likely, that the true mammal diversity is significantly underestimated. Nevertheless, analysis of the available distribution data provided in the IUCN (2019) online database and the African Chiroptera Report (ACR, 2018), just over 100 mammal species are considered to have the potential to occur in the Huambo region. However, this includes three game species restricted to reserves in the area and seven species considered unlikely to occur on-site based on lack of suitable habitat.

A total of 25 mammal species were recorded in the Project area during the 2019 wet (10 spp.), 2019 dry (18 spp.) and 2021 wet (18 spp.) season surveys. Together with the habitats in which they were detected, these species are listed in the Avifauna and Mammals specialist report appended in Appendix J. Some examples of mammals encountered on-site are shown in Figure 4-90.

Live trapping of small mammals during the 2019 dry season survey was conducted at various locations throughout the study area was highly successful, yielding high capture rates were observed during both survey periods (particularly so during the dry season survey with 80% capture rates). This, together with the high diversity and abundance of raptors, suggests a healthy small mammal population on-site. Trapped species in order of highest to lowest capture frequency included Thomas Rock Rat (*Aethomys thomasi*), Natal Multimammate Mouse (*Mastomys natalensis*), Angolan Wood Mouse (*Hylomyscus carillus*) and Chestnut Climbing Mouse (*Dendromus mystacalis*). However, trapping during the 2021 wet season survey yielded no captures. Such a stark difference between seasons was unexpected and may have to do with trap shyness as new mammal traps were used for the 2021 survey.

Active searches in 2019 for diurnal bat roosts yielded Egyptian Free-tailed Bat (*Tadarida aegyptiaca*) from a crevice along the north-western hilltop crag line (B3: 12°55'19.02"S; 15°13'37.79"E) and more significantly a moderately sized cave large enough to stand up and walk around (B1: 12°55'19.89"S; 15°13'30.63"E) supporting a large colony of roosting horseshoe bats (>300 individuals). The bulk of the colony roosts in a tight huddle on the roof of the main entrance chamber, with another smaller huddle in the second (smaller) chamber deeper in. Upon entering it was immediately apparent that at least two species were present: larger, more numerous species with a grey pelage and smaller considerably less numerous species with a fawn pelage. These species were subsequently identified by analysing their search phase echolocation calls as *Rhinolophus fumigatus and R. lobatus,* respectively. Due to the timing of the survey outside of the breeding season, it is currently uncertain whether the cave is used for breeding, although a very large pile of Guano suggests high roost fidelity (Figure 4-91). The cave was revisited in the 2021 survey and roughly the same to slightly fewer bats revealing that the cave is utilised year-round and supports a resident breeding population of horseshoe bats that do not appear to be migrating away from the area.

Figure 4-90: Examples of mammal species detected in the Project area: A) Thomas Rock Rat (*Aethomys thomasi*), B) Chestnut Climbing Mouse (*Dendromus mystacalis*), C) Angolan Wood Mouse (*Hylomyscus carillus*), D) Thick-tailed Bushbaby (*Otolemur crassicaudatus*), E) Large Grey Mongoose (*Herpestes ichneumon*), F) Large-spotted Genet (*Genetta maculata*) G) Slender Mongoose (*Herpestes sanguineus*), H) Bush Hyrax (*Heterohyrax brucei*)

Figure 4-91: Examples of bat roosts encountered on-site A) Guano pile in main roost chamber, B) close-up of *Rhinolophus fumigatus*, C) Crevice hosting *Tadarida aegyptiaca*, D) Horseshoe bat congregation on roof of main chamber

Acoustic sampling revealed two additional bat species namely, Cape Serotine Bat (*Neoromicia capensis*) from around the Pensana geological camp and Natal Long-fingered Bat (*Miniopterus natalensis*) from the Carbonatite Outcrop. Echolocation call data for the identified species are given in Table 4-48, while examples of their respective spectrograms are shown in Figure 4-92.

Table 4-48: Representative echolocation[37] call data for bats identified during the acoustic surveys

Species	Fmax	Fmin	Fmean	Fk	Fc	Tk	Tc	Duration
Miniopterus natalensis	68.97	55.56	59.86	60.15	57.14	1.2	3.26	3.41
Neoromicia capensis	39.6	37.56	38.38	38.46	37.56	1.54	6.35	7.19
Rhinolophus fumigatus	57.55	54.05	56.15	56.34	54.05	13.3	14.81	15.1
Rhinolophus lobatus	114.29	109.59	111.54	109.59	111.11	3.08	3.37	3.62

[37] Values represent the eight time most important diagnostic vocalisation parameters. Frequency parameters are measured in kilohertz (kHz) and time parameters in milliseconds (ms). Fmax, maximum frequency of the call; Fmin, minimum frequency of the call; Fmean, mean frequency of the call; FK; frequency at the knee, FC; characteristic frequency, Dur; duration of the call, TK; time into the call when FK is reached; and TC time into the call when FC is reached.

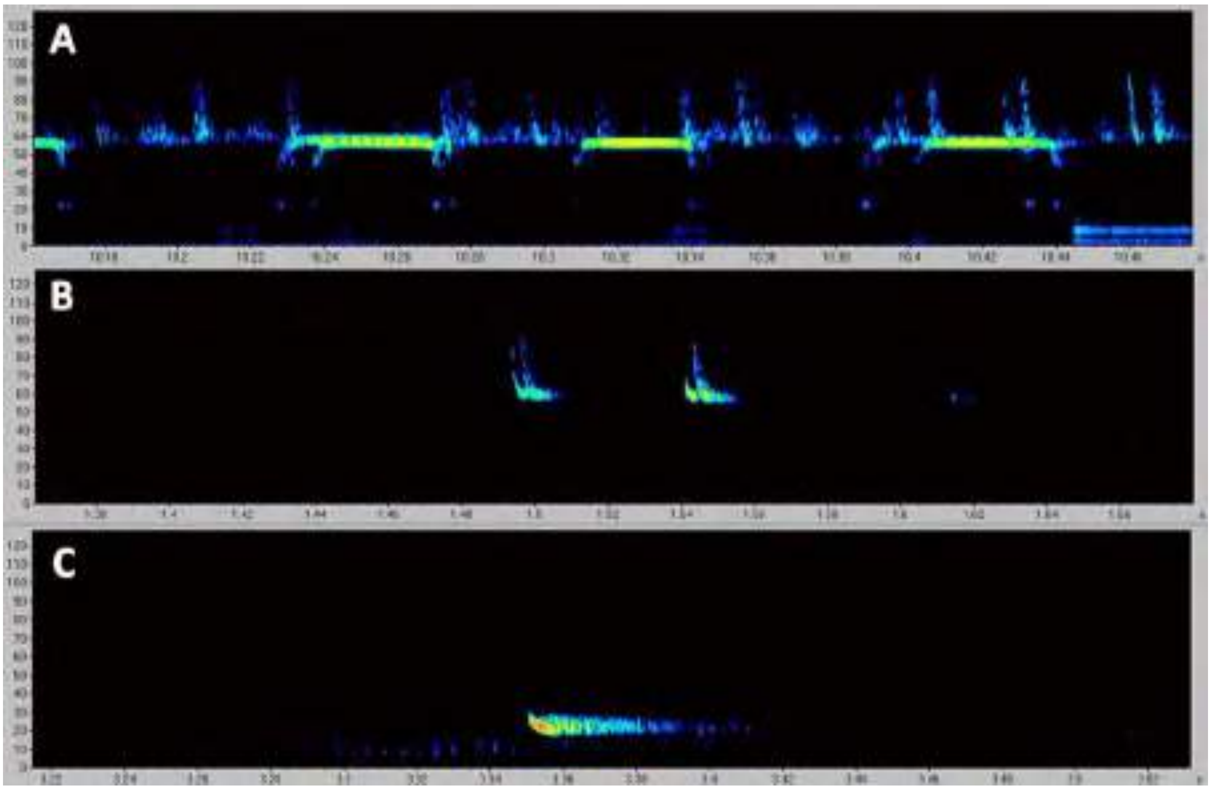


Figure 4-92: Examples of sonagrams of the calls of three bat species recorded on-site namely A) *Rhinolophus fumigatus*, B) *Miniopterus natalensis* and C) *Tadarida aegyptiaca*

4.15.3 Species of Conservation Concern (SCC)

A total of 10 IUCN Red-listed species has the potential to occur in the Project area based on the availability of suitable habitat (Table 4-49). Field surveys revealed the presence of two Red data species, namely African Clawless Otter (*Aonyx capensis*) recorded with the ravine / riparian habitat and Ground Pangolin (*Manis temminckii*) recorded in the general vicinity. The only other potentially occurring threatened mammal species, namely Leopard (*Panthera pardus*), is considered moderately likely to occur because of the large extent of remaining natural habitat and overall low human habitation in the area. In addition, the ravines and abundance of mango trees provide suitable habitat for Angolan Epaulette Fruit Bat (*Epomophorus angolensis*) and African Straw-colored Fruit Bat (*Eidolon helvum*) In contrast, a suitable cave roosting habitat exists on-site for Striped Leaf-nosed Bat (*Hipposideros vittatus*). Although the horseshoe bats observed roosting in the cave on-site are listed as Least Concern, their population trend is currently unknown and significant congregations such as this should be considered conservation important. The potentially occurring Category A listed mammal species (listed as Endangered) according to Angola's national Red List (Ministerio Do Ambiente, 2018) is Brown Hyaena (*Hyaena brunnea*).

Table 4-49: Present and potentially occurring mammal SCC

Species	Common Name	LO
Vulnerable		
Manis temminckii	Ground Pangolin	1
Panthera pardus	Leopard	3
Near Threatened		
Aonyx capensis	African Clawless Otter	1
Epomophorus angolensis	Angolan Epaulette Fruit Bat	2
Eidolon helvum	African Straw-coloured Fruit Bat	3
Hipposideros vittatus	Striped Leaf-nosed Bat	3
Data Deficient		
Crocidura erica	Heather Shrew	2
Dasymys nudipes	Angolan Marsh Rat	2
Graphiurus angolensis	Angolan African dormouse	2
Plerotes anchietae	D'Anchieta's fruit bat	2

4.15.4 Habitat sensitivity / Critical habitat

Results of this avifaunal and mammal survey highlight the Carbonatite Outcrop as supporting a unique and vital mammal assemblage and is of High importance and sensitivity.

This project spans a period in which the IFC PS6 criteria on critical habitat were updated. Until the beginning of 2019, the Carbonatite outcrop qualified as Tier 2 Critical Habitat from an avifaunal perspective under Criteria 2 b of the IFC Performance Standard 6. This standard notes that critical habitat assessment, which states that habitat is known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range of species/subspecies where that habitat could be considered a discrete management unit for that species, where data are available and / or based on expert judgement.. However, the June 2019 update to IFC PS 6 excludes the 2b threshold making this point obsolete. Importantly, though, the habitat still qualifies as Critical Habitat under Criterion 3 of the updated version entitled; "International Finance Corporation's Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, 2019" based on these caves acting as important bat roosts hosting significant congregations of horseshoe bats.

As per GN77 of the Guidance Note: "Congregatory species are defined as species whose individuals gather in large groups on a cyclical or otherwise regular and / or predictable basis". Examples include the following:

- Species that form colonies;
- Species that form colonies for breeding purposes and / or where large numbers of individuals of a species gather at the same time for non-breeding purposes (for example, foraging and roosting);
- Species that utilize a bottleneck site where significant numbers of individuals of a species occur in a concentrated period (for example, for migration);
- Species with large but clumped distributions, such as individuals, may be concentrated in a single or a few sites while the rest of the species is largely dispersed; and
- Source populations where specific sites hold populations of species that make an inordinate contribution to recruitment of the species elsewhere (vital for marine species)".

Following IFC PS6 best practice guidelines, it is essential that the High sensitivity Fenite outcrop be avoided and that its bat colony be subject to a robust long term monitoring and action program to demonstrate that the project does not lead to measurable adverse impacts on the bat colony. It is further recommended that the pair of cave chats be monitored simultaneously.

In terms of buffers on this habitat, it is impossible to ascribe a universal pre-defined buffer because there is a general paucity of information regarding the exact effects of mining on roosting bat colonies. Additionally, there is considerable variation in results and overall findings for the studies done due to the different ways the buffers are customarily calculated and the environmental circumstances in each case. Typically for bats, the procedure for buffer determination would involve the installation and monitoring of seismic and acoustic devices to measure vibration and noise in conjunction with dedicated bat population monitoring over several seasons and often years. A definitive buffer is required because distances at which bats are likely to be affected by the stressors vary considerably depending on several factors (e.g. the substrate, type of mining and species). However, this protracted approach is unlikely to be feasible in terms of time and budget. South Africa is undoubtedly the leading Southern African country in research into bats and buffers and was thus used for reference purposes for the Angolan context. According to South African requirements, the onus falls on the specialist to define the buffer based on his / her expertise in such circumstances where empirically derived or guideline buffer distances are either lacking or do not apply to the type of development in question. Bat-specific buffers in South Africa focus primarily on the renewable energy sector, but the auxiliary infrastructure associated with these developments does not fall below 200m. There is also very limited to no consensus among the data on tolerable vibration and sound levels, bearing in mind that sensitivities are likely to vary among species and are confounded by the habituation. Buffers on entire bat roosts, particularly maternal roosts, often involve 500 m for various development types (MacEwan, 2019). Consequently, it advised implementing a buffer zone as close as practically possible to / up to 200m of the High sensitivity Carbonatite outcrop. The mining pit layout has been updated accordingly to fulfil this requirement, effectively excluding the outcrop from the mining pit / mining footprint.

The habitat sensitivity map is shown in Figure 4-93. Although the proposed footprint for the large southern TSF occurs mainly in non-Critical Habitat, it does overlap a watercourse classified as High sensitivity Natural Habitat. No alternatives are feasible, and its loss would therefore be unavoidable (see Aquatic Ecology study – Appendix I).

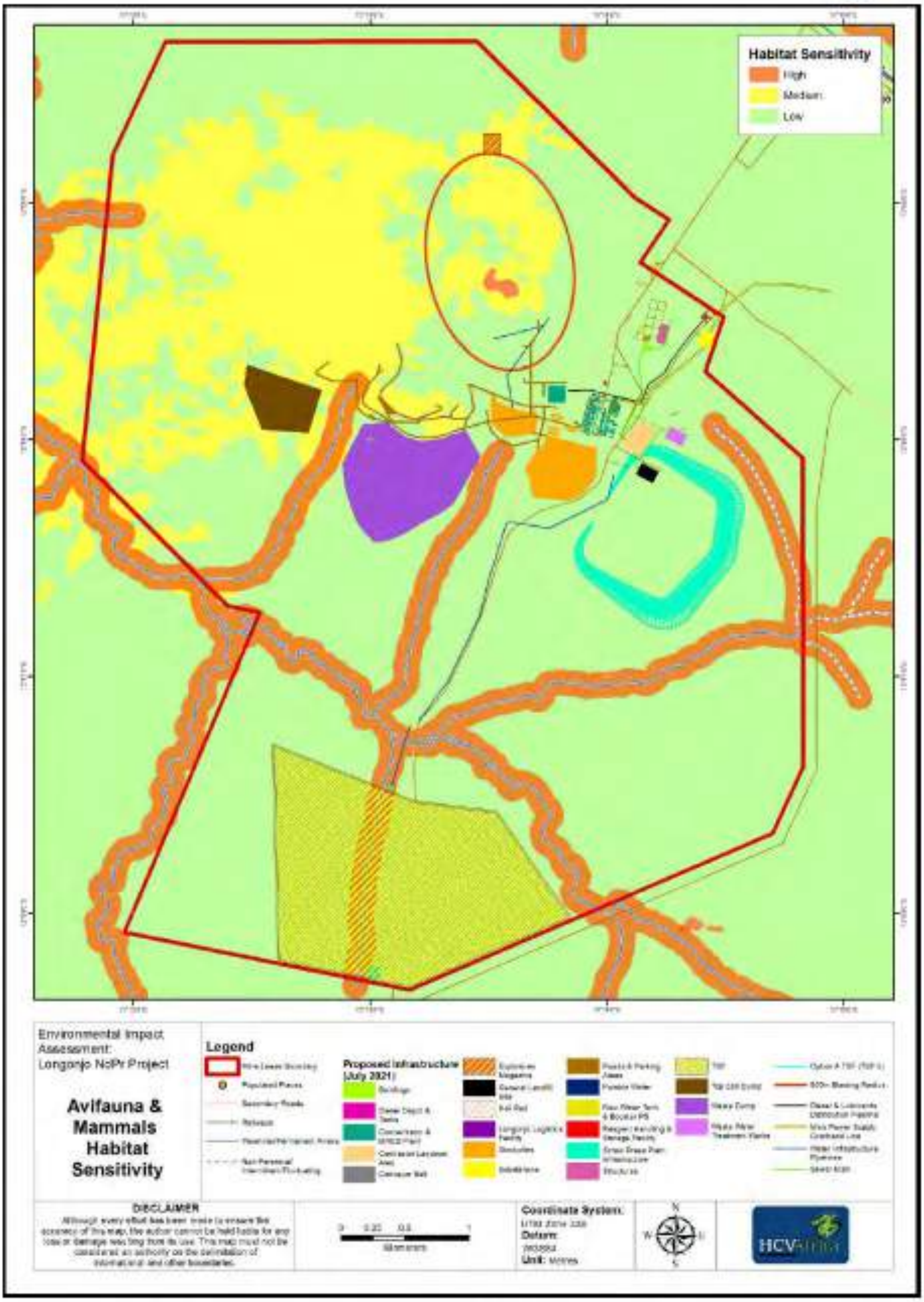


Figure 4-93: Avifaunal and mammal habitat sensitivity in and surrounding the Project Area. Note the High Sensitivity Carbonatite outcrop qualifies as Critical Habitat from a mammal perspective. The mining pit has been adjusted to avoid this outcrop.

4.16 Social and socio-economics

4.16.1 National context

The Angolan census (2014) reports a population of 24.4 million people comprising 51.6% females as a percentage of the total population; 62.3% live in urban areas, and population density country-wide is 19/km^2.

Angola is exceptionally rich in resources. It is sub-Saharan Africa's second largest oil producer, with output recorded at 1.82 million barrels a day [38]. The oil and gas industries make up approximately 45% of Angola's gross domestic product (GDP). Despite its economic stature, poverty in Angola is rife, with 68%[39] of the population living below the poverty line. Angola is currently ranked 147 out of 189 countries on the Human Development Index. The ongoing determination by the government to address poverty levels is reflected in the recently launched flagship programme: The Integrated Local Development and Poverty Alleviation Program (PIDLCP) program (2018-22). This programme builds on experience obtained from the Integrated Rural Development and Poverty Alleviation Program (PMIDCP) (2010-2015) and aims to lift 3 million Angolans out of poverty by 2022 and reduce poverty incidence from 36.6% to 25% by 2022. Angola is Sub-Saharan Africa's third-largest economy. The large oil reserves place the country in a strong fiscal position allowing decisive investment decisions by Government.

4.16.2 Local context

4.16.2.1 Huambo Province

The population of Huambo province is 2,019,555[40] inhabitants, representing 8% of the country's population. It is the 4th most populous province, as shown in Figure 4-94.

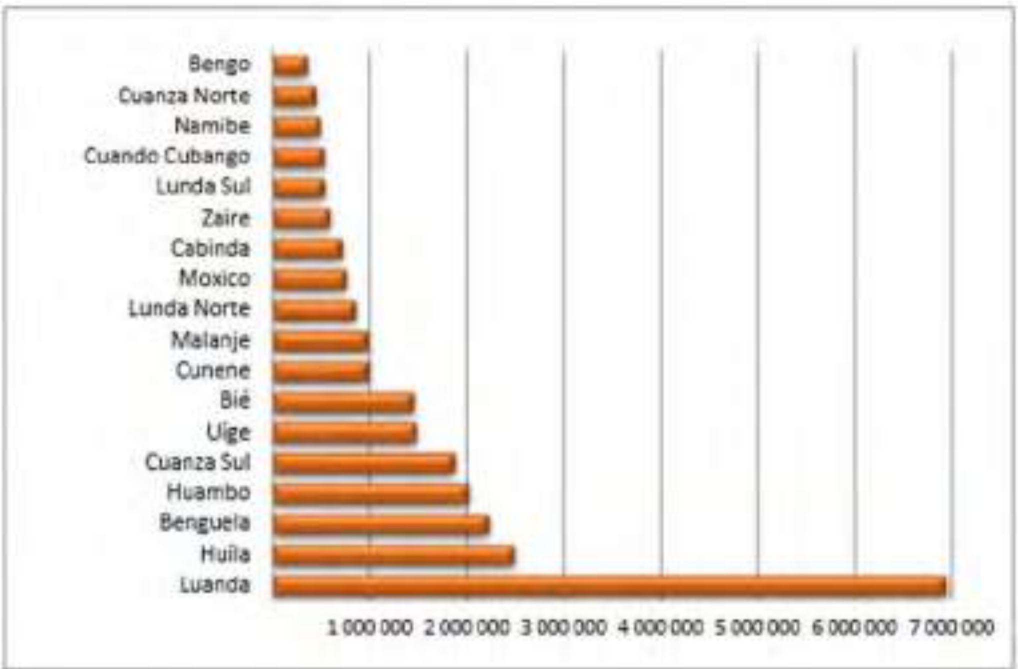


Figure 4-94: Population by province in Angola

[38] https://www.worldatlas.com/articles/top-10-oil-producing-countries-in-africa.html
[39] https://borgenproject.org/poverty-angola-causes-updates-statistics
[40] CARACTERIZAÇÃO SOCIOECONÓMICA

Just over half of the Huambo population live in rural areas. There are 11 municipal administrations in Huambo Province, where Longonjo municipality is the 8th most populous, with approximately 92,000 inhabitants. Seventy percent of the population of Huambo Province are 24 years and younger, with an average age of 20 years old.

4.16.2.2 Longonjo municipality

The municipality of Longonjo has 46 villages (Provincial Government of Huambo, 2018), the total number of households is 31,845, with the average number of members per household between 2 and 18 people. In addition, the municipality of Longonjo has the Benguela Railroad to transport people and goods, and a total of 355km of secondary and tertiary roads, which need rehabilitation to enable the free movement of people and goods (Government of Huambo Province, 2018).

4.16.2.3 Traditional and formal governance structures

Traditional structures report to municipal administrators and communal administrators (Figure 4-95). In Huambo Province there are no District Administrations.

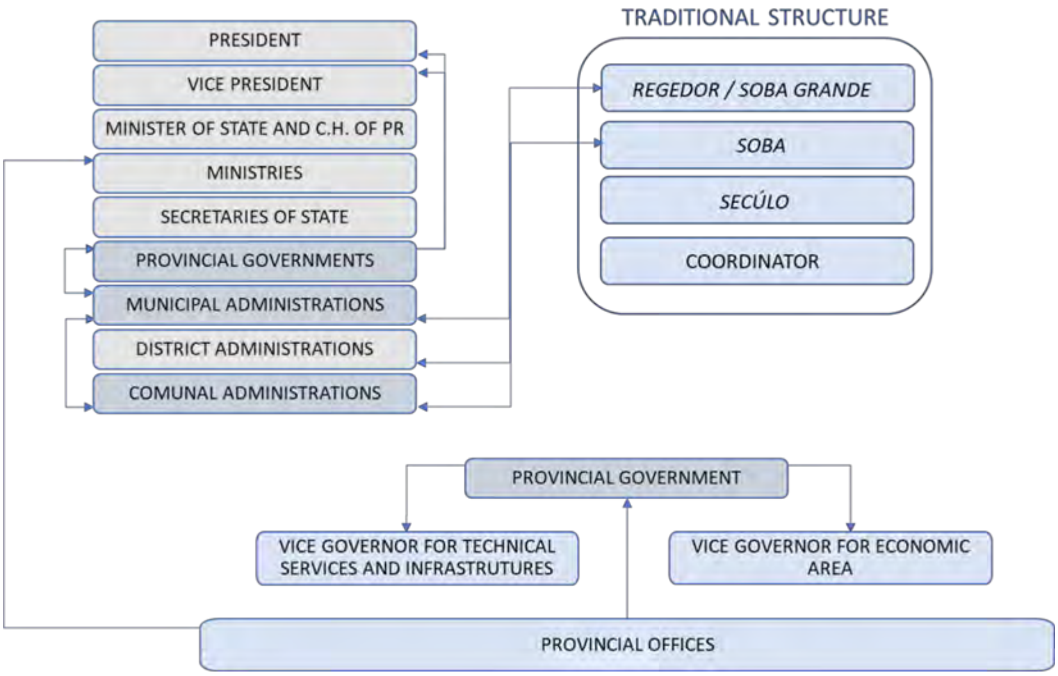


Figure 4-95: The relationship between the traditional and formal governance structures

4.16.2.4 Land tenure practices

For the first time since the Colonial Period, Angolan Government, through their Land Law Act 2004, recognises customary land tenure arrangements as legally binding (Section 2 Article 9(1)). The law endeavoured to harmonize customary practice and modern-day freeholding land governance and property rights.

However, PESA[41] observes that the actual operationalisation and implementation of these constitutional rights have been hampered due to i) the lack of political will and ii) the inherent contradiction in the same law. Article 9(2) states that the state retains the right to expropriate communal land. Although communal land tenure is legally permissible, the state has a radical right over all land in the country.

Customary land tenure arrangements are predominant for households in the study area, and therefore they have no security of land tenure. The traditional leadership determines the rules and regulations for occupying and cultivating land, and portions of land are allocated to villagers according to these rules.

[41] PESA: Angola Land Reform and Rural Transformation Overview

There are two types of farmers:

- *Camponeses* - These are primarily farmers who work on smaller plots of land and usually live on or near their *lavra (fields)* located in the village itself. Almost all farmers are part of the main lineages in the village. The C*omponeses* depend on the local authorities (lineage elders and soba) regarding access to land.
- *Agricultores* - This term denotes a landowner who controls at least 10-15 hectares of land. (These landowners can control as much as 120ha). The *agricultores* rely on a combination of government and local authorities. A*gricultores* have some formal title to their land and are recognised by the administrator in the respective commune[42].

The farmers operating in the Project area are predominantly *camponeses.* This makes them vulnerable to any change in the current land tenure arrangements caused by new projects (e.g. the Longonjo mine). Access to land and natural resources is central to the rural communities' livelihoods located in and near the Project area.

4.16.3 Socio-economic Survey Results

The surveys show that the social baseline is very similar in all villages in the Project area (i.e., subsistence farming, with fishing and some hunting to supplement diets). Meat is eaten only once or twice a month, and the staple foods are cassava, maize and beans. Food security is a persistent problem as all villages reported a reduction in the yield of their crops.

Cultivation of crops is similar across all villages where farming methods and tools are rudimentary. Households predominantly work two portions of land, one adjacent to the homestead and another in the fertile soils alongside the closest watercourse known as the '*naca*' or '*onaka*'. These are valuable assets allowing for cultivation during the dry season. Women undertake most of the farming. Staple crops are maize, cassava and beans, and others crops include sweet potatoes, potatoes, cabbage, onion, tomatoes, yam, and ground nuts. Inequalities across households appear insignificant but a few higher-income earning households were reported during the survey. Camaco village reported the highest earnings (maximum earnings of 80,000kmz per month) from cops planted, Lucambo and Tena reported the lowest (maximum earnings of 20,000kmz per month). The results from Lumingo village also show low earnings, but due to the incomplete survey for this village, there is careful consideration of these results.

The communities are land-dependent for their livelihoods and welfare. Provisioning ecosystem services include soil, water (wells for drinking and domestic purposes), timber (used for fuel and houses) and hunting.

Infrastructure and services are inadequate. There is no electricity supply, and households use wood and charcoal to cook and lanterns or fire for light at night. Household water supply is from hand-dug wells and nearby streams. For most villages, except for Tena, the closest Health Facility is the Municipal Hospital in Longonjo. Residents of Tena use the health facility in Chingongo.

Public transport does not serve the area, and very few privately-owned vehicles, taxis, motorbikes and mini-busses are used to go to markets and towns. However, walking is the most common way of getting to fields and villages.

The rural land used by the community for their housing and farming is theirs through "inheritance" and "usufruct" (i.e., they have land tenure rights, although these are mostly informal).

The villages in the local Project area will likely continue to live as they do now, unless there is an investment in infrastructure and services (including schools), and unless job opportunities arise from the proposed mine. Villages are isolated, so the people tend to support each other (in each community) when labour-intensive tasks are being undertaken.

Table 4-50 presents the village demographics per village.

[42] Customary Agriculture in Angola

Table 4-50: Socio-economic survey results - Village demographics

Village	Soba / Seculo	Est. Population	No. of households	Household size	Village Established	Land Tenure	Ethnic Group	Source of Income	Est. Monthly Income (Kz)
Camaco	Mr. Alberto Carvalho	2,800	501	2-18 per hh	1935	Inherit-ance	Bantu/Ovimbundu	Subsistence farming	5,000 - 80,000
Chianga	Mr. Bernardo Nguelengue	348	67	3 - 9 per hh	1920	Inherit-ance	Bantu/Ovimbundu	Subsistence farming	2,000 - 25,000
Lucamba	Mr Adriano Chivela	5,000	496	2-10 per hh	1960	Inherit-ance	Bantu/Ovimbundu	Subsistence farming	5,000 - 20,000
Lumingo	Mr Cajamba *	1,200	204	2 - 13 per hh	1933	Inherit-ance	Bantu/Ovimbundu	Subsistence farming	3,000 - 5,000
Tchakengenga	Mr Bento Sabino	120	-	2 - 18 per hh	Unknown	Inherit-ance	Bantu/Ovimbundu	Subsistence farming	20,000 – 30,000
Tena	Mr Cambolo (First Soba)	78	-	3 - 13 per hh	1922	Inherit-ance	Bantu/Ovimbundu	Subsistence farming	4,000 - 20,000

Table 4-51 presents the basic services found in each village and distance to secondary schools.

Table 4-51: Socio-economic survey results - Basic services per village

Village	Household Water Supply	Sanitation	Primary School	Secondary School	Distance to Secondary School	Nearest Health Facility
Camaco	Hand dug wells	Pit Latrines	1	Longonjo	0,5 km	Longonjo
Chianga	Hand dug wells	Pit Latrines	1	Centro Chenga	2 - 3 km	Longonjo
Lucamba	Hand dug wells	Pit Latrines	1	Longonjo	0,5 km	Longonjo
Lumingo	Hand dug wells	Pit Latrines	1	Longonjo	1,5 km	Longonjo
Tchakengenga	Tchakengenga River	Pit Latrines / Bush	1	Longonjo	5 km	Longonjo
Tena	Cumbi Liandomene River	Pit Latrines / Bush	0	Chingongo	2 - 3 km	Chingongo

Although the villages share the same socio-economic environment with slight variation, summarised results of the social surveys for each village are given in sections 4.16.3.1 to 4.16.3.6. More details are available in the Socio-economic specialist report in Appendix N.

4.16.3.1 Camaco Village

Camaco Village is led by Mr Alberto Carvalho, the 11th Soba since the establishment of the village around 1935. He is part of the traditional governance structure, which links with the formal governance structure. The village member attendees of the consultation meeting are shown in Figure 4-96.

Figure 4-96: Meeting with Camaco villagers

4.16.3.1.1 Population and ethnic group

The population in the village is estimated to be 2,806 people (482 women, 410 men and 1,914 children/youths) who are grouped in families of two to eighteen occupants. Most of the population of the community is not native to the village. They have moved mainly because of the civil war that affected the country, and a few people came to join relatives in the village to improve their living conditions. There is one ethnic group - the Bantu/Ovimbundu ethnolinguistic group. Their main language is Umbundu, and Portuguese is the official language but is not widely spoken among elders and women.

4.16.3.1.2 Livelihoods and income

The primary means of livelihood for the Camaco population is subsistence agriculture. Crops are grown for family consumption and trading. When crops are sold, they bring in between 5,000 and 80,000 Kz (per month). In the community, a household that claimed to have a combined income of 180,000 Kz/month. Most residents have plots of land that are used on an ongoing basis and it was reported that the yield of crops has been decreasing. Most households have the *lavras* (fields) where they raise crops located near Tchimbilundo and near Malanga stream, with the most fertile soils being those alongside watercourses ("nacas"). Staple crops are maize, beans and sweet potatoes, and others crops include cassava, potatoes, soybean, cabbage, onion, *massambala* and tomatoes. A portion of the crop is sold for income and a portion kept for consumption. Produce is sold in Longonjo, Huambo and Benguela if the quantities are big enough. Some of the villagers use animals to plough. A shortage of supplies is commonplace due to a lack of seeds and fertilisers (which are expensive), and yields are reported as being low due to poor rainfall. Animal husbandry is informal, with chickens and goats being the most common animal reared, followed by cattle and pigs. Eggs are left to hatch and not eat to produce more chickens. The Land is occupied and farmed through "inheritance", but the villagers have no official documents to describe their ownership or the occupant's rights. The villagers do not commonly practice hunting. However, it is occasionally carried out in Tchimbilundo and Tchiyuvi, using traps, dogs and arrows. The animals killed are used for their own consumption, and some trading for raising money when needed. The villagers reported eating meat once or twice a month.

4.16.3.1.3 Housing, sanitation and infrastructure

Most houses are made of local materials (adobe, wood, grasses for roofs). Corrugated iron is used on some houses, in which case the roof is gently sloping or flat and held in place by rocks. Some houses are built of more durable materials (cement blocks). A typical house consists of one to five bedrooms and a living room. In some cases, there is an outside latrine. Cooking takes place in a separate room attached to the house but is an open structure. No infrastructure or services are present. Water is mainly obtained from hand-dug wells (water can be up to 15-20 metres below the surface; a system of ropes and buckets are used to bail water).

4.16.3.1.4 Health and education

There are no health facilities in the villages. The nearest is in Longonjo (Municipal Hospital of Longonjo), approximately 0.5 kilometres away. The most common illnesses include malaria, coughing, diarrhoea, fever and vomiting. Since modern medicine is not readily available, some villagers use medicinal plants, such as *Quanana, Ongiriti, muringa (*used for stomach-ache and headache). Camaco has one primary school (from 1st to 6th grade) that village children attend. However, the nearest secondary school is in Longonjo (0.5 kilometres away).

4.16.3.1.5 Ecosystem services

The community is land-dependent for their livelihoods and welfare. Provisioning ecosystem services include soil, water (wells for drinking and domestic purposes), timber (used for fuel and construction of houses) and hunting. Residents reported changes to the environment (soil fertility), which they said could be caused by a lack of rainfall. In addition, the number of game animals was reported to be decreasing due to increased hunting.

4.16.3.1.6 Culture and leisure

The community is predominantly Adventist and Catholic, with some Protestant (IEKA). Traditional festivals are limited to a few ceremonies such as *alambamento* (traditional marriage), *Evamba* (male circumcision), *Hosse* (female genital mutilation or female circumcision), *Eyele* (ceremony for the first harvest) and *ekuivalenca*. Leisure time is mainly spent playing football and socialising when the young and elders engage.

4.16.3.2 Chianga Village

Chianga is not in the Project footprint and is accessed through the national road (EN260).

Figure 4-97: Consultation meeting with community

4.16.3.2.1 Population and ethnic groups

The village population is estimated to be 348 people who are grouped in families of three to nine occupants (father, mother and children). The family's father primarily heads households, but widows may be appointed the head of a household. The community is Christian and Adventist.

Most of the community population are native to the village and belong to the Bantu ethnic group /Ovimbundu ethnolinguist group. The Ovimbundu speak Umbundu as their first language and Portuguese. Portuguese is the official language, but it is not widely spoken among elders and women. The people tend to grow up in the village and only leave their parental home when married.

4.16.3.2.2 Livelihoods and income

The primary means of livelihood for Chianga's population is subsistence agriculture. Crops are mainly grown for family consumption. A surplus of crops may be sold alongside the highway, and between 2,000kz and 25,000kz may be raised (per month). The pharmacist who works in the municipal hospital of Longonjo obtains an income of 16,000kz / month and a trained bricklayer 2,000kz / month when working.

Most residents have plots of land that are used on an ongoing basis, and it was reported that the yield of crops has been decreasing. Most households have small lavras (fields) to raise crops adjacent to their homes. Larger lavras are located 30 min to 1-hour walk from the village. The most fertile soils are those alongside watercourses (such as Rio Dongo, Rio Casseque and Rio Chicanda), known as "nacas". In these *nacas,* the most common crops are maize, tomatoes and sugar cane. It is mostly women who are involved in farming. Staple crops are maize and beans and other crops include sweet potatoes, cassava and potato.

Figure 4-98: Women preparing maize

The land is occupied and farmed through "inheritance", but the villagers have no official documents to describe ownership or the occupant's rights. Based on observations, the farming methods are rudimentary. Despite the farmers understanding of how quality could be improved, they lack the resources to do so. Cash incomes are erratic. Animal husbandry is informal, with chickens and ducks being the most common animals reared, followed by goats and cattle. The villagers do not commonly practice hunting. However, for those who do hunt, it is carried out in wooded areas (Sohongo Mountain), which is not far away from the village, using traps and arrows. Species such as pigeons, antelope and rabbits are killed. Some households also fish and they catch tilapia and catfish (bagre). Although some animals are reared, chickens and ducks are commonplace in the village, villagers rarely eat meat (once or twice a month), and animals are used primarily for trading and raising money when needed (for medical treatment, clothes and school fees). Eggs are not eaten as they are left to hatch to produce more chickens. Therefore, the average diet is low in protein and high in carbohydrates.

4.16.3.2.3 Housing, sanitation and infrastructure

Most houses are made of local materials (adobe, wood, grasses). Corrugated iron is used on some houses, in which case the roof is gently sloping or flat and held in place by rocks. A typical house consists of a bedroom (shared by siblings), a bedroom for parents, a living room and in some cases, an outside latrine. In the absence of a latrine, residents go to the bush, which is more common. Cooking takes place in a separate room attached to the house but is an open structure.

Figure 4-99: Adobe drying before used to build houses

There is no infrastructure in the village, and meetings occur in the *Jango* (structure made of wood and grasses) used for gatherings and shelter from the sun and rain. There is no electricity supply, so people rely on wood for cooking and lanterns or fires to provide light at night. Water is mainly obtained from the Cuiva River for domestic purposes.

4.16.3.2.4 Health and education

There are no health facilities in the village. The nearest hospital is in Longonjo (Municipal Hospital of Longonjo), approximately eight kilometres away (around one-hour walking distance). The most common illnesses include malaria, diarrhoea, vomiting, stomach-ache, rheumatism, typhoid fever, and Hepatitis A. Modern medicine is not readily available. Therefore some villagers make use of medicinal plants, such as *Quanana* (stomach-ache), *Ongiriti* (headache) and *Chinengue* (snake bites). Chianga has one primary school (from 1st to 6th grade) that village children attend. It has five teaching rooms and five teachers. The nearest secondary school is in Centro Chenga, approximately thirty to forty-five minutes away (walking time).

4.16.3.2.5 Ecosystem services

The community is land-dependent for their livelihoods and welfare. Provisioning ecosystems services include soil, water (wells for drinking and domestic purposes), timber (used for fuel and construction of houses) and hunting. Residents reported changes to the environment (soil fertility), which they said could be caused by a lack of rainfall. In addition, the number of game animals was reported to be decreasing due to increased hunting.

4.16.3.3 Lucamba Village

Lucamba is not in the Project footprint and is accessed through the unpaved road that crosses Longonjo from the national road - EN260.

4.16.3.3.1 Population an ethnic group

The village population is estimated to be around 5,000 people who are grouped in families of two to ten people. Although the community is predominantly Christian, some men have children with different partners, so the large families are directly related.

Figure 4-100: Consultation with Lucamba community

A majority of the population were born in the village, with few people joining relatives in the village to improve lives due to the civil war that affected the country. There is one dominant ethnic group, the Bantu/Ovimbundu ethnolinguist group. The Ovimbundu's main language is Umbundu; Portuguese is the official language but is not widely spoken among elders and women.

4.16.3.3.2 Livelihoods and income

The basic means of livelihood for Lucamba´s population is subsistence agriculture. Crops are mainly grown for family consumption. If there are surplus crops, this is sold and, 5,000 Kz to 20,000 Kz might be raised (per month). A farmer in the village derives an income from the Government of 18,000 Kz/month, and a traditional midwife can earn up to 30,000 Kz/month when working. Most of the residents have plots of land used on an ongoing basis. It was reported that the yield of crops has been decreasing. Most households have *lavras* (fields) where they raise crops located on both sides of the road that crosses the villages and behind the houses. They also have fields with the most fertile soils alongside watercourses, known as "*nacas"*. Staple crops are maize, massambala and beans, and other crops include potatoes, cassava, sweet potatoes, tomatoes and onions.

Tools used are axes, machetes and hoes. Some villagers use animals to plough, but a certain amount of money must be paid to the plough owner. The lack of seeds and fertilisers (which are expensive) is a challenge, and yields are reported to be low due to low rainfall. The land is occupied and farmed through "inheritance", but the villagers have no official documents to describe ownership or the occupant's rights. In the community, there is a Colela Lucamba Farming Association. Based on observations, the farming methods are rudimentary; despite the farmers understanding of how quality could be improved, they lack the resources to do so. Cash incomes are erratic.

Animal husbandry is informal, with chickens, goats and pigs being the most common animals reared, followed by cattle, ducks, pigeons and sheep. Animals are used for consumption and trading to raise money when needed. The villagers eat meat about once a month. The villagers do not commonly practice hunting. However, it is carried out in the wooded areas (such as in Tchimbilundo mountain and the mountains in the Rafael community) for those who hunt. Hunting methods include traps and dogs. Species such as antelopes, monkeys, snakes, aardvark and rabbits are caught. Fishing is not practised in this village.

4.16.3.3.3 *Housing, sanitation and infrastructure*

Most houses are made of local materials (adobe, wood, grasses). Corrugated iron is used on some houses, in which case the roof is gently sloping or flat and held in place by rocks. Some houses are built of more durable materials (cement blocks). A typical house consists of one or two bedrooms, a living room, and some have an outside latrine. Cooking takes place in a separate room attached to the house but is an open structure.

There is no infrastructure in the village, meetings take place under trees, and people gather in the open areas to socialise. There is no electricity supply, so people rely on wood and charcoal for cooking and lanterns or fires to provide light at night. Water is mainly obtained from hand-dug wells (*cacimba*), and water can be found 10-12 metres below the surface; a system of ropes and buckets are used to bail water. Households also obtain water directly from the river. Most of the villagers do not treat the water. There are three community wells with a pump in the village, but only one is working.

Figure 4-101: Water well in Lucamba

Figure 4-102: Water well not working because the pump system is broken

4.16.3.3.4 *Health and Education*

There are no health facilities in the village. The nearest is in Longonjo (Municipal Hospital of Longonjo), approximately ten kilometres away. The most common illnesses include malaria, stomach-ache and diarrhoea. Modern medicine is not readily available; therefore villagers use medicinal plants, such as *Quanana and Ongiriti* (used for stomach-aches and headaches). In addition, there is a group of traditional midwives in the village that help deliver babies born to women from the village in the absence of health centres.

Figure 4-103: Traditional midwives

Lucamba has one primary school with 6 classrooms (from 1st to 6th grade) that is attended by village children. However, the nearest secondary school is in Longonjo 10 kilometres away.

Figure 4-104: Lucamba primary school

4.16.3.3.5 Ecosystem services

The community is land-dependent for their livelihoods and welfare. Provisioning ecosystems services include soil, water (from rivers and wells for drinking and domestic purposes), timber (used for fuel and construction of houses) and hunting. Residents reported changes to the environment (soil fertility), which said the community ascribed this to be due to a lack of rainfall.

4.16.3.3.6 Culture and leisure

The community is predominantly Catholic, with some Protestant or Adventists. Traditional festivals are limited to a few ceremonies such as *alambamento* (traditional marriage), *Evamba* (male circumcision) and *Eyele* (ceremony for the first harvest). Leisure time is mainly spent playing football and socialising when the young and elders engage. The community has three informal grave sites.

4.16.3.4 Lumingo Village

Lumingo is not in the Project footprint and is accessed through an unmarked track from the main unpaved road passing through Longonjo.

Figure 4-105: Consultation meeting with the community

4.16.3.4.1 Population and ethnic group

The population in the village is estimated to be 1,200 people (700 women and 500 men) who are grouped in families of two to thirteen. Although the community is predominantly Christian, some men have children with different partners, so the large families are directly related. The family's father primarily heads households, but widows may be appointed as the head of a household and tend to live alone. Most of the population of the community is native to the village. There is one ethnic group - the Bantu/Ovimbundu ethnolinguist group. The main language is Umbundu. Portuguese is the official language but is not widely spoken among elders and women.

4.16.3.4.2 Livelihoods and income

The main means of livelihood for Lumingo´s villagers is subsistence agriculture. Crops are mainly grown for family consumption. If there is a surplus of crops, it is sold for between 3,000 Kz and 6,000 Kz (per month). In addition, there is a soldier (from the Angolan armed forces) who earns 10,000 Kz/month in the community.

Most of the residents have plots of land used on an ongoing basis. However, it was reported that the yield of crops has been decreasing. Most households have small lavras (fields) where they raise crops adjacent to their homes and larger lavras are located near Tchimbilundo, with the most fertile soils being those alongside watercourses (such as Rio Chicanda and Rio Babaela), these fields are known as “nacas”. Women are primarily involved in farming. Staple crops are maize and beans, and other crops include sweet potatoes, potatoes, cassava, cabbage, onion, tomatoes, yams and ground nuts.

Figure 4-106: Woman preparing maize

Animal husbandry is informal, with chickens and goats being the most common animals reared, followed by cattle, sheep and pigs. The animals are used for consumption and trading to raise money when needed. This village is an exception in that they reported eating meat more frequently (once a week). The villagers do not commonly practice hunting.

4.16.3.4.3 Housing, sanitation and infrastructure

Most houses are made of local materials (adobe, wood, grasses). Corrugated iron is used on some houses, in which case the roof is gently sloping or flat and held in place by rocks. A typical house consists of one to four bedrooms, a living room and an outside latrine. Cooking takes place in a separate room attached to the house but these are open structures as shown in Figure 4-107.

Figure 4-107: Oven in the household

There is no infrastructure in the village, meetings take place under trees, and people gather in the open areas to socialise. There is no electricity supply, and people rely on wood and charcoal for cooking and lanterns or fires to provide light at night.

4.16.3.4.4 Health and education

There are no health facilities in the village. The nearest is in Longonjo (Municipal Hospital of Longonjo), approximately 1.5 kilometres away. The most common illnesses include malaria, diarrhoea, vomiting, fever, backache and rheumatism. As with the other villages, modern medicine is not readily available, and medicinal plants such as *Quanana, Ongiriti, ombongue (*used for stomach-ache and headache) are used. Lumingo has one primary school (from 1st to 6th grade) that village children attend. The school has 285 students, 3 teaching rooms and 8 teachers. The nearest secondary school is in Longonjo (1.5 kilometres away).

4.16.3.4.5 Ecosystem services

The community is land-dependent for their livelihoods and welfare. Provisioning ecosystem services include soil, water (from rivers and wells for drinking and domestic purposes), timber (used for fuel and houses) and hunting. Residents reported environmental changes (soil fertility), which a lack of rainfall could cause.. In addition, the number of wild animals is decreasing due to fire and charcoal production.

4.16.3.4.6 Culture and leisure

The community is Catholic and Protestant, with some Adventists. Traditional festivals are limited to a few ceremonies such as *alambamento* (traditional marriage), *Evamba* (circumcision), *Hosse* (female genital mutilation or female circumcision), *Eyele* (ceremony for the first harvest) and *ekuivalenca*. Leisure time is mainly spent playing football and socialising when the young and elders engage.

4.16.3.5 Tchakengenga Village

Tchakengenga is in the Project footprint and is accessed through an unmarked track from the main unpaved road that crosses Longonjo.

4.16.3.5.1 Population an ethnic group

The village population is estimated to be 120 people who are grouped in families of two to eighteen. Although the community is predominantly Christian, some men have children with different partners, so some families are directly related. The father of the family primarily, but widows may be appointed the head of a household and they tend to live alone.

Most of the population were born in the village, with a few people having moved in the village to improve their living conditions during the civil war, which affected the country. There is one ethnic group - the Bantu/Ovimbundu ethnolinguist group. Their main language is Umbundu and Portuguese is the official language but is not widely spoken among elders and women.

4.16.3.5.2 Livelihoods and income

The primary means of livelihood for Tchakengenga´s population is subsistence agriculture. Crops are mainly grown for family consumption. If surplus food is sold and 20,000 Kz to 30,000 Kz may be earned (per month).

Most residents have plots of land used on an ongoing basis, and it is reported that the yields of crops have been decreasing. Most households have small *lavras* (fields) where they raise crops adjacent to their homes, and larger *lavras* are located near Tchimbilundo with the most fertile soils alongside watercourses (such as Rio Tchakengenga and Rio Cuiva). These fields are known as “*nacas”*. Staple crops are maize and beans, and other crops include potatoes, cassava, sweet potatoes, pumpkin and garlic.

Tools for farming used are axes, machetes and hoes. Some villagers use animals to plough, but money must be paid to the plough owner. Shortage of supplies is commonplace due to a lack of seeds and fertilisers (which are expensive) and low rainfall. The land is occupied and farmed through “inheritance”, but the villagers have no official documents to describe ownership or the occupant’s rights.

Based on observations, the farming methods are rudimentary; despite the farmers understanding of how quality could be improved, they lack the resources to do so as cash incomes are erratic. Animal husbandry is informal, with chickens and goats being the most common animals reared, followed by cattle, ducks and pigs. The villagers do not commonly practice hunting, but it is sometimes practised in the wooded areas (not far from the village) and Tchimbilundo. Hunting methods used include traps, dogs and arrows. Species such as bush goats, rabbits and porcupines are caught and killed.

Although animals are reared, chickens and goats are commonplace in the village. The villagers rarely eat meat (once or twice a month), and animals are used primarily for trading and raising money when needed. Eggs are not eaten as they are left to hatch and produce more chickens. Therefore, the average diet is low in protein and high in carbohydrates.

4.16.3.5.3 Housing, sanitation and infrastructure

Most houses are made of local materials (adobe, wood, grasses). Corrugated iron is used on some houses, in which case the roof is gently sloping or flat and held in place by rocks. A typical house consists of two to five bedrooms, a living room, and in some cases, an outside latrine In the absence of a latrine, residents go to the bush. Cooking takes place in a separate room attached to the house but is an open structure.

Figure 4-108: Latrine in Tchakengenga

There is no infrastructure in the village, meetings take place under trees and people gather in the open areas to socialise. There is no electricity supply, so people rely on wood and charcoal for cooking, and lanterns or fires to provide light at night.

Water is mostly obtained from the Tchakengenga River for domestic purposes. Some households obtain water from hand-dug wells (water can be up to 15-20 metres below surface, a system of ropes and buckets is used to bail water). Most of the villagers do not treat the water.

There is no formal waste management system, waste is commonly buried in pits near houses or may be burned (in the pits or on open ground).

4.16.3.5.4 Health and Education

There are no health facilities in the village. The nearest is in Longonjo (Municipal Hospital of Longonjo),approximately six kilometres away. The most common illnesses include malaria, headache, bronchitis, diarrhoea, rheumatism, typhoid fever and stomach-ache. Medicinal plants used are *Quanana* (stomach-ache), *Ongiriti* (headache)*, Ndembi* (chest pain) *and Tumbandjali (*typhoid fever).

Tchakengenga has one primary school (from 1st to 4th grade) that village children attend. The school has three teachers, 45 students and three classes. The nearest secondary school is in Longonjo, six kilometres away.

Figure 4-109: Primary school in Tchakengenga

4.16.3.5.5 Ecosystem services

The community is land-dependent for their livelihoods and welfare. Provisioning ecosystem services include soil, water (from rivers and wells for drinking and domestic purposes), timber (used for fuel and houses) and hunting. Residents reported environmental changes (soil fertility), which a lack of rainfall could cause. In addition, the number of wild animals is decreasing due to fire and charcoal production.

4.16.3.5.6 Culture and leisure

The community is predominantly Catholic and Protestant. Traditional festivals are limited to a few ceremonies such as *alambamento* (traditional marriage), *Evamba* (male circumcision), *Eyele* (ceremony for the first harvest) and *ekuivalenca*. Leisure time is mainly spent playing football and socialising when the young and elders engage.

4.16.3.6 Tena Village

Tena is not part of the Project footprint and is accessed through a road that crosses over a river via a bridge. The bridge presents risks to vehicles, and it is best accessed by motorbikes or walking.

4.16.3.6.1 Population and ethnic groups

The village is estimated to have 78 houses, and families have between three and thirteen people. Although the community is predominantly Christian, some men have children with different partners, so some families are directly related. The father of the family mostly heads households. There is one ethnic group, the Bantu/Ovimbundu ethnolinguist group. Their main language is Umbundu, and Portuguese is the official language but not spoken by many people.

4.16.3.6.2 Livelihoods and income

The primary means of livelihood for Tena's population is subsistence agriculture. Crops are mainly grown for family consumption and trading. When it is sold, the price is between 4,000kz and 20,000kz (per month), but this is an unreliable source of income. Most residents have plots of land that are used on an ongoing basis, and it was reported that the yield of crops has been decreasing. Most households have small *lavras* (fields) where they raise crops adjacent to their homes, larger *lavras* located around the village with the most fertile soils are alongside watercourses (such as in Rio Cuiva, Rio Tena and Acumbi stream), known as "*nacas*". Staple crops are maize, beans and cassava, and others crops include potatoes, sweet potatoes, tomatoes, onions, cabbage and garlic. The land is occupied and farmed through "inheritance", but the villagers have no official documents to describe ownership or the occupant's rights.

Animal husbandry is informal, with goats and chickens being the most common animals reared, followed by pigs and cattle. The villagers do not commonly practice hunting, but it is sometimes practised in the mountain (*Caundji*) using traps and dogs. As a result, species such as antelope, monkeys, rabbits and porcupine are caught. Some households reported that they practice fishing in Rio Cuiva.

Although animals are reared in the village, villagers rarely eat meat (once or twice a month). Instead, animals are used primarily for trading and raising money, as and when needed. Likewise, eggs are not eaten as they are left to hatch and produce more chickens. Therefore, the average diet is low in protein and high in carbohydrates.

4.16.3.6.3 Housing, sanitation and infrastructure

Most houses are made of local materials (abode, wood, grasses). Corrugated iron is used on some houses, in which case the roof is gently sloping or flat and held in place by rocks. A typical house consists of three bedrooms, a living room and an outside latrine. There is no infrastructure or electricity, and water is mainly obtained from the Tena or Cumbi Liandomene Rivers for domestic purposes. Water is treated with medicine given by the hospital or is boiled. There is no formal waste management system, waste is commonly buried in a pit near the house, and organic waste is used as fertiliser.

4.16.3.6.4 Health and Education

There are no health facilities in the village. The nearest is Chingongo which is approximately thirty minutes' walk away. The most common illnesses include malaria, bronchitis, fever, headache, diarrhoea, cough and rheumatism. Some villagers use of medicinal plants such as *Quanana, Ongiriti* (used for stomach aches and headaches). In addition, the community has a traditional healer who uses local plants to treat various illnesses. Tena does not have a primary or secondary school. The nearest primary or secondary school is in Chingongo. Some families have children who have gone to study in Benguela, where they stay with relatives, however, this is not commonplace.

4.16.3.6.5 Ecosystem services

The community is land-dependent for their livelihoods and welfare. Provisioning ecosystem services include soil, water (from the river and wells for drinking and domestic purposes), timber (used for fuel and houses) and hunting. Residents reported that there are changes to the environment (soil fertility), which they said could be caused by a lack of rainfall.

4.16.3.6.6 Culture and Leisure

The community is predominantly Catholic, and some villagers are Protestant. Traditional festivals are limited to a few ceremonies such as *alambamento* (traditional marriage), *Evamba* (male circumcision), *Eyele* (ceremony for the first harvest) and *ekuivalenca*. Leisure time is mainly spent playing football and socialising when the young and elders engage.

4.17 Cultural Heritage

4.17.1 Local Context

The village of Longonjo was founded on May 28, 1958, by the Portuguese Adriano Lourenço Maya and rose to the category of Municipal Administration in October 1963, by Decree nº 12,925. The initial construction was of "pau-a-pic", where the commune of Longonjo-headquarters is located today. The origin of the name Longonjo is due to its proximity to the small mountain called "Longonjo", located about 3 kilometres to the north, where travellers who travelled to Benguela rested and removed bark from trees called "oduko", for the manufacture of "ongondjo" which was an object used to transport the goods to the coast (Figure 4-110). Therefore, Longondjo, in the Umbundo language, is the plural of the word "Ongondjo".

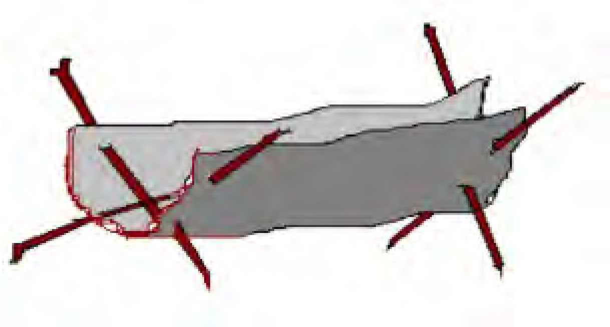


Figure 4-110: Freight transport object illustration – 'Ongondjo'.

4.17.2 Religious Architecture

The "Nossa Senhora do Rosário" parish was erected in the Comuna Sede on 7 October 1957 (Figure 4-111), as shown in the Portuguese Yearbook of 1968. Its founder was Father Joaquim Ribeiro de Lima Campos, who governed it until 1971 and went to Portugal in 1974.

Figure 4-111: Nossa Senhora do Rosario parish

Due to the influx of pilgrims, Father Ribeiro de Lima Campos built a small chapel on Mount Chimbilundo. The chapel was inaugurated in June 1964. For many years there was a pilgrimage to Chimbilundo; however, this practice was interrupted by the civil war, which led to the destruction of the small chapel (Figure 4-112).

Although the ruins of the chapel are within the Project footprint, no mining infrastructure or mining is planned in the vicinity of the ruins.

The latest (2021) mining pit layout and infrastructure layout indicate that the chapel has effectively been excluded from any development as part of this Project.

Figure 4-112: Ruins of the small chapel on Chimbiluno

4.17.3 Informal graves

Figure 4-113 shows that there are several historical and current grave sites in the Longonjo area, and the small villages surrounding the Project. There are eight graves sites in the Project polygon (buffer zone), and three informal graves (#14, #15 and #16) are located in the area where TSF9/10 is planned to be located.

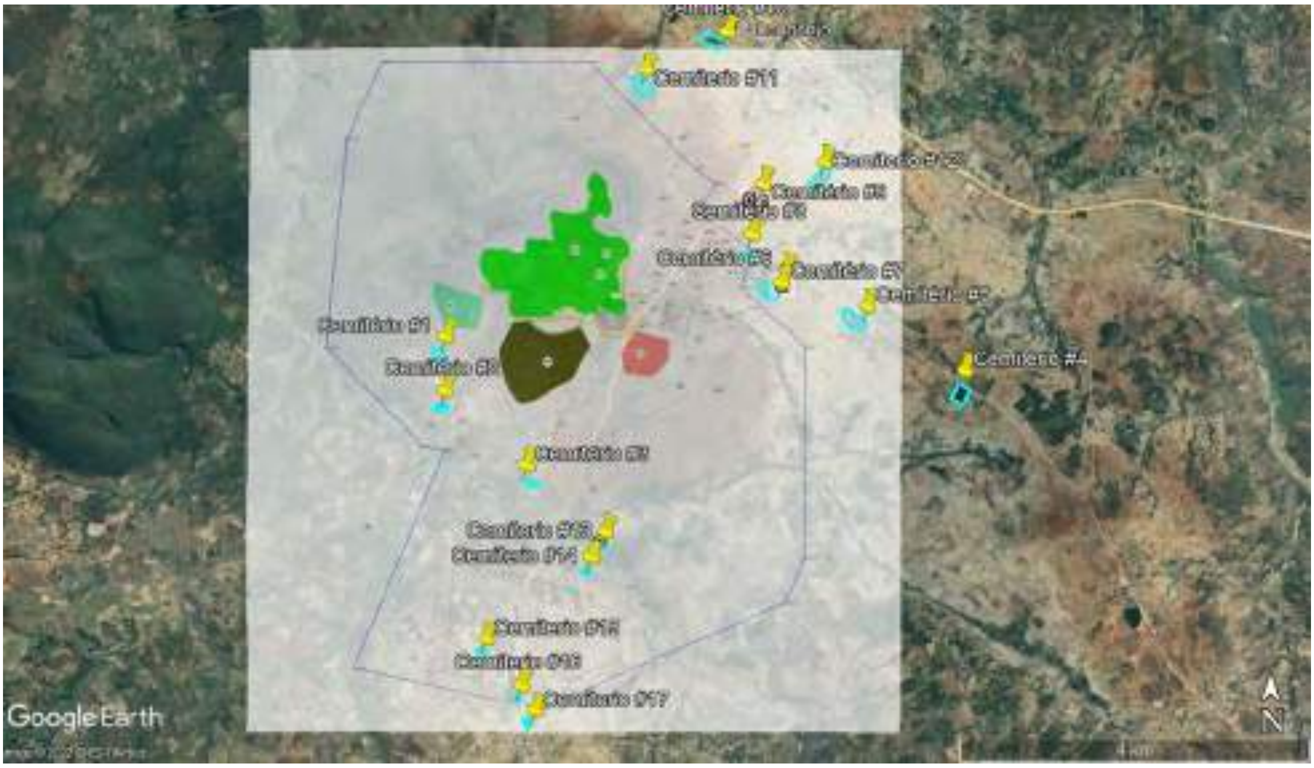


Figure 4-113: Informal grave sites in the vicinity of the Project

4.17.4 Natural heritage sites and landscapes

The Longonjo municipal area hosts the following sites of cultural heritage importance, none of which are located in the Project area:

- Hoha rock painting, Yava Samaria, Catabola;
- Capacote rock painting, Bongo Lepi;
- Cangolo Rock Painting;
- Cachilala caves known as Akokotos, Bungue Sede;
- Nambi caves known as Akokotos, Chiuta Sede;

- Serra Ongonjo Cave, Catome Sede;
- Pedra do Lepi stone and cave, (Figure 4-114);
- Pedra Goya Cave, Jony 1º Lepi;
- Cuvindu stone, Chilata;
- Essenje Liovita stone;
- 'Upanga wa suku', Chilata; and
- Tuvili caves, Ayenja Sede.

Figure 4-114: Lépi Stone

4.17.5 Rituals and cultural acts of significance

The cultural component of the socio-economic study indicated that villages attempt to preserve the cultural rituals, habits, and customs. This may include dances, masks, and the 'Ayele' ritual that is performed by the elders that calls for increased productivity of the land and for rain. Cultural habits require the respect for 'places of memory', such as the informal graves sites where ancestors are buried, the preservation of the 'Ombalas' (a place of traditional authority), which are all elements of the common heritage.

The socio-economic and cultural heritage team identified no other tangible resources in the Project footprint.

4.18 Traffic Baseline

Traffic counts were conducted on four weekdays in August 2019 on the road passing through the Project area in the east, where the construction camp is currently located. The road connects Longonjo to the north-east, with Lucamba Village to the south. Traffic was counted travelling in the direction of Longonjo and the direction of Lucamba. The traffic on this road represents the most relevant pre-mining traffic flow. During each survey, the type of vehicle, time and direction were recorded and are presented in

Table 4-52 to Table 4-59.

The traffic data shows definite morning and afternoon peaks with most vehicle types except motorbikes. Motorbikes travel up and down the Longonjo-Lucamba road throughout the day until 18:00. From a traffic point of view, the most important trend is the high number of motorbikes throughout the day. This is because motorbikes are used as the cheapest form of motorised transport, and the traffic management plan at mitigation measures for the potential Project induced impacts, will have to focus on the safety of motorbike users on the Longonjo-Lucamba road.

Table 4-52:Traffic count 1a – Towards Longonjo (5 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00				41		41
08:00 – 10:00	1	1	1	68	1	72
10:00 – 12:00	1		2	43	2	48
12:00 – 14:00	1	2	1	44		48
14:00 – 16:00		1	2	40	2	45
16:00 – 18:00		1	2	31	2	36
18:00 – 20:00				14		14
TOTAL	3	5	8	281	7	

Table 4-53:Traffic count 1b – From Longonjo (5 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00	3	2	1	52	2	60
08:00 – 10:00		3	1	58	3	65
10:00 – 12:00		2	1	54		57
12:00 – 14:00			2	45	1	48
14:00 – 16:00			2	33		35
16:00 – 18:00		1	2	46		49
18:00 – 20:00		3	1	8		12
TOTAL	3	11	10	296	6	

Table 4-54:Traffic count 2a – Towards Longonjo (6 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00	3	4	3	36	2	48
08:00 – 10:00		1	4	31	2	38
10:00 – 12:00		2	3	49	1	55
12:00 – 14:00		1		36	1	38
14:00 – 16:00		2	2	44	1	49
16:00 – 18:00			2	48	1	51
18:00 – 20:00		1	1	3		5
TOTAL	3	11	15	247	8	

Table 4-55:Traffic count 2b – From Longonjo (6 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00		3		44		47
08:00 – 10:00	1	2	1	54		58
10:00 – 12:00	1		2	52	2	57
12:00 – 14:00	1	2		36		39
14:00 – 16:00		3		34	2	39
16:00 – 18:00		3	4	30	3	40
18:00 – 20:00		1	3	6	1	11
TOTAL	3	14	10	256	8	

Table 4-56:Traffic count 3a – Towards Longonjo (7 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00		1		37		38
08:00 – 10:00	1	2	1	57		61
10:00 – 12:00	1	1	1	48	1	52
12:00 – 14:00	1	1		25	1	28
14:00 – 16:00		1	1	42	2	46
16:00 – 18:00		1	2	33	1	37
18:00 – 20:00			3	11		14
TOTAL	3	7	8	253	5	

Table 4-57:Traffic count 3b – From Longonjo (7 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00	3	5	1	27	2	38
08:00 – 10:00			1	54	1	56
10:00 – 12:00		2	3	47	2	54
12:00 – 14:00		2	1	22		25
14:00 – 16:00		1		35	2	38
16:00 – 18:00		2	1	28		31
18:00 – 20:00				7		7
TOTAL	3	12	7	220	7	

Table 4-58:Traffic count 4a – Towards Longonjo (15 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00		2	3	33		38
08:00 – 10:00				52		52
10:00 – 12:00		1	4	34	3	42
12:00 – 14:00	1	3	2	30	3	39
14:00 – 16:00		1	2	31	3	37
16:00 – 18:00	1	3	4	41		49
18:00 – 20:00		3	7	15		25
TOTAL	2	13	22	259	9	

Table 4-59:Traffic count 4b – From Longonjo (15 August 2019)

TIME	TYPE					TOTAL
	BUS	TRUCK	CAR	MOTORBIKE	TAXI	
06:00 – 08:00	2	4	6	34	4	50
08:00 – 10:00		2	1	44	6	53
10:00 – 12:00		1	4	40		45
12:00 – 14:00			3	33	1	37
14:00 – 16:00		3	1	51	1	56
16:00 – 18:00		1	3	43		47
18:00 – 20:00		1	1	9		11
TOTAL	2	12	19	254	12	

5 ASSESSMENT AND EVALUATION OF THE ENVIRONMENTAL AND SOCIAL IMPACTS

5.1 Impact Assessment Approach

The ESIA (including its specialist studies) for the Longonjo NdPr Mining Project has been conducted in compliance with Angolan legislation and conformance with the IFC Performance Standards and other applicable international standards. The integrated ESIA process is illustrated in Figure 5-1.

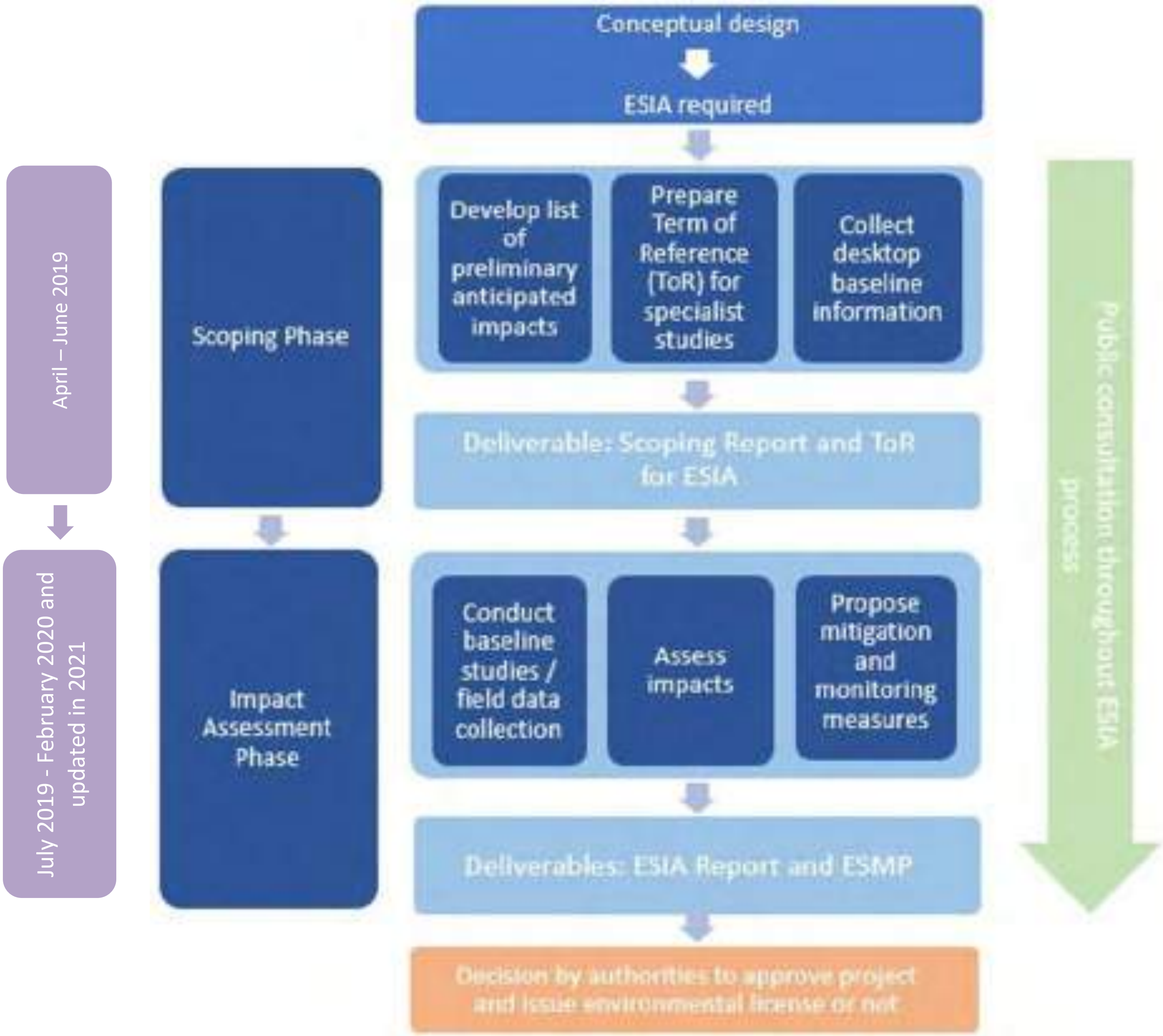


Figure 5-1: The integrated ESIA process

5.1.1 Impact Assessment Methodology

Impacts have been assessed using information from baseline and desktop studies and the detailed Project description.

The significance of the impacts determined using the approach illustrated in Table 5-1. Impacts are described before and after mitigation (after mitigation is applied, impacts are termed “residual impacts”).

Table 5-1: Impact Classification for Impact Assessment

Incidence			Severity				Environmental and Social Consequence
Direction	Duration	Probability	Geographic Reach	Frequency	Magnitude	Reversibility	

Where the impact parameters are defined as:

Direction	This parameter can be defined as positive, neutral or negative with respect to the particular impact.
Duration	Duration of an impact is the total time over which an environmental or social impact can occur. Duration types are: • temporary (<1 year); • short-term (0 - 5 years [i.e. construction phase]); • medium-term (5 to 15 years [i.e. operational phase]); • long-term (>15 years with impact ending at closure of a project); or permanent (post-closure). The duration categories will be adjusted as the Project description is finalised, if necessary.
Probability	Probability of an impact taking place can be: • unlikely (less than 5% probability); • low (5% to 40% probability); • medium (40 % to 60 % probability); • high (most likely, 60% to 90% probability); or • definite (an impact will definitely occur). Assessment of probability is based on the experience of the team for similar projects / developments
Geographic Reach / Scale	Scale/Geographic reach refers to the surface area that could be affected by the specific impact and is defined as: • site / local: effect restricted to the Local Project area (LSA); • regional: effect extends beyond the LSA into the Regional Project area (RSA); or • beyond regional: effect extends beyond the RSA site. NOTE: The Angolan national environmental legislation mentions three areas of influence: i) Directly Affected Area (DAA) – the area that is directly exposed to project facilities; ii) Direct Influence Area (DIA) – the area affected by the direct impacts from the project's infrastructures and activities and surroundings; and iii) Indirect Influence Area (IIA) – the wider geographic area affected by the indirect impacts of the project's infrastructures and activities. When reference is made to LSA – this would imply 'DAA'; similarly, RSA would imply 'DIA'; equally, beyond regional would imply 'IIA'.

Frequency	Frequency of the impact occurrence is defined as: • low: occurs as a single event; • medium: occurs periodically; or • high: occurs on a continuous basis.
Magnitude	This defines the 'degree of change' and is expressed as: • negligible: no measurable effect (<1%) from baseline conditions; • low: <10% change from baseline conditions; • medium: 10 to 20% change from baseline conditions; and • high: >20% change from baseline conditions.
Reversibility	An impact can either be reversible or irreversible.
Environmental and Social Consequence	Environmental and social consequence is the total residual impact for each effect and will be defined as: • negligible – no impact; • low – low impact with low significance. Mitigation can easily be achieved and/or minimal mitigation is needed; • moderate – the impact is significant, but not high in comparison to other impacts that potentially could occur. Mitigation is normally feasible and achievable; or • high – maximum impact that could potentially occur. No possible mitigation can offset the impact, and/or mitigation of the impact is difficult to achieve.

5.1.2 Confidence of Prediction

There remains a degree of uncertainty in any impact assessment due to the availability of Project and other relevant information, the dynamic nature of the social and biophysical environments, and the predictive nature of assessment methods.

In cases where there are concerns about the prediction confidence of a specific environmental and social aspect, these are discussed in the impact assessment. However, when low confidence prediction is evident, the ESIA specialists will make subjective assessments considering the information at hand at the time of the assessment and their professional experience and opinion. In such uncertain cases, the ESIA specialists will make their recommendations based on the precautionary principle and possibly recommend the collection of additional data and regular monitoring to improve data availability and thus informed decision making.

5.1.3 Formulation of Mitigation Measures

A key objective of an ESIA process is to propose and implement mitigation measures to manage and mitigate potential impacts. Mitigation measures must be environmentally and technically efficient and socially acceptable while remaining as cost-effective as possible and/or in line with internationally accepted best practise.

In line with good international industry practice (GIIP), mitigation hierarchy is applied when formulating mitigation measures to reduce the significance of effect:

- **Avoid / reduce at source**: (e.g., move to a more suitable site, rerouting an activity away from sensitive areas, engineer a solution, or use different technology);
- **Minimise**: by applying mitigation (e.g., by, amending the layout of the project; pollution control equipment; or using alternative technology);
- **Rehabilitate / restore/repair unavoidable damages/impacts to a resource**: (e.g., measures to improve and reinstate ecosystems where impacts could not be avoided nor minimised); and
- **Offset / compensate**: (e.g., measures to compensate for residual adverse impacts where avoid-minimise- rehabilitate cannot be applied). Offsets for biodiversity can be complex and costly but are used where other steps cannot be used. For physical and economic resettlement, legislative / regulatory processes and international standards detail requirements (e.g., compensation rates for loss of crops, land access: and livelihood and housing restoration guidelines).

5.1.4 Presentation of Mitigation Measures

The mitigation measures are either presented in the impact assessment tables at the end of each environmental aspect / specialist discipline or in a dedicated subsection in cases where the mitigation measures exceed the space available in the impact assessment tables.

Mitigation measures are further included in the Environmental and Social Management Plan (ESMP) – section 1, while monitoring requirements are stipulated in section 9.

5.2 Scoped Issues and Terms of Reference

During the Scoping Phase of the ESIA (April – June 2019), important issues were highlighted, critically evaluated and prioritized. Extraneous issues, that would not result in significant impacts, were also identified but not further investigated during the specialist studies. Specialists were appointed to assess the significance of potential impacts further. The scoped issues informed the specialist Terms of Reference (ToR).

The Scoping Report and ToR provided information on:

- The Project team;
- The location and characteristics of the Project;
- Preliminary baseline information;
- The environmental topics proposed to be the focus of the ESIA Report;
- Any topics not requiring further consideration;
- The approach to, and the methodologies for conducting baseline studies;
- ToR for environmental and social specialist studies;
- Legal, policies and other requirements;
- First-round for stakeholder consultation / public participation; and
- The scope of the framework EMPs.

The following scoped issues / preliminary potential impacts were identified for the Project (Scoping report and ToR as per Appendix B):

- Potential generation of dust during site clearance and diffuse source emissions from diesel-powered equipment;
- Emissions from mining in the open cast pit and diffuse source emissions from the operations;
- Potential impacts due to water abstraction (groundwater or surface water – yet to be determined);
- Clearing of indigenous vegetation on the site footprint and associated loss of biodiversity;
- Degradation or loss of sensitive habitats;
- Impacts on downstream aquatic ecosystems due to contamination;
- Impacts on terrestrial fauna and flora due to contamination;
- Potential impacts on the site footprint from various pollution sources (chemical storage and use, waste storage, hydrocarbon use and spills);

- Potential loss of soil as a resource due to soil erosion;
- Potential radiation risk (NORM) and radio-active source equipment;
- Potential socio-economic and cultural heritage impacts on local community currently informally using parts of the Project footprint (which in turn might result in impacts of involuntary resettlement);
- Potential loss of access to land and fields, water resources and other ecosystem services; and
- Positive socio-economic impacts (direct and indirect) due to the creation of job opportunities during construction and operation, training of the workforce, improved infrastructure in the vicinity of the Project (e.g. roads, electricity, a communication network).

During the 2021 update of the ESIA, the updated project description was evaluated by the ESIA project team, and the scoped issues and terms of reference were deemed to remain relevant, while the spatial scope was extended to include the increased footprint of the Project.

5.3 Impact Assessment

PHYSICAL ASPECTS

5.3.1 Air Quality and GHG[7]

Reference

Specialist study 1 – Appendix C

Key specialists

Reneé Von Grunewald - Airshed Planning Professionals, South Africa

Study objectives

The objectives of the air quality specialist study were as follows:

- To review relevant Project documentation as available at the time of the study;
- To consider the relevant Air Quality Standards (AQS) - IFC and Angolan;
- To establish the baseline air quality for the area from internationally accepted modelled data sources;
- To undertake a quantitative potential dust impact assessment for construction and operation;
- To undertake a qualitative assessment of diffuse source emissions from vehicles and plant equipment;
- To identify the environmental significance of any potential impacts; and
- To formulate appropriate management and mitigation methods / actions.

Sensitive receptors of relevance to Air Quality impacts are presented in Section 4.4.2.

5.3.1.1 Impacts During Planning/Design and Construction Phases

The construction phase will comprise various different operations including land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing and compaction. As a result, it is anticipated that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions (This is in contrast to most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle).

A list of the potential dust generation activities expected during the construction phase is provided in Table 5-2. Unmitigated construction activities provide the potential for impacts on local communities, primarily due to nuisance and aesthetic impacts associated with fugitive dust emissions. On-site dust-fall may also represent a nuisance to employees, particularly the small particle size (0,002mm) of some soil types in the Project area. During the dry season, the fine particles dry bulk density (g/cm^3) increase, i.e., become drier and more susceptible to wind erosion and thus increasingly airborne.

Table 5-2: Typical sources of fugitive particulate emission associated with construction

Impact	Source	Activity
Gasses (NOx, SOx, CO etc.)	Vehicle exhausts	Transport and general construction activities
PM_{10} and $PM_{2.5}$	Stockpile areas and open areas	Clearing of groundcover
		Levelling of area
		Wind erosion from open areas
		Materials handling
	Transport infrastructure	Clearing of vegetation and topsoil
		Levelling of areas

5.3.1.1.1 Fugitive Pollutant and Traffic Related Air Quality Impacts

Literature[1] suggests that the concentrations of vehicle emissions [e.g. nitrogen oxides (NOx), sulphur oxides (SOx), carbon monoxide (CO), and particulates ($PM_{2.5}$, PM_{10}) and other volatile organic carbons (VOC)] impacts decrease rapidly from the kerbside; rendering the effective contribution of vehicle emissions beyond 200m, insignificant.

During the construction phase, the potential exists for air quality impacts from road vehicle exhaust emissions associated with traffic movements, such as Heavy-Duty Vehicles (HDVs) (e.g. hauling trucks, mining plant equipment) involved with opencast mining and material haulage and Light-Duty Vehicles (LDVs) utilised by mining staff. Guidance in the Environmental Protection UK (EPUK) Development Control: Planning for Air Quality (2010 Update) (EPUK, 2010) indicates that an assessment of the emissions from construction traffic will be required when there are an increase of 200 Heavy Goods Vehicles (HGV) movements per day (or more) as a result of development, defined as a single vehicle trip / delivery either to or from the site.

Table 5-4 summarises the existing and proposed one-way traffic movements associated with the proposed Project. As noted in Section 4.17.5, ~89% of the baseline traffic comprises motorcycles.

Table 5-3: Average daily traffic anticipated change

Scenario	Cars, Motorcycles and Miscellaneous Equipment	Trucks, Heavy Equipment and Mining Equipment
Baseline	278[2] (258 motor cycles)	11
Project max contribution during construction	20	45 vehicles[3] / day for construction 1 truck / day of supplies
Baseline plus Project max contribution during construction	298	56
Project during Operation	20	91 vehicles[3]/ day hauling ore and/or concentrate 1 truck / day of supplies
Baseline plus Project during Operation	318	133

Based on the baseline traffic data, estimated mining fleet and the DMRB criteria presented above, it is assessed that road traffic generated by the Project is unlikely to have a significant impact on human health or local air

[1] UK Design Manual for Roads and Bridges (DMRB), Volume 11, Section 3, Part 1 Air Quality, May 2007, Highways Agency
[2] Derived average as per Section 4.17.5
[3] Excavators, Haul Trucks, Dozers, Front End Loaders, Grader, Roller, Grade Control Drill Rig, Water Truck

quality. Vehicle exhaust emissions were not quantified as the impacts from these sources are localised and will not exceed ambient guidelines and limits offsite.

5.3.1.1.2Impact

Increased nuisance dust and potential vehicle exhaust emissions and low levels of PM_{10} and $PM_{2.5}$.

5.3.1.1.2.1 Mitigation Measures

Incremental PM_{10} and $PM_{2.5}$ concentrations and deposition rates due to the Project's construction phase will be of relatively short-term and of local impact. However, implementing effective controls during this phase would also serve to set a precedent for mitigation during the operational phase.

Dust control measures that may be implemented during the construction phase are outlined in Table 5-4. Control techniques for fugitive dust sources generally involve watering, chemical stabilisation, and the reduction of surface wind speed, though the use of windbreaks and source enclosures in problematic areas.

Table 5-4: Dust control measures to be implemented during the construction phase

Construction Activity	Recommended Control Measure(s)
Materials storage, handling and transfer operations	• Wet suppression where feasible on stockpiles and materials handling activities
Open areas (windblown emissions)	• Minimise extent of disturbed areas. • Reduction of frequency of disturbance. • Early re-vegetation • Stabilisation (chemical, rock cladding or vegetative) of disturbed soil

5.3.1.2 Impacts During Operational Phase

Atmospheric emissions represent the environmental aspects of concern for the assessment of the Project. The sources of these emissions were determined by first identifying the inputs and outputs to the various processes and, secondly, considering the disturbance to the environment by the proposed operations. Possible aspects associated with the operations of relevance in terms of air quality impacts are listed in Table 5-5. Particulates present the main pollutant of concern from mining operations. Fugitive dust from vehicle movement, materials handling operations and screening are classified as routine emissions and are relatively constant throughout the year.

Table 5-5: Potential air pollutants emitted from the proposed project

Operational phase		
Aspects	**Source**	**Activities**
Vehicle movements		
Gaseous and particulate emissions; fugitive dust	Vehicle activity on paved and unpaved roads	• Transportation of Run of Mine (ROM) from pit to stockpile/crusher • Transportation of waste rock/saprolite • Transportation of product
Material handling		
Fugitive dust	Materials handling operations	• Remove ROM and waste from opencast mining areas • Tip waste at waste rock dumps • Tip ROM at ROM pad • Crushing • Mineral screening

Operational phase		
Aspects	**Source**	**Activities**
In-pit mining operations		
Fugitive dust	Mining operations within open pit	Removal of waste and ROM by excavator and loading of haul trucks
Storage piles		
Fugitive dust	Wind erosion	Windblown dust from the tailings storage facility, waste rock stockpile and ROM pad
Processing plant		
Gaseous and particulate emissions	Stacks	Process operations

5.3.1.2.1 Quantification of Environmental Aspects and Impact Classification

Scenarios

Two scenarios were assessed for the operational phase:

- Scenario 1: assuming the preferred TSF location ~3 km south of the open pit; and
- Scenario 2: assuming an alternative location for the TSF, east of the plant.

The preferred and alternative TSF locations were provided in Figure 2-4.

The sources of emissions from the processing plant were not available for assessment as the plant design has not been finalised. However, once the plant design is finalised, the air quality impact assessment is recommended to update it to incorporate all operational sources of emissions.

Emissions Inventory

The operation phase is assessed quantitatively with the emissions provided; the emission factors and calculated emission rates are provided in the Air Quality Specialist study (Appendix C). In addition, particle size distribution tables are also presented in the Air Quality Specialist study (Appendix C).

5.3.1.2.2 Synopsis of Particulate Emissions from Various Sources at the Project due to Proposed Operational Activities

Fugitive particulate emissions calculated for various source types are given in Table 5-6. Conditions were assessed for both unmitigated and mitigated (applying 75% control efficiency on unpaved road surfaces and 50% control efficiency on screening activities (control efficiency documented by Australia's National Pollution Inventory as being achievable through water sprayers)). For unmitigated operations, vehicle entrainment on unpaved surfaces represents the most significant source of particulate emissions (Figure 5-1). Therefore, only Scenario 1 is shown in Figure 5-1. The fugitive particulate contribution for Scenario 2 is similar to Scenario 1.

Table 5-6: Fugitive particulate emissions due to routine operations for the project

ACTIVITY	Emissions (tpa)			% Contribution			Rank
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP
Scenario 1: Preferred TSF location							
Unmitigated							
Vehicle entrainment	5 261.54	1 866.00	186.60	98.55	97.94	89.72	1
Materials handling	0.96	0.45	0.07	0.02	0.02	0.03	4
Crushing	15.00	6.00	1.11	0.28	0.31	0.53	3
Wind erosion	61.42	32.74	20.19	1.15	1.72	9.71	2
TOTAL	**5 338.92**	**1 905.20**	**207.97**	**100.00**	**100.00**	**100.00**	
Mitigated: control efficiency of 75% applied to unpaved roads; 50% applied to crushing activities							
Vehicle entrainment	1 315.39	466.50	46.65	94.96	92.80	69.15	1
Materials handling	0.96	0.45	0.07	0.07	0.09	0.10	4

ACTIVITY	Emissions (tpa)			% Contribution			Rank
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP
Crushing	7.50	3.00	0.56	0.54	0.60	0.82	3
Wind erosion	61.42	32.74	20.19	4.43	6.51	29.93	2
TOTAL	**1 385.26**	**502.70**	**67.47**	**100.00**	**100.00**	**100.00**	
Scenario 2: Alternative TSF location							
Unmitigated							
Vehicle entrainment	5 261.54	1 866.00	186.60	98.82	98.70	95.17	1
Materials handling	0.96	0.45	0.07	0.02	0.02	0.03	4
Crushing	15.00	6.00	1.11	0.28	0.32	0.57	3
Wind erosion	46.63	18.16	8.30	0.88	0.96	4.23	2
TOTAL	**5 324.13**	**1 890.61**	**196.08**	**100.00**	**100.00**	**100.00**	
Mitigated: control efficiency of 75% applied to unpaved roads; 50% applied to crushing activities							
Vehicle entrainment	1 315.39	466.50	46.65	95.98	95.57	83.94	1
Materials handling	0.96	0.45	0.07	0.07	0.09	0.12	4
Crushing	7.50	3.00	0.56	0.55	0.61	1.00	3
Wind erosion	46.63	18.16	8.30	3.40	3.72	14.94	2
TOTAL	**1 370.47**	**488.12**	**55.57**	**100.00**	**100.00**	**100.00**	

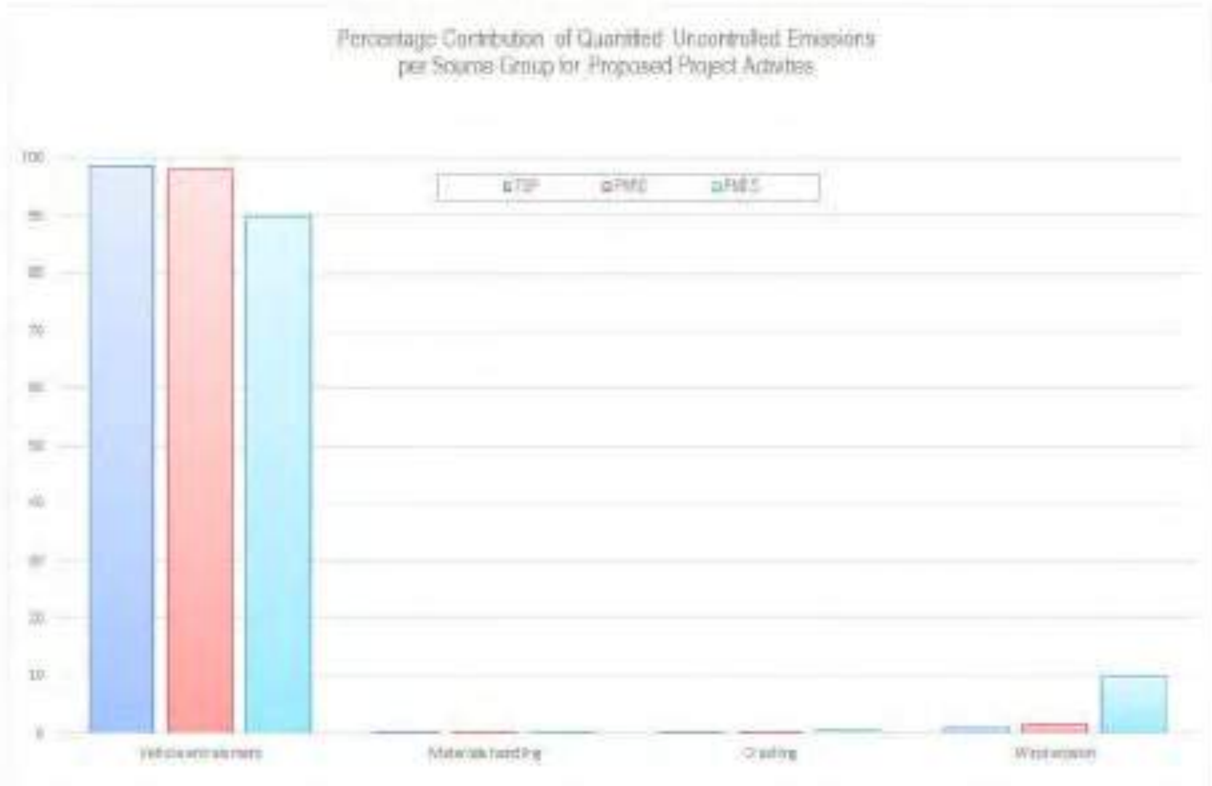


Figure 5-1: Percentage contribution of fugitive particulate emissions due to unmitigated operations for the project (Scenario 1)

5.3.1.2.3 Dispersion Simulation Results and Compliance Assessment

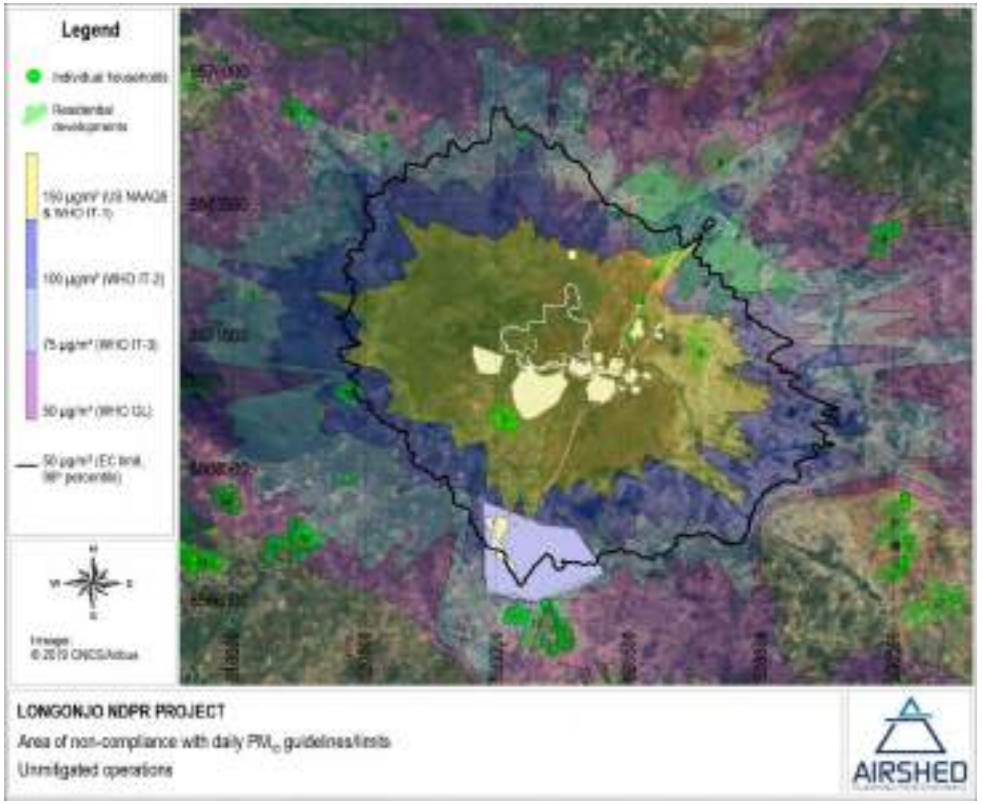
Criteria Pollutants

Simulations were undertaken to determine particulate matter (PM_{10} and $PM_{2.5}$) ground-level concentrations due to Project activities. Impacts were screened against the WHO IT and GV, the EC limits and the US NAAQS. The plots provided for the relevant pollutants of concern during the operational phase are given in Table 5-7.

Table 5-7: Isopleth plots presented in the current section

Pollutant	Scenario	Averaging Period	Operating Conditions	Figure
PM_{10}	Scenario 1: preferred TSF location	Highest daily	Unmitigated operations	Figure 5-1
			Mitigated operations (assuming 75% control efficiency (CE) on unpaved roads and 50% CE on crushing activities)	Figure 5-3
		Annual average	Unmitigated operations	Figure 5-5
			Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	Figure 5-7
PM_{10}	Scenario 2: alternative TSF location	Highest daily	Unmitigated operations	Figure 5-2
			Mitigated operations (assuming 75% control efficiency (CE) on unpaved roads and 50% CE on crushing activities)	Figure 5-4
		Annual average	Unmitigated operations	Figure 5-6
			Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	Figure 5-8
$PM_{2.5}$	Scenario 1: preferred TSF location	Highest daily	Unmitigated operations	Figure 5-9
			Mitigated operations (assuming 75% control efficiency (CE) on unpaved roads and 50% CE on crushing activities)	Figure 5-11
		Annual average	Unmitigated operations	Figure 5-13
			Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	Figure 5-15
$PM_{2.5}$	Scenario 2: alternative TSF location	Highest daily	Unmitigated operations	Figure 5-10
			Mitigated operations (assuming 75% control	Figure 5-12

Pollutant	Scenario	Averaging Period	Operating Conditions	Figure
			efficiency (CE) on unpaved roads and 50% CE on crushing activities)	
		Annual average	Unmitigated operations	Figure 5-14
			Mitigated operations (assuming 75% CE on unpaved roads and 50% CE on crushing activities)	Figure 5-16



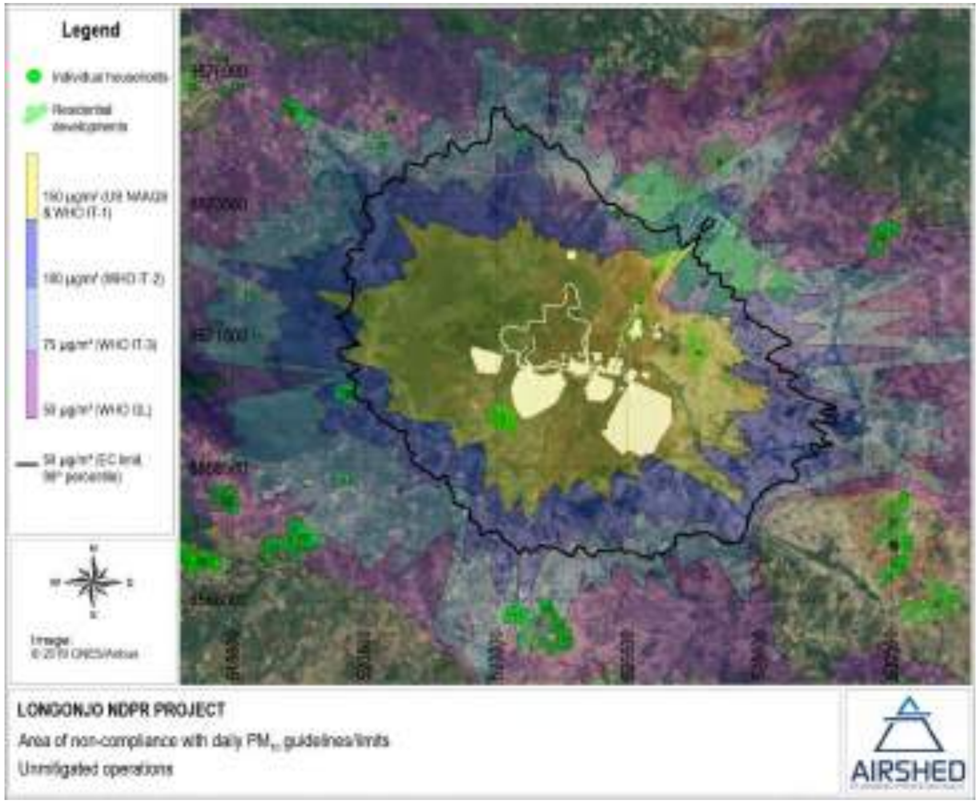


Figure 5-2: Area of non-compliance of daily PM_{10} evaluation criteria due to unmitigated Project operations (Scenario 1)

Figure 5-3: Area of non-compliance of non-compliance of daily PM_{10} evaluation criteria due to unmitigated project operations (Scenario 2)

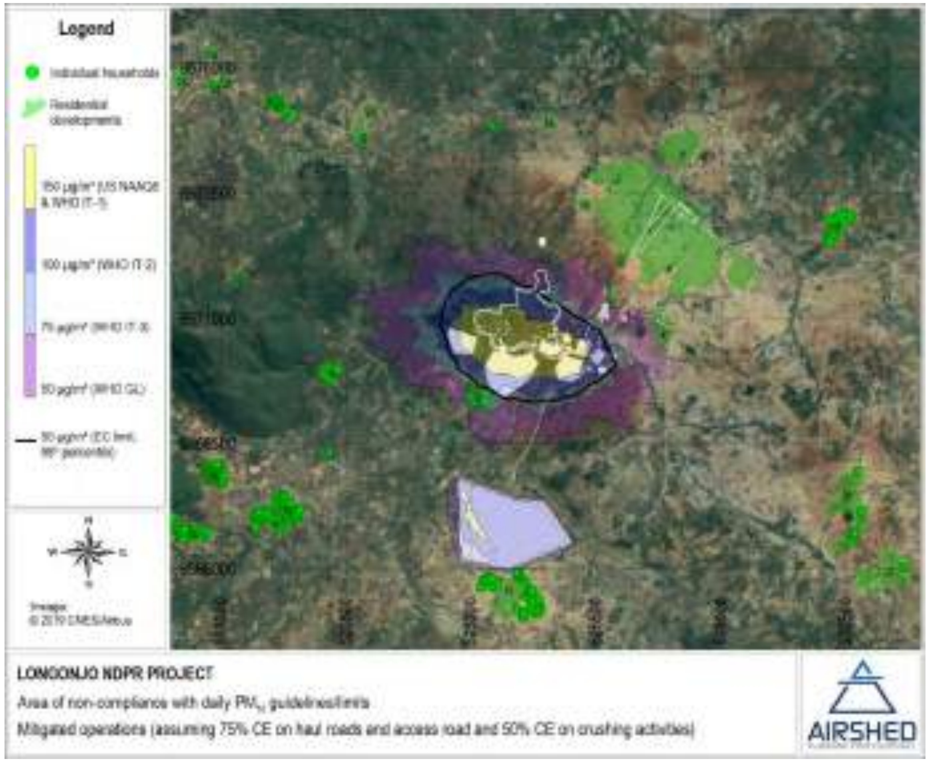


Figure 5-4: Area of non-compliance of daily PM_{10} evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 1)

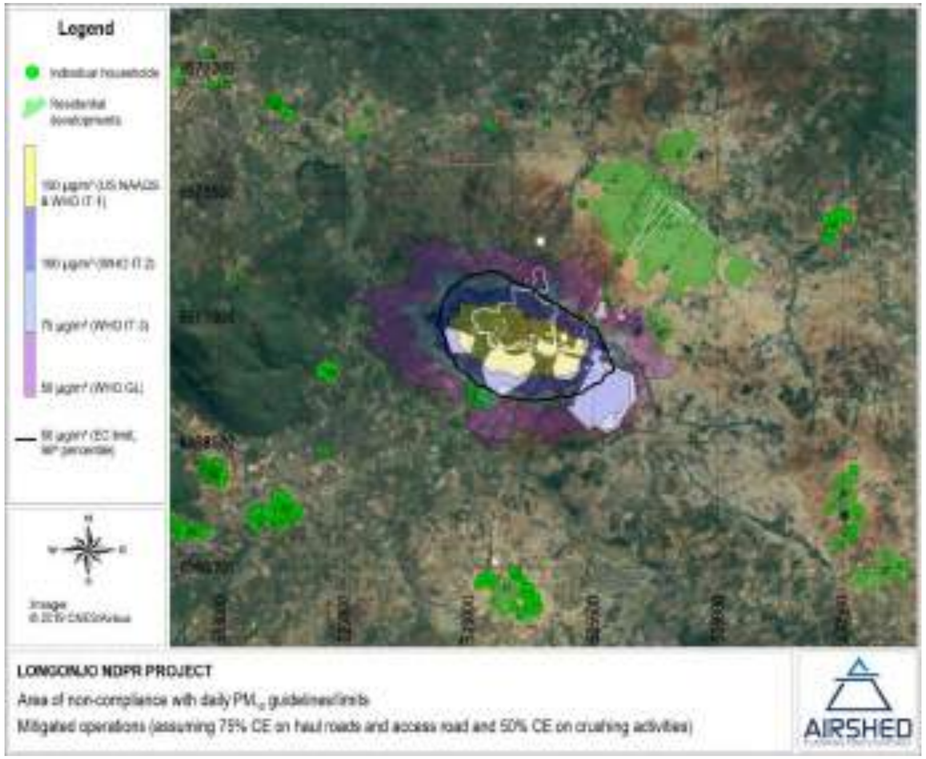
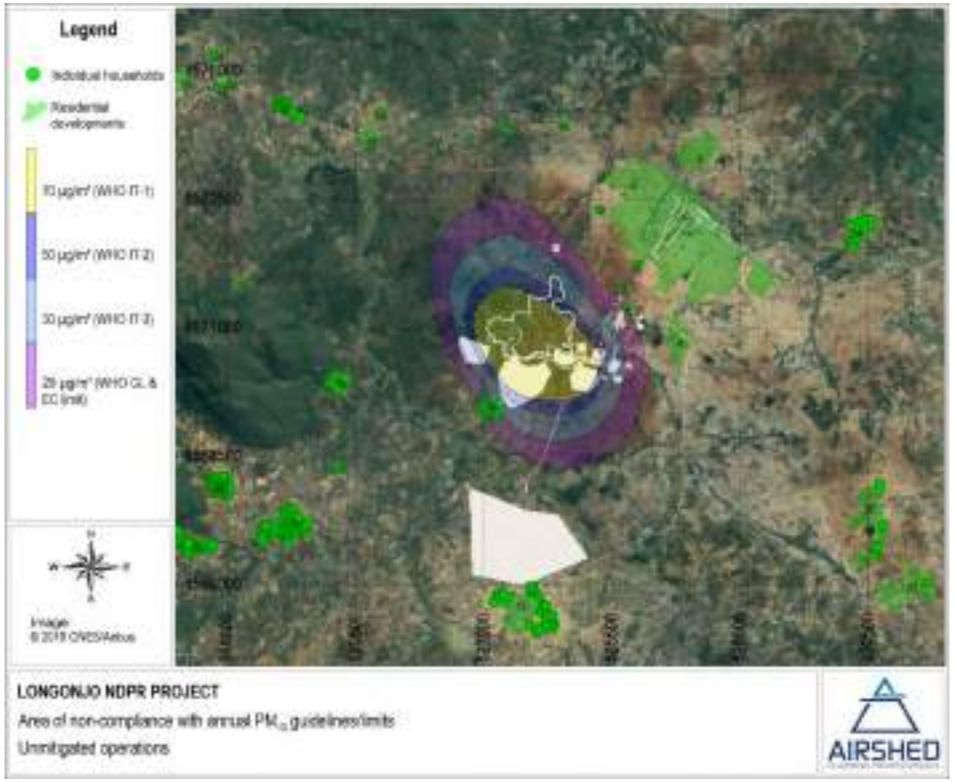


Figure 5-5: Area of non-compliance of daily PM_{10} evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 2)



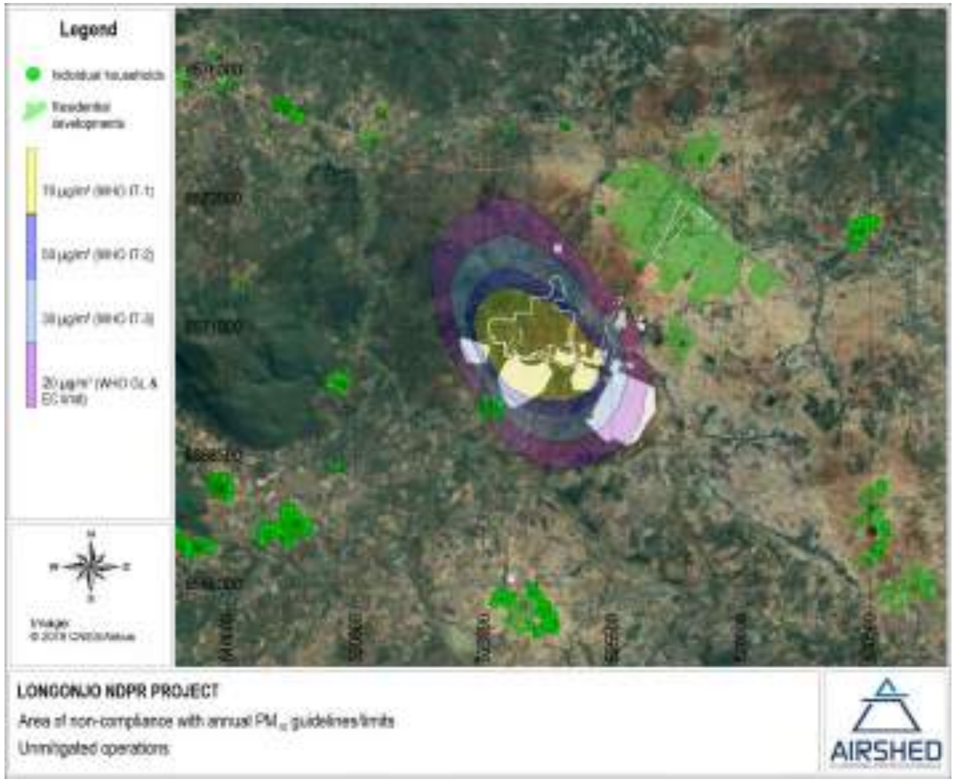


Figure 5-6: Area of non-compliance of annual PM_{10} evaluation criteria due to unmitigated project operations (Scenario 1)

Figure 5-7: Area of non-compliance of annual PM_{10} evaluation criteria due to unmitigated project operations (Scenario 2)

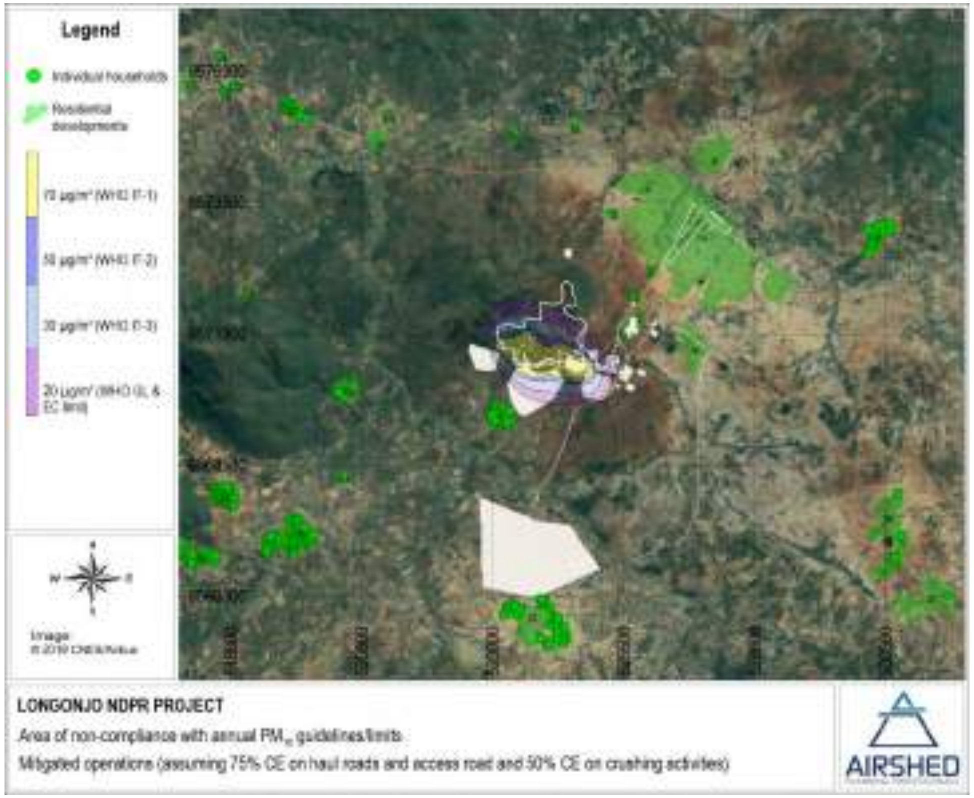


Figure 5-8: Area of non-compliance of annual PM_{10} evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 1)

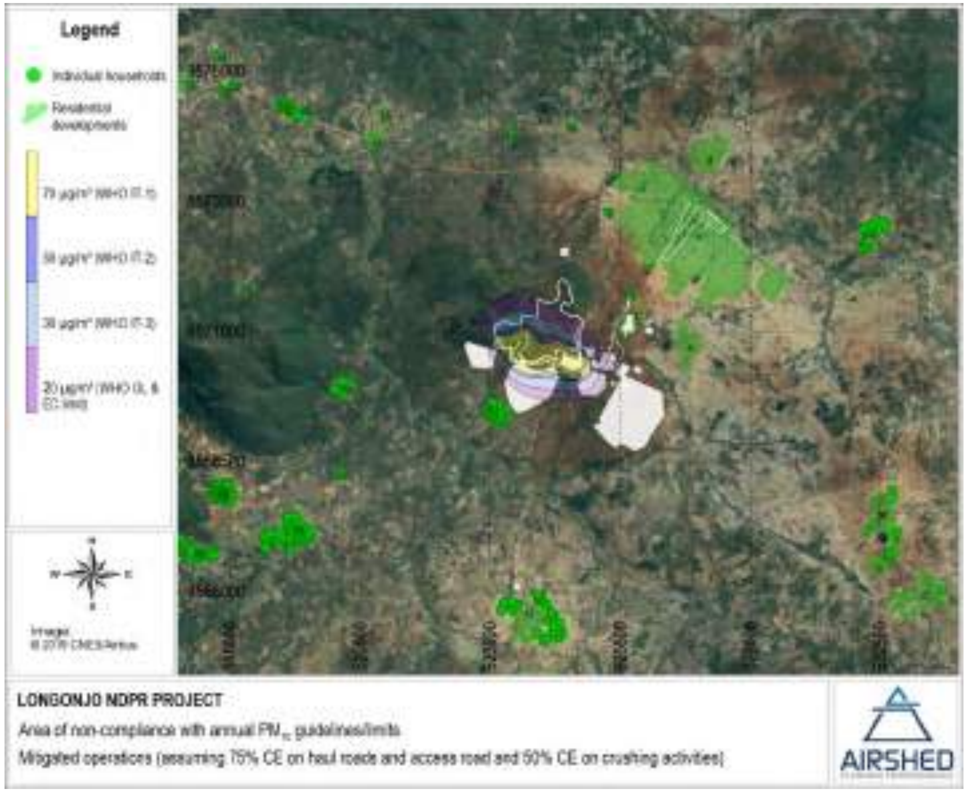


Figure 5-9: Area of non-compliance of annual PM_{10} evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 2)

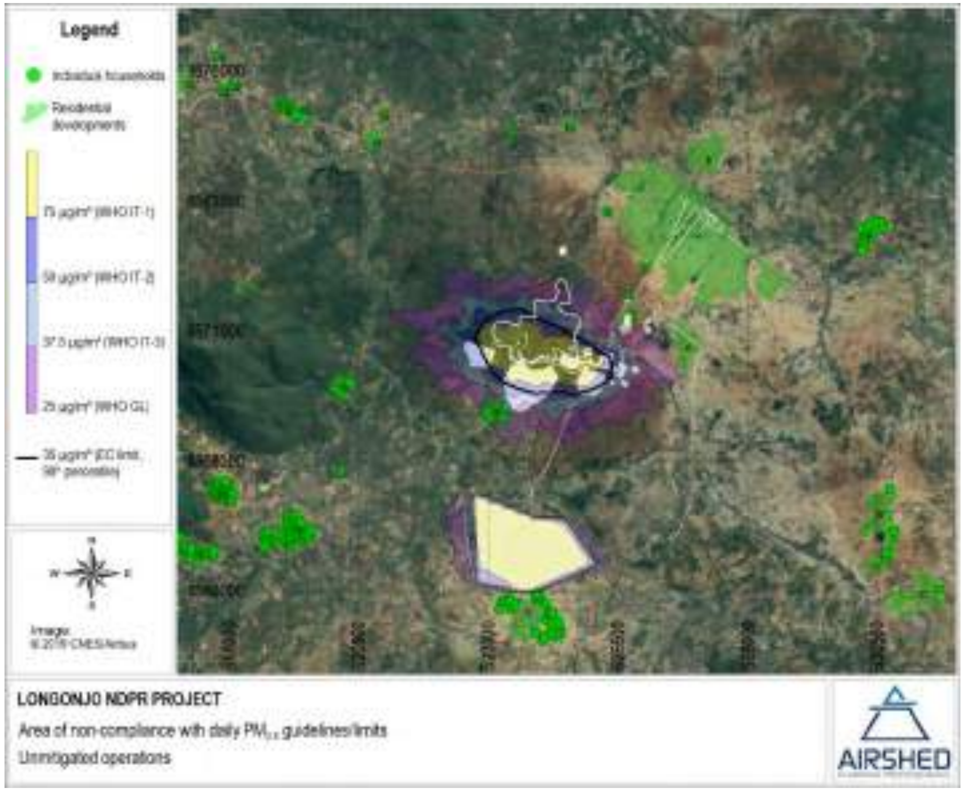


Figure 5-10: Area of exceedance of daily $PM_{2.5}$ evaluation criteria due to unmitigated project operations (Scenario 1)

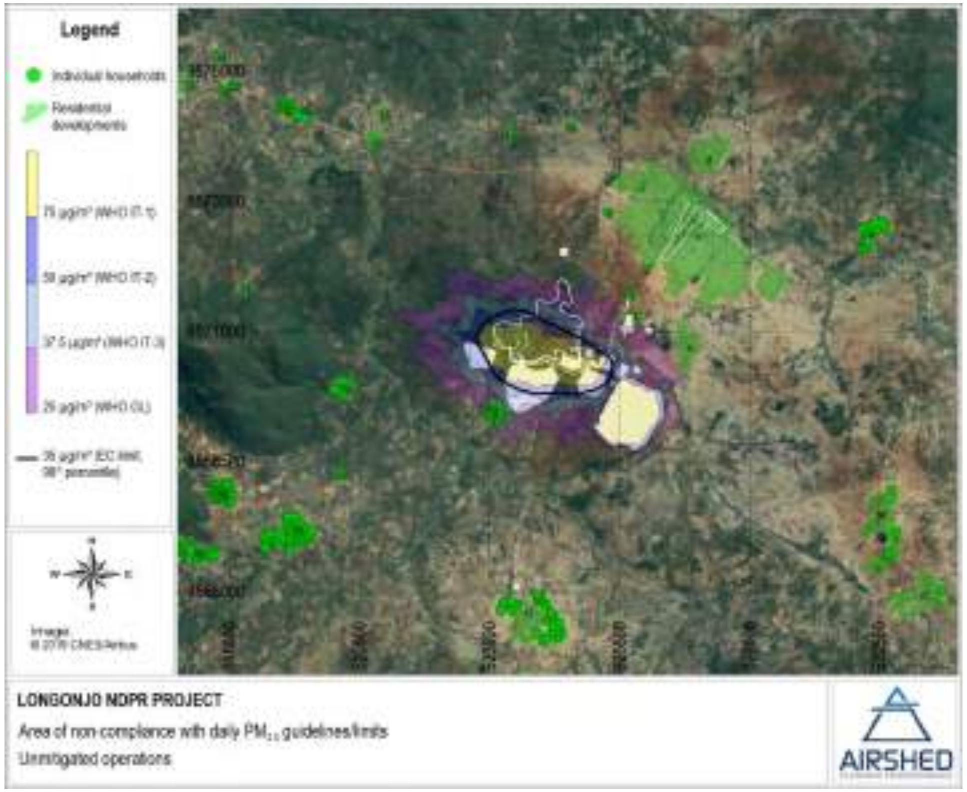


Figure 5-11: Area of exceedance of daily $PM_{2.5}$ evaluation criteria due to unmitigated project operations (Scenario 2)

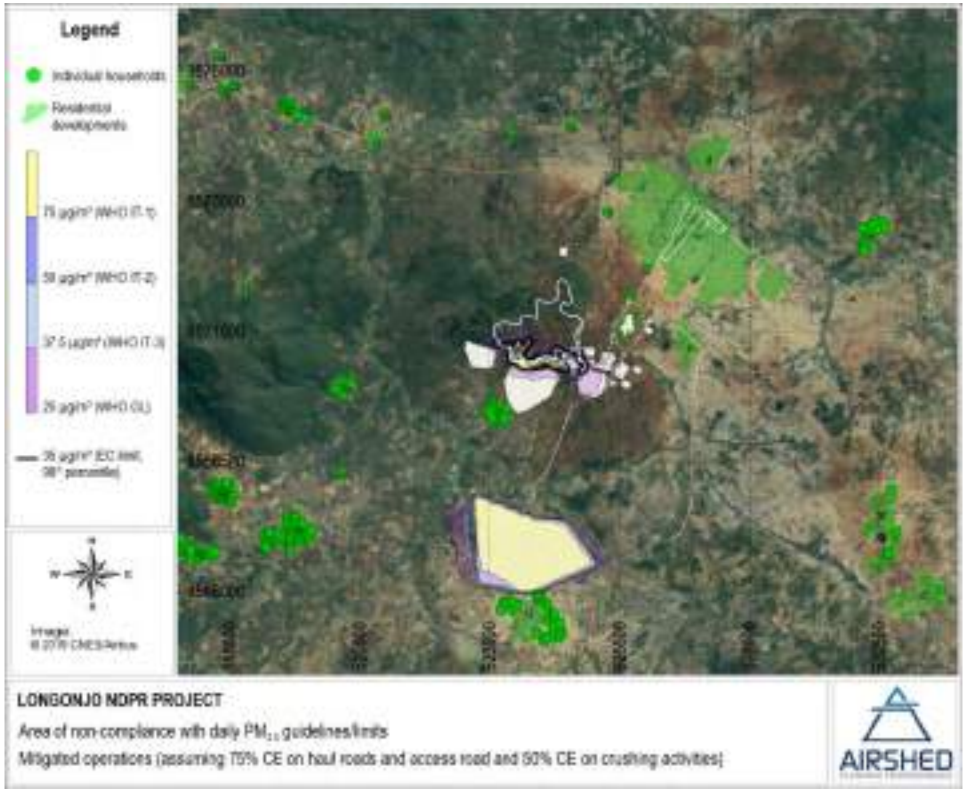


Figure 5-12: Area of exceedance of daily $PM_{2.5}$ evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 1)

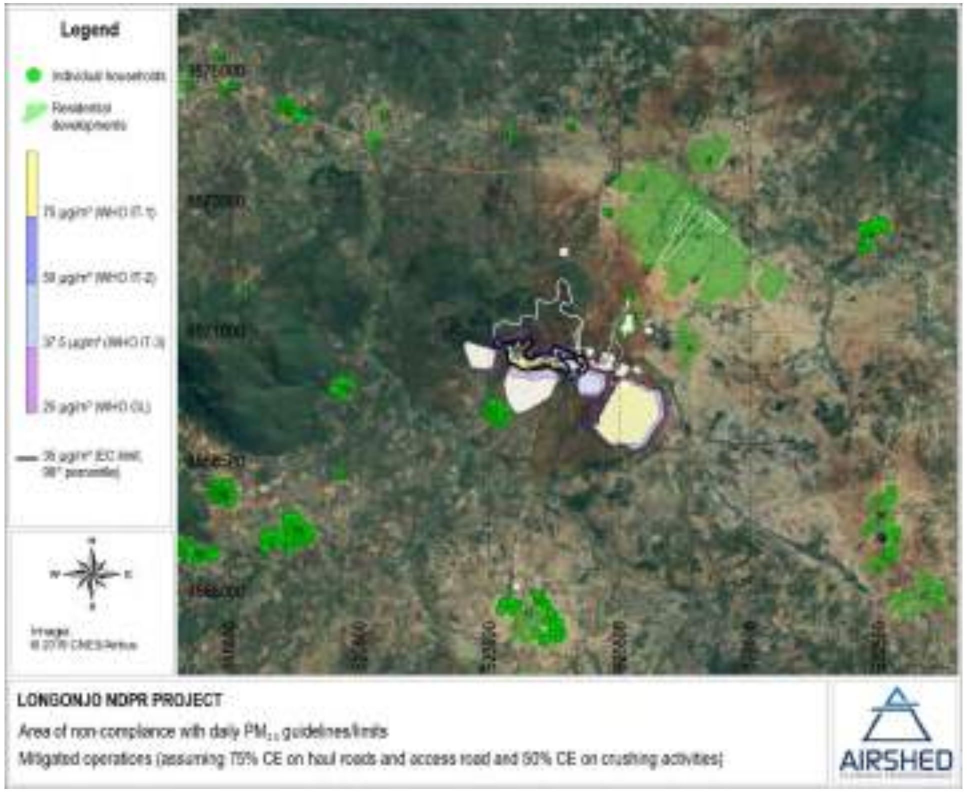


Figure 5-13: Area of exceedance of daily $PM_{2.5}$ evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 2)

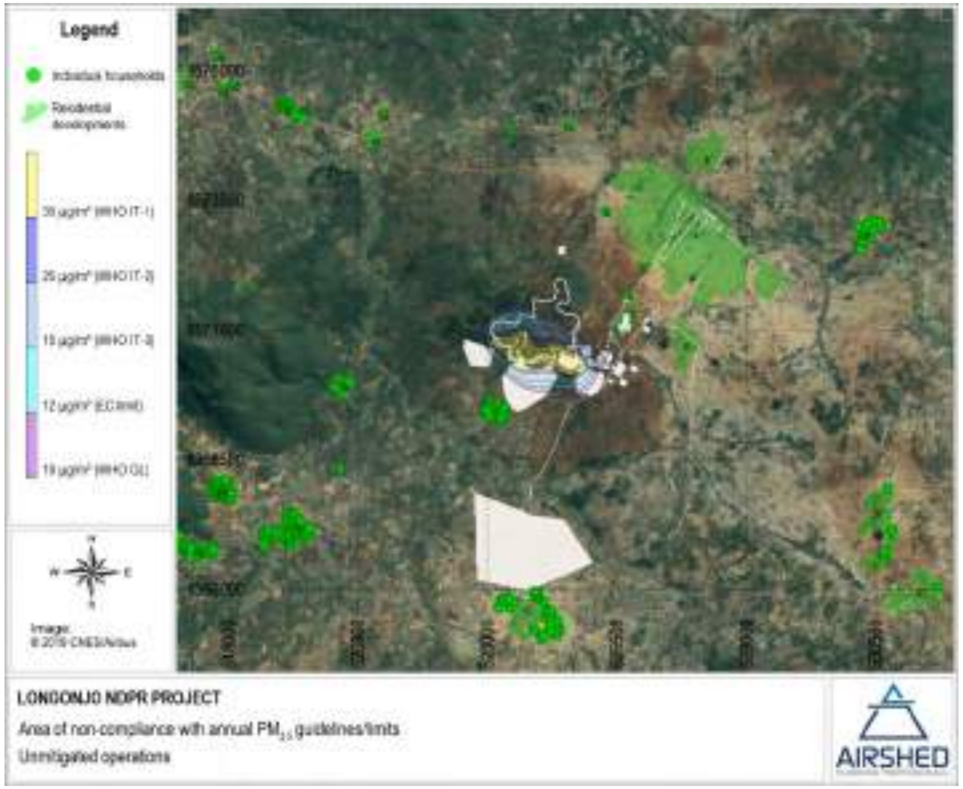


Figure 5-14: Area of exceedance of annual $PM_{2.5}$ evaluation criteria due to unmitigated project operations (Scenario 1)

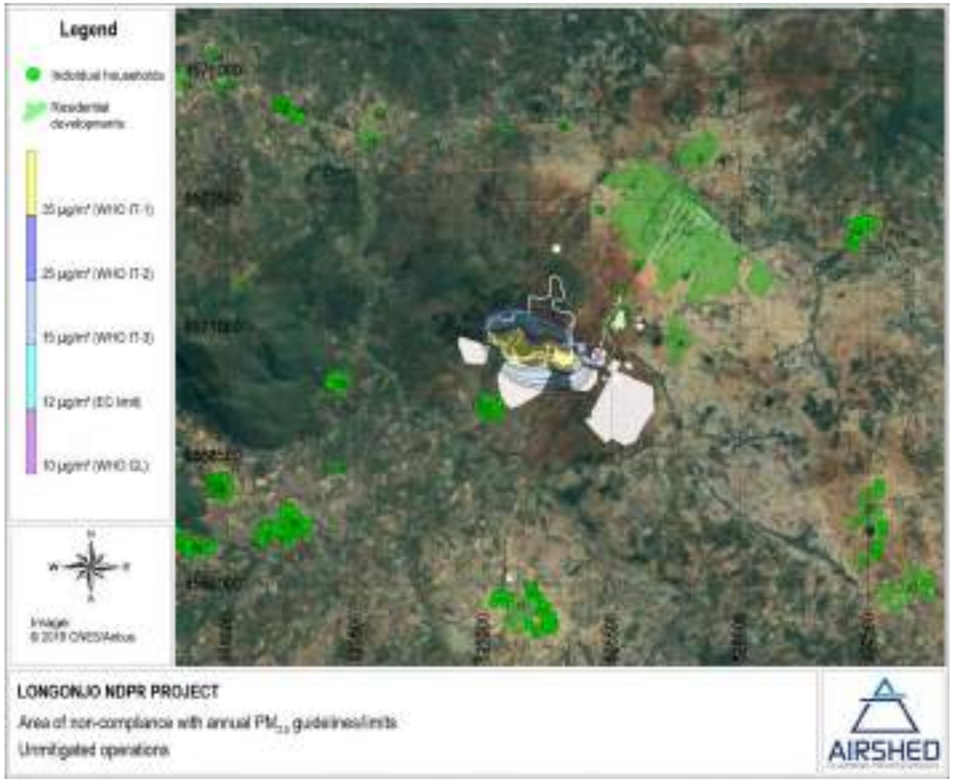


Figure 5-15: Area of exceedance of annual $PM_{2.5}$ evaluation criteria due to unmitigated project operations (Scenario 2)

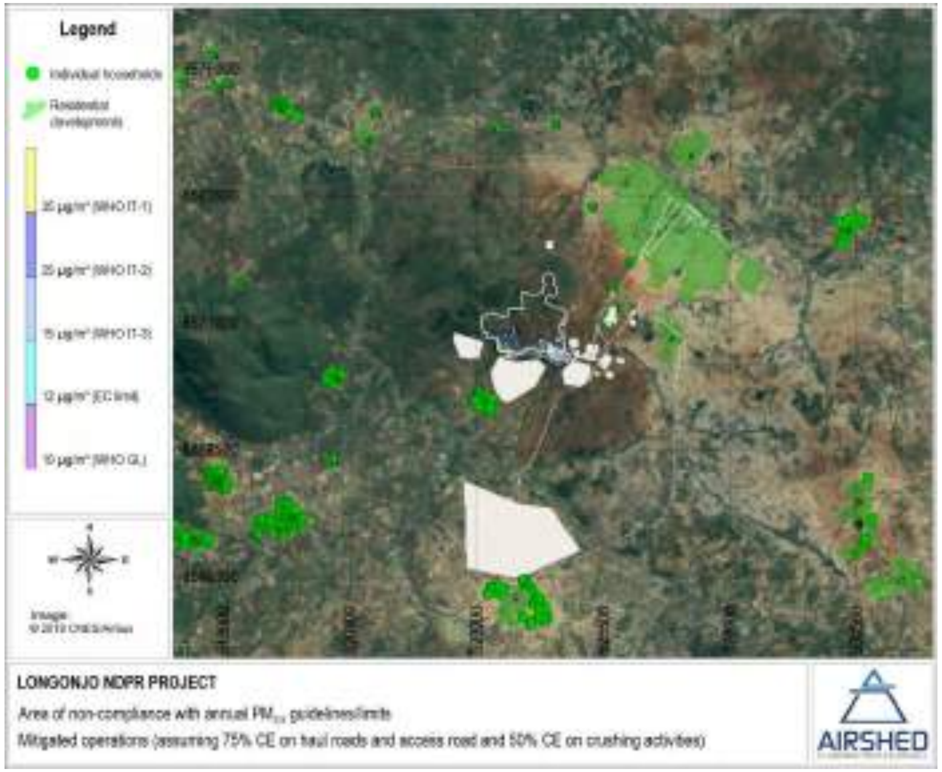


Figure 5-16: Area of exceedance of annual $PM_{2.5}$ evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 1)

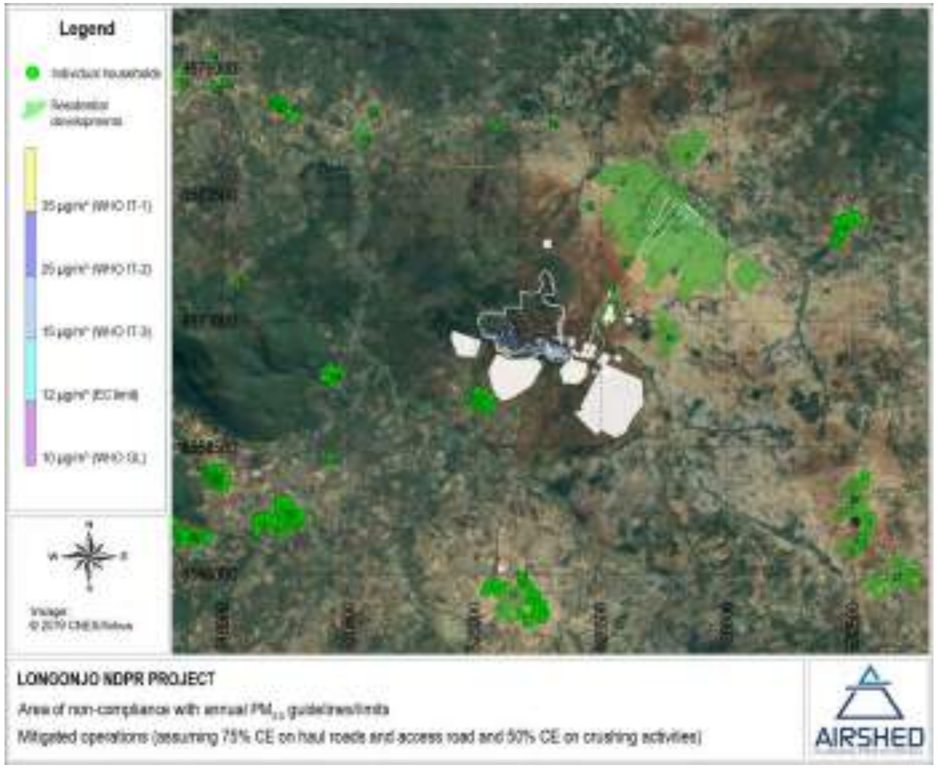


Figure 5-17: Area of exceedance of annual $PM_{2.5}$ evaluation criteria due to mitigated project operations (assuming 75% control efficiency on unpaved roads and 50% control efficiency on crushing activities) (Scenario 2)

The dispersion model results show that the impacts of $PM_{2.5}$ ground-level concentrations are lower than that of the PM_{10} impact area. The effective management of PM_{10} (including the ambient monitoring of this pollutant) should thus be efficient to achieve acceptable levels of $PM_{2.5}$ ground level concentrations. Compliance of PM_{10} and $PM_{2.5}$ ground-level concentrations due to Project operations with WHO, EC and US evaluation criteria at sensitive receptors in the area of influence is provided in the Air Quality Specialist Report (Appendix C).

The highest simulated PM_{10} concentrations due to unmitigated Project operations are in non-compliance with daily and annual evaluation criteria at sensitive receptors in the area of influence (Figure 5-2 and Figure 5-3). When activities are mitigated (assuming 50% control efficiency on crushing activities and 75% control efficiency on unpaved roads), the PM_{10} concentrations reduce notably in magnitude and spatial distribution with exceedances of daily WHO interim target (IT) 3, WHO guideline value (GV) and EC limit at the closest sensitive receptors surrounding the mine (i.e. R1 and R2 for WHO IT3 and EC limit and R1, R2, R3, R4 for WHO GV) (Figure 5-4 and Figure 5-5). The annual PM_{10} evaluation criteria are exceeded at sensitive receptors surrounding the mine for unmitigated Project operations (Figure 5-6 and Figure 5-7). When activities are mitigated (assuming 50% control efficiency on crushing activities and 75% control efficiency on unpaved roads), the annual PM_{10} concentrations are within all evaluation criteria at all sensitive receptors within the study area (Figure 5-8 and Figure 5-9).

For unmitigated operations, the simulated daily $PM_{2.5}$ ground-level concentrations are in non-compliance with the WHO GV at the closest sensitive receptors (i.e. R1 and R2) (Figure 5-10 and Figure 5-11).

Daily $PM_{2.5}$ ground-level concentrations are within all evaluation criteria at all sensitive receptors (Figure 5-12 and Figure 5-13). In addition, annual $PM_{2.5}$ concentrations due to Project operations are within evaluation criteria at all sensitive receptors in the area of influence (Figure 5-14 to Figure 5-17).

5.3.1.2.3.1 Mitigation Measures

The impact assessment concluded that impacts from the unpaved road surface and, to a lesser extent, crushing and screening activities were significant for the Operation phase.

The modelled impacts from materials handling activities and windblown dust from the storage piles did not exceed the relevant ambient criteria at sensitive receptors in the area of influence. Furthermore, although there will be incidences of high particulate concentrations during high wind speed episodes from these sources (duration from a few minutes to hours), the evaluation criteria for particulate matter are for daily and annual averages; thus, it is expected that the nett effect in terms of the guidelines will not be exceeded.

5.3.1.2.4 Dust Control Options for Unpaved Roads

Three types of measures may be taken to reduce emissions from unpaved roads: (a) measures aimed at reducing the extent of unpaved roads, e.g. paving, (b) traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and (c) measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilisation.

The main dust-generating factors on unpaved road surfaces include:

- Vehicle speeds;
- Number of wheels per vehicle;
- Traffic volumes;
- Particle size distribution of the aggregate;
- Compaction of the surface material;
- Surface moisture; and
- Climate.

According to research conducted by the Desert Research Institute at the University of Nevada, an increase in vehicle speed of 10 miles per hour increased PM_{10} emissions by 1.5 and 3 times. However, a similar study conducted by Flocchini et al. (1994) found a decrease in PM_{10} emissions of 42±35% with a speed reduction from

40 km/hr to 24 km/hr (Stevenson, 2004). Therefore, similar effects will be achieved by reducing the truck volumes on the roads.

Water sprays on unpaved roads is the most common means of suppressing fugitive dust due to vehicle movement at mines, but it is not necessarily the most efficient means (Thompson and Visser, 2000). Thompson and Visser (2000) developed a model to determine dust suppression cost and management implications on haul roads using water or other chemical palliatives. The study was undertaken at 10 mine sites in Southern Africa. The model was first developed by looking at the re-application frequency of water required for maintaining a specific degree of dust palliation. Then, the cost-effectiveness of water spray suppression could be determined and compared to other strategies. Factors accounted for in the model included climate, traffic, vehicle speed and the road aggregate material. Several chemical palliative products, including hygroscopic salts, lignosulfonates, petroleum resins, polymer emulsions and tar and bitumen products, were assessed to benchmark their performance and identify appropriate management strategies. Cost elements considered included amongst others capital equipment, operation and maintenance costs, material costs and activity-related costs. The main findings were that water-based spraying is the cheapest dust suppression option over the short term. Over the longer term, however, the polymer-emulsion option is marginally cheaper with added benefits such as improved road surfaces during wet weather, reduced erosion and dry skid resistance (Thompson and Visser, 2000).

An empirical model, developed by the US EPA (EPA, 1996), can be used to estimate the average control efficiency of certain quantities of water applied to a road. The model takes into account rainfall, evaporation rates and traffic.

Chemical suppressant has been proven to be effective due to the binding of fine particulates in the road surface increasing the surface material's density. In addition, dust control additives are beneficial because they also improve the compaction and stability of the road. The effectiveness of a dust palliative includes numerous factors such as the application rate, method of application, moisture content of the surface material during the application, palliative concentrations, mineralogy of aggregate and environmental conditions. Thus, for different climates and conditions, different chemicals are required, one chemical might not be as effective as another under the same conditions, and each product has various advantages and limitations of each own. In general, chemical suppressants achieve a PM_{10} control efficiency of 80% to 90% when applied regularly on road surfaces (Stevenson, 2004).

There is, however, no cure-all solution but rather a combination of solutions. A cost-effective chemical control programme may be developed by establishing the minimum control efficiency required on a particular roadway and evaluating the costs and benefits of various chemical stabilization practices. Appropriate chemicals and the most effective relationships between application intensities, reapplication frequencies, and dilution ratios may be considered in evaluating such practices.

Spillage and track-on from the surrounding unpaved areas may result in the deposition of materials onto the chemically treated or watered road resulting in the need for periodic "housekeeping" activities (Cowherd et al., 1988; EPA, 1996). In addition, the gradual abrasion of the chemically treated surface by traffic will result in loose material on the surface, which would have to be controlled. The minimum frequency for the reapplication of watering or chemical stabilizers thus depends not only on the control efficiency of the suppressant but also on the degree of spillage and track-on from adjacent areas and the rate at which the treated surface is abraded. The best way to avoid dust-generating problems from unpaved roads is to properly maintain the surface by grading and shaping cross-sectional crowning to prevent dust generation caused by excessive road surface wear (Stevenson, 2004).

One of the main benefits of chemical stabilisation in conjunction with wet suppression is the management of water resources (MFE, 2001).

5.3.1.2.5 Crushing and Screening

The enclosure of crushing and screening operations is very effective in reducing dust. The Australian NPI indicates that a telescopic chute with water sprays would ensure 75% control efficiency, and enclosure of storage piles where tipping occurs would reduce the emissions by 99%. According to the Australian NPI, water sprays can have up to 50% control efficiency and hoods with scrubbers up to 75%. If, in addition, the scrubbers and screens were to be enclosed, up to 100% control efficiency can be achieved. Hooding with fabric filters can result in control efficiencies of 83%. This control equipment must be maintained and inspected regularly to make sure that the expected control efficiencies are met.

If the ROM material maintains a high moisture content (i.e. 10%), this should be sufficient to control the emissions from this source.

5.3.1.3 Decommissioning and Closure Phase

It is assumed that all the operations will have ceased by the closure phase of the Project. The potential for impacts during this phase will depend on the extent of rehabilitation efforts during closure. Aspects and activities associated with the decommissioning phase of the proposed operations are listed in Table 5-8. The same mitigation measures for the construction phase can be implemented for the decommissioning phase.

Table 5-8: Activities and aspects identified for the decommissioning phase

Impact	Source	Activity
Generation of $PM_{2.5}$ and PM_{10}	Open surfaces	Dust generated during rehabilitation activities
Generation of $PM_{2.5}$ and PM_{10}	Offices and buildings	Demolition of the structure
Gas emissions	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase

5.3.1.3.1Mitigation Measures

Dust control measures for open areas can include of wet suppression, chemical suppressants, vegetation and wind breaks. Wet suppressants and chemical suppressants are generally applied for temporary storage pile durations. However, vegetation frequently represents the most cost-effective and efficient control for long-term control measures.,

5.3.1.4 Greenhouse Gas Emissions (GHG)

The mining sector is viewed internationally as a direct and indirect contributor to GHG emissions through various activities, e.g. land clearing, the use of fossil fuels during construction and operation, processing / beneficiation, and the subsequent supply chain. Direct and indirect emissions for economic sectors can be categorised into three broad 'scopes'. Scope 1 being all direct GHG emissions; Scope 2 being indirect GHG emissions (e.g. consumption of purchased electricity); and Scope 3 being other indirect emissions (e.g. extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, outsourced activities, and activities not covered in Scope 2). The various scopes of GHG reporting are conceptually illustrated in Figure 5-18.

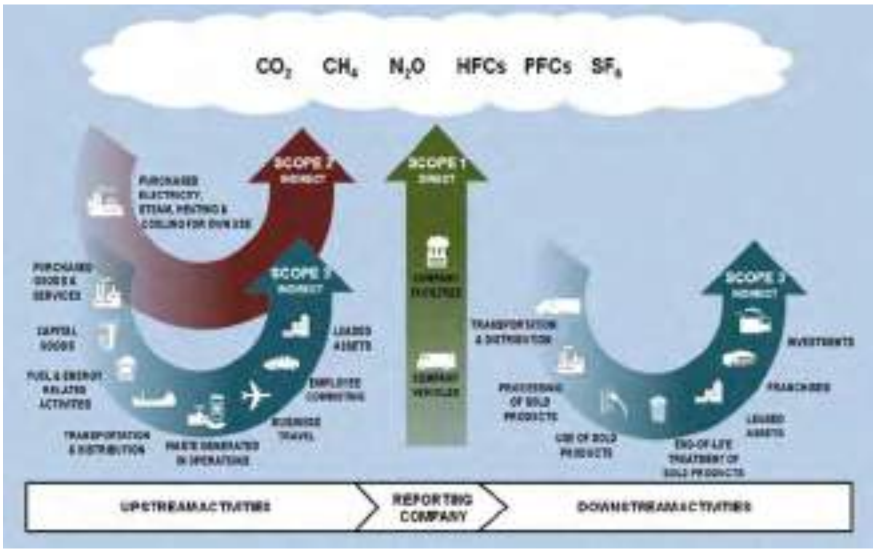


Figure 5-18: GHG scopes[46]

Construction

Land-use change from the current undeveloped state to a commercial agriculture facility results in GHG emissions from construction equipment / vehicles / electricity generation through generators (combustion of hydrocarbon fuel) and land-use change (carbon in waste biomass during vegetation clearing).

Operation

During the Project's operational phase, the bulk of emissions are expected from diffuse sources through operational mining vehicles and equipment.

Quantification

Methods for determining greenhouse gas (GHG) emissions are provided by the IPCC[47]. The following methods are given:

- Tier 1: A bare minimum method using readily available statistical data on the intensity of processes (activity data) and default emission factors. This method is the simplest and has the highest level of uncertainty;
- Tier 2: Similar to Tier 1 but uses technology or country-specific emission factors. Tier 2 methods reduce the level of uncertainty;
- Tier 3: Defined as any methodology more detailed than Tier 2 and might include process models and direct measurements. Tier 3 methods have the lowest level of uncertainty.

Category 1A2i is provided for mining and quarrying and applies to the project activities. Annual diesel usage was provided for the project. For diesel emissions, only tier 1 emission factors are available. As the diesel usage ratio between stationary and mobile equipment was not provided, emissions were calculated assuming a 50% contribution for each respectively. A summary of all GHG emissions from the Project operations is given in Table 5-10.

A summary of CO_2eq GHG emissions is given in Table 5-9. CO_2eq is a term for describing different GHG in a standard unit. For any quantity and type of GHG, CO_2eq signifies the amount of CO_2 which would have the equivalent global warming impact. A quantity of GHG can be expressed as CO_2eq by multiplying the amount of

[46] IPCC Guidelines
[47] https://www.ipcc.ch/2019/05/13/ipcc-2019-refinement/

the GHG by its global warming potential (GWP). E.g. if 1kg of CH_4 is emitted, this can be expressed as 21kg of CO_2eq and 1kg of N_2O can be expressed as 310 kg of CO_2eq[48].

The predicted CO_2eq emissions from the project would be about 0.0423446 million metric tons per year. This should be seen in the perspective of the annual Angolan and global emission rate of GHG, which is approximately 99.992 million metric tons[49] and 48 928 million metric tonnes[50], respectively expressed as carbon dioxide equivalent. Therefore, the project's CO2 emissions contribute approximately 0.042% of Angola's GHG emissions and 0.00009% of the global GHG emissions.

Table 5-9: Greenhouse Gas emissions for the Project

IPPC Code	Subcategory (disaggregated by fuel/ product type/ production process)	Activity data			Emissions (tonnes/year)								
		Name of activity data	Value of activity data	Units of activity data	GHG-CO_2			GHG-CH_4			GHG-N_2O		
					Value	Tier	Ref	Value	Tier	Ref	Value	Tier	Ref
1A2i	Diesel	Mining	3 000 000	litres/year	8 077.27	1	IPPC	0.3270	1	IPPC	0.0654	1	IPPC
1A2i	Diesel	Acid bake kiln	10 006 650	litres/year	26 942.14	1	IPPC	1.0908	1	IPPC	0.2182	1	IPPC
1A2i	Diesel	Infrastructure	100 000	litres/year	269.24	1	IPPC	0.0109	1	IPPC	0.0022	1	IPPC
1A2i	Diesel	Mobile equipment	2 858 215	litres/year	6 818.59	1	IPPC	0.3589	1	IPPC	0.3589	1	IPPC

Table 5-10: Equivalent CO_2 emissions for the Project

Energy Consumption	CO_2 equivalent emissions (tpa)			TOTAL
	CO_2	CH_4	N_2O	
Diesel	42 107.25	37.54	199.83	42,344.61
Total				**42,344.61**

5.3.1.4.1 Mitigation

The following practical mitigation measures can be applied to reduce the total GHG footprint:

- During planning, PENSANA shall make sure that the mine layout is optimised in such a manner as to avoid conversion of high-carbon stock areas, e.g. wetlands and woodlands;
- Rehabilitate disturbed areas to increase carbon stocks;
- Manage buffer zones to have healthy vegetation (to reflect pre-development vegetation), which will increase carbon stocks and also promote suitable habitat for fauna;
- Reduce hydrocarbon usage as an energy source. Explore opportunities to implement energy-efficient systems and consider the implementation of renewable energy where relevant (e.g. solar power);
- Open burning of waste biomass during site clearance and operational phases will be restricted to situations where there is no feasible alternative (e.g. weeds are sometimes placed in heaps and burned to prevent further spread);
- Implementing good soil conservation management practices to avoid erosion (see section 5.3.5); and
- Re-use waste plant material (waste carbon) to improve nutrition content ("natural fertiliser) of soils.

[48] Reference obtained from the Nationally Determined Contribution (INDC) of the Republic of Angola (May 2021) - https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Angola%20First/NDC%20Angola.pdf

[49] Based on the GHG emissions inventory data for Angola concluded in November 2020 obtained from the Nationally Determined Contribution (INDC) of the Republic of Angola (May 2021) - https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Angola%20First/NDC%20Angola.pdf

[50] Based on the 2018 Global GHG emissions - World Resources Institute Climate Analysis Indicators Tool (WRI CAIT) (https://www.climatewatchdata.org) accessed on 2 September 2021. Emissions including Land-Use Change and Forestry.

5.3.1.5 Impact assessment

The Air Quality impact assessment table is presented in Table 5-11.

Table 5-11: Air quality and GHG impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Dust generation through: • Transport and general construction activities • Clearing of groundcover and levelling of area • Materials handling • Wind erosion from open areas	C	N	S	D	LSA	H	H	R	Moderate	See Section 5.3.1.1.2.1	Low
Materials handling and wind erosion	O	N	L	D	LSA	H	H	R	Moderate	See Section 5.3.1.2.3.1	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence Direction N = Negative; P = Positive	Incidence Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity Frequency Low – L; Medium – M; High – H	Severity Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Production of dust and fugitive vehicle emissions from vehicles activity and equipment on paved and unpaved roads and open pit	O	N	L	D	RSA	H	M	R	High	See Section 5.3.1.2.3.1	Moderate
Production of dust and fugitive emissions during decommissioning of structures, movement of vehicles and fugitive emissions from vehicles and equipment	C	N	S	D	LSA	H	M	R	Moderate	See Section 5.3.1.2.3.1	Low
GHG emissions	COD	N	M	D	RSA	M	L	I	Moderate	See Section 5.3.1.4.1	Low

5.3.2 Hydrogeology

Reference

Specialist study 2 – Appendix D

Key specialists

Ross Sephton - HCV Africa, South Africa

Study objectives

The objectives of the hydrogeology specialist study were as follows:

- A detailed literature review of all information relevant to the Project area and relating to subsurface water in this region or within similar ore bodies;
- Conduct a hydrocensus to characterise the groundwater baseline conditions;
- Data capture and interpretation of laboratory analyses of groundwater samples;
- Development of a Hydrogeological Conceptual Site Model;
- Develop a groundwater monitoring programme;
- Provide a qualitative groundwater impact assessment for the project; and
- Recommend mitigation measures as required.

Impacts to the geology and hydrogeology are similar in all Project phases, e.g. contamination by hydrocarbons can occur whenever vehicles are used. For this reason, the impacts discussed apply to all phases unless noted otherwise.

5.3.2.1 Open Pit Excavation Intersecting Shallow Aquifer

During the initial development of the open pit, no groundwater will be encountered as the excavation will be limited to the soft high-grade shallow ore mainly located above the water table. Therefore, the groundwater elevations in the initial open pit limits are between 15 and 25 meters below ground level (mbgl), and these depths will only be attained during the later stages of the open pit development. This will allow time to gather additional groundwater information and develop a complete 3D Numerical Groundwater Model which will assist in predicting any groundwater inflows and help develop a dewatering strategy to be implemented in advance of mining below the water table.

5.3.2.2 Abstraction of Groundwater Impacting the Shallow Aquifer

As most of the initial mining will occur above the water table or aquifer system, the initial impact on these systems should be negligible from a groundwater flow volume perspective. Only once active dewatering starts (which will only be towards the latter phases of the Project) may this aspect become a concern. This can be addressed by adequate water management and modelling practices.

Initially, the most significant impact is likely to be water quality-related due to spillages (e.g. hydrocarbons, solvents, chemicals) in the Pit. These may ultimately contaminate the underlying groundwater and impact the local aquifer systems over time. A spill response plan shall be in place to mitigate this impact. Adequate maintenance of plant equipment and vehicles is required. Routine monitoring of the groundwater and local water resources should provide early detection of any water-related contamination and potentially the remediation or response to that.

5.3.2.3 Accidental Spills During Storage and Transport

The requirement to use, store and transport potential contaminants is unavoidable for the entire operational life of the Project. The storage of hydrocarbons is regulated by law, and the proposed Project's design will make sure that best practice is observed and applied, especially adequate bunding. Similarly, the transport of hazardous products is strictly regulated, and these regulations will apply. However, over the operational timeline of the Mine, the probability of incidents taking place is considered very high, and the magnitude could be high.

Therefore, further actions include equipment audits and inspections programs and the application of Standard Operating Procedures (SOPs).

Mitigation measures can range from design (make sure that storage and transport are located away from potential receptors and easy intervention assured), periodic maintenance and regular checks of the integrity of the structures.

5.3.2.4 Inadequate Drainage Management

Design and application of drainage management based on the “clean-and-dirty-water-separation” principle make sure that contamination of groundwater and other receptors is avoided. The drainage management system requires permanent maintenance to make sure that it can handle the required volumes of water. A potential impact is associated with the failure of the drainage system to function to its capacity, which will result in the release of dirty or contaminated water to the receiving environment - in this case, seep into the ground and eventually contaminate shallow aquifers.

5.3.2.5 Leachate Seepage Infiltration from Waste Material Dump

The waste rock generated and discarded at the waste material/rock dump is not hazardous. However, leachate generation is expected, despite calcium carbonates' potential chemical buffering. The magnitude of the impact is moderate before and after mitigation. The mitigation is not straightforward due to the permeable nature of the deposits underlying the site and the high rainfall volumes recorded. Rock waste is oxidised material with no sulphide minerals that could otherwise form acidic conditions. Additionally, carbonate is a naturally neutralising material.

The waste rock dump footprint can be capped with clay and topsoil obtained during the site excavations thereby causing as little water ingress into the dump and reducing the leachate volumes. A sound drainage system surrounding the dump will also assist in controlling dirty water movement.

5.3.2.6 Seepage from TSF

Depending on the selected location (section 2.29.5) and lining of the proposed Tailings Storage Facility (TSF) and related infrastructure and the operation and maintenance thereof, seepage from the TSF may have various impacts on the underlying groundwater environment. The first is direct ingress, or water loading from the TSF should the underlying lining leak or not be adequately designed.

Tailings should not contain significant sulphide due to the nature of the orebody, and as a result, water emanating from the TSF is unlikely to be acidic (low risk of acid mine drainage (AMD)). In addition, the carbonates contained in the tailings will also provide a buffering capacity against acid formation. As a result, the impact of any seepage leaking from the TSF is likely to be more saline and basic. From a water quality perspective, the only time the content of the tailings leachate will be confirmed once the appropriate leach testing has been conducted on the final tailings material.

In the interim, the routine water quality monitoring of the groundwater around the proposed TSF footprint is considered essential to establish the baseline groundwater quality trends before deposition commences and how these may change over time. To this effect, recently. 13 deep and shallow piezometers have been installed around the footprint of both proposed TSF sites (TSF 5 and TSF South (TSF9/10)). These have been sampled and the samples sent to the laboratory for detailed analysis to establish the baseline groundwater quality before any tailings deposition begins.

5.3.2.7 Tailings spillage and leaks

Spillages or leaks of tailings material and spillage of the tailings liquor during high rainfall events may impact water resources due to inadequate design, construction and/or operation of the TSF and related infrastructure.

It remains highly likely that there may be spillages from ruptured tailings pipes or pipe fittings, especially if the tailings slurry is to be pumped over long distances. This risk is likely to be much higher should TSF 9/10 be selected for deposition as the tailings would have to be pumped several kilometres and through a river valley. Any ruptures or failures in the pipeline are likely to occur at the lowest point and impact on the river and local watercourses more than the immediate groundwater environment.

All TSF pipelines must be carefully maintained and monitored undertaken to avoid spillages. It is recommended that the mine implement a spill clean-up strategy and SOP to react as quickly and efficiently as possible to any spillage of tailings material.

5.3.2.8 Seepage into the shallow aquifer

The latest groundwater survey indicates that the aquifer system where both proposed TSF sites are located, is shallow and contains very good groundwater quality. This system is located within the shallow, highly weathered saprolitic and granitic layers above the nearly impervious solid crystalline granite. The depth of this system varies from surface level to about 7.5m deep, and springs or seepage zones are typically found where the hardrock granite is close to the surface. This results in the weathered aquifer systems seeping water from the weathered and hardrock contact zone.

The local communities use this shallow aquifer system extensively through a system of hand-dug canals used to irrigate their vegetable crops, especially in the dry season. Therefore, any adverse impact a TSF may have on the shallow aquifer system and the groundwater stored therein will directly negatively impact the local community and possibly the growth of their produce.

Regular monitoring of the tailings dam piezometers is mandatory, including monitoring of important community spring located below the TSF 9/10 site, to indicate any possible changes in water quality. An additional measure that should be considered would be the installation of a shallow interception trench below the final TSF wall to intercept any poor-quality seepages. However, should this be considered, an alternative supply of irrigation water may need to be provided to the local communities.

5.3.2.9 Closure and Rehabilitation - Waste Rock Dumps and Proposed Landfill Site

Closure and rehabilitation of the proposed landfill site can only take place based on an approved *Closure and Rehabilitation Plan*. The plan will follow relevant regulatory environmental requirements, including a specific monitoring plan to document the environmental responses over an extended period after the rehabilitation has been completed. Rehabilitation of all waste rock/material dumps typically occurs by sealing or capping with topsoil and revegetation, post-closure according to the *Closure and Rehabilitation Plan.* A long-term ground- and surface water quality monitoring plan should also be implemented to assess any contamination migrating off the site.

5.3.2.10 Closure and Rehabilitation - Pit and All Mining Operations

Once mining is complete, the pit will be decommissioned, closed and rehabilitated according to the *Closure and Rehabilitation Plan.* As a result, there is likely to be both decant and seepage of potentially contaminated water from operational areas, which will need to be monitored. Modelling various closure scenarios can assist in understanding the anticipated decant / seepage flows and further manage the resulting impacts.

5.3.2.11 Impact assessment

The impact assessment table for hydrogeology is shown in Table 5-12.

Table 5-12: Hydrogeology impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N – Negative; P – Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Seepage from the Tailings Dam into the underlying groundwater resource	O, D	N	L	H	RSA	M	M	I	Medium	• Install adequate engineered lining under TSF • Manage tailings deposition well • Groundwater monitoring plan around TSF • Install a shallow interception trench down-gradient of the TSF	Low
Tailings spillages or leaks from TSF or related infrastructure	O, D	N	S	H	RSA	L	M	R	High	• Maintain adequate freeboard especially during the wet season • Monitor and maintain all TSF infrastructure • Audit TSF infrastructure on regular basis • Have a TSF spillage management plan in place	Med

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Open pit intercepting shallow groundwater	O	N	M	H	LSA	M	M	R	Medium	• 3D modelling of open pit groundwater regime to understand volumes and chemistry; • Monitor inflows, outflows and groundwater; and • Remediate contamination sources and treat water if necessary.	Low
Abstraction of groundwater	CO	N	L	H	LSA	H	M	R	High	• Model water inflows in order to understand volumes and chemistry; • Monitor inflows, outflows and groundwater; and • Remediate contamination sources and treat water if necessary.	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Accidental spill of materials stored on-site, fuel, oil products	ECOD	N	S	M	LSA	L	M	R	Medium	• Storage and Handling Plan • Spill kits available • Training of personnel • Bunded storage of hydrocarbons and spill kits available • Regular environmental auditing • Waste management plan	Low
Inadequate drainage management system and failure to maintain traps and separators	OD	N	L	M	RSA	M	M	R	Medium	• Implement stormwater management plan • Clean dirty water separation • Ground- and surface water monitoring programme	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Leachate, seepage infiltration from waste dump, PCD and TSF.	OD	N	L	H	RSA	M	M	I	High	• Conduct proper testing on materials prior to mining • Plan and manage all waste dumps according to management recommendations • Drill adequate monitoring borehole and implement a routine monitoring programme • Monitor any contamination plume and remediate if necessary • Use the readily available low permeability materials in the construction design	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Closure and rehabilitation of Longonjo Project landfill, waste rock dumps and infrastructure	D	N	ML	H	RSA	M	LM	R	Medium	• Implement proper closure and rehab plan • Monitor and measure	Low
Closure of Pit and mining areas and decant of poor quality water from this infrastructure	D	N	L	MH	RSA	M	M	R	Medium	• Implement proper closure and rehab plan • Monitor and measure • Model and prepare for decant	Low
Generation of sanitary wastewater discharges	ECOD	N	L	H	LSA	M	M	R	Medium	• Management of this type of waste can be easily achieved. • Reducing the volume of sanitary waste generated on-site • Build permanent and adequate sanitary facilities	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Accidents/spillage during storage and transport of potential contaminants	COD	N	S	M	LSA	L	M	R	Medium	• Transport, Storage and Handling Plan • Emergency response • Auditing and legal compliance • Training of personnel	Low
Release of contaminated water into local drainage systems and groundwater environment	OD	N	ML	L	RSA	M	M	R	High	• Impound and manage all dirty water • Routine monitoring of surrounding water bodies • Employ adequately trained environmental staff	Low
Closure and rehabilitation of Longonjo Project landfill, waste rock dumps and infrastructure	D	N	ML	H	RSA	M	LM	R	Medium	• Implement proper closure and rehab plan • Monitor and measure	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – L&A; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Closure of Pit and mining areas and decant of poor quality water from this infrastructure	D	N	L	MH	RSA	M	M	R	Medium	• Implement proper closure and rehab plan • Monitor and measure • Model and prepare for decant	Low

5.3.3 Hydrology

Reference

Specialist study 3 – Appendix E

Key specialists

Flip Krugel - GFK via HCV Africa, South Africa

Study objectives

The objectives of the hydrology specialist study were as follows:

- To identify catchment areas and affected streams/watercourses;
- To characterise the hydrological regime, including wet and dry seasons;
- Review layout plans and drawings of preliminary designs;
- Review clean and dirty water systems and make recommendations on findings;
- Review all aspects relating to water sourcing, water discharge, water re-use;
- Review downstream users and the cumulative water quality implications of the Project downstream;
- Compare hydrology aspects to the relevant legislative standards, requirements and guidelines; and
- Conduct impact assessment and formulate mitigation measures.

It should be noted that the philosophy of the mine design is to establish a zero-discharge mine whereby no contaminated / process / decant (from TSF) water / effluent, will be released. Instead, all water captured would be recycled. As an example, decant water from the TSF collected in the Pollution Control Dam(s) (PCD) will be pumped back to the processing plant as the elevated pH (~pH 9) would be ideal for re-using in the process as it would reduce the use of chemicals to increase the pH to optimal levels as per the processing plant requirements.

5.3.3.1 Change of Surface Water Regime

It is expected that once construction commences, the current surface stormwater runoff, Mean Annual Runoff (MAR), soil loss potential and water quality would change. This is because of the fact that clean and dirty water areas will be separated from the onset through channels and berms. Dirty water areas will be contained by berms for stormwater to collect in return water dams / PCD. The embankment for the proposed TSF containment facility will be constructed towards the end of the construction phase and into the early operational phase (the TSF is a progressive structure developed as the mine develops).

5.3.3.2 Stormwater Runoff and Mean Annual Runoff - Construction and Operation

Land cover on the Project footprint will change from natural vegetation and cultivated land to mining activities (open cast pits, TSF, waste rock and overburden stockpiles, areas rehabilitated under various grass cover conditions, Run Of Mine (ROM) and stockpile pads, roads and hard parks) It is expected that the stormwater runoff from the Project area and the Mean Annual Runoff (MAR) will decrease for most catchments during mining operations. This is due to the infiltration of rainwater that will increase at rehabilitated areas (post construction) and a significant volume captured by the open pit, pollution control dams and the TSF. Although stormwater at the processing plant and hard park areas will increase, this runoff will most likely be contained as it may be polluted, or the water may be required for operations.

5.3.3.3 Surface Runoff Near End of Life of Mine

Surface runoff should be affected most towards the end of life of the mine as the largest area would be disturbed at that stage. The figures below represent the end of life of mine-affected areas. Additional to the existing land cover where the catchment will not be disturbed, the mining areas will deteriorate to poor grass (areas under rehabilitation), fallow (areas cleared for mining and areas not yet rehabilitated), impervious areas (buildings) and impervious dirty areas (stockpile, TSF and plant areas). Conversely, the total catchment area for runoff purposes will decrease due to the open pits, TSF and pollution control dams / return water dams.

Table 5-13 : Catchment areas and CN numbers towards end of life of mine

CATCHMENT NO	WOODS FAIR (ha)	WOOD - GRASS FAIR (ha)	GRASS FAIR (ha)	FARMLANDS GOOD (ha)	RESIDENTIAL ROADS,ETC. (ha)	GRASS POOR (ha)	FALLOW (ha)	IMPERVIOUS (ha)	IMPERVIOUS DIRTY YARDS (ha)	TOTAL AREA (ha)	MAR (Mm^3)
CN VALUE WET	78	81	84	89	94	92	95	98	95		
SOIL CLASS ESTIMATE	B	B	C	B	C	B	B	D	D		
1	10	30	28	135	3	45	20			271	1.0
2	8	16	38	40	5	20	10			137	0.5
3	5	6	5	50	0	16				82	0.3
4	73	16	2	25	1	3	1			121	0.5
5	15	15	16	138	2	2	2			190	0.7
6	0	1	0	0	0	1	1			3	0.0
7	1	3	10	10	98					122	0.5
TOTAL AREA (1-5)	111	83	89	388	11	86	33	0	0	801	3.0
TOTAL AREA (6+7)	1	4	10	10	98	1	1	0	0	125	0.5

Note that the total catchment area is less due to open pit areas and areas contained by berms for stormwater to collect in dams and due to tailing facilities.

Table 5-14 : Wet season runoff towards end of life of mine

NO	CATCH MENT AREA (km^2)	STREAM LENGTH (km)	SLOPE STREAM (%)	OVERLAND FLOW LENGTH (km)	OVERLAND SLOPE (%)	OVERLAND ROUGHNESS n	TC	AVE CN	PEAK DISCHARGE FOR RETURN PERIODS AS INDICATED (m^3/s)				
									5	10	20	50	100
1	2.7	3.2	8.5%	0.1	10.0%	0.3	**0.62**	88	44	55	70	82	94
2	1.4	2.3	8.0%	0.1	5.0%	0.3	**0.57**	87	23	29	37	44	50
3	0.8	3.0	5.0%	0.1	5.0%	0.3	**0.73**	88	11	14	18	21	24
4	1.2	1.8	14.0%	0.1	10.0%	0.3	**0.42**	81	22	28	37	45	52
5	1.9	2.4	2.5%	0.1	1.0%	0.3	**0.87**	87	21	27	34	40	46
6	0.0	0.4	17.0%	0.1	5.0%	0.3	**0.29**	89	1	1	2	2	2
7	1.2	2.7	4.5%	0.1	15.0%	0.3	**0.65**	92	22	27	34	39	44

(Note that results for volumes have to be divided by 10 for actual volumes in million cubic meters. This has been done due to table space constraints.)

Table 5-15 : Difference Operational phase/Pre-development towards end of life of mine

CATCHMENT NO	PEAK DISCHARGE DIFFERENCE %					MAR %
RETURN PERIOD	5	10	20	50	100	5
1	-8.2	-9.4	-10.5	-11.2	-11.8	-16.9
2	-39.3	-39.4	-39.4	-39.4	-39.4	-39.6
3	-80.7	-80.8	-80.9	-80.9	-80.9	-81.2
4	-3.4	-3.5	-3.7	-3.8	-3.9	-4.7
5	-68.7	-68.6	-68.5	-68.4	-68.3	-67.8
6	-53.4	-54.7	-56.0	-56.7	-57.3	-62.5
7	1.2	1.0	0.9	0.8	0.7	0.0

It is expected that stormwater runoff will increase insignificantly for only the catchment number. 1, 4 and 7. For the other areas, the runoff and MAR will reduce significantly due to stormwater being contained for large portions of these catchments and also where the minimum size open pit will comprise a large portion of the catchment. Therefore, it is assumed that surface water collected in the pits, slurry containment facilities, and pollution control dams will be fully utilized for mining operations and that there will not be excess water or shortages.

The total catchment area of catchment numbers 1 to 5 in the mine's southern operational area forms part of the Luluvile/Cuiva River catchment. The total catchment area towards the end of life of mine comprises only 1.3% of the total catchment of the Luluvile/Cuiva River system up to just downstream of the mining right area. The surface water from the mine's northern operational areas will flow within catchments numbers 6 and 7, which forms part of the river's catchment flowing just north of the proposed Longonjo Logistics Facility (at the railway line). The total catchment area toward the end of life of mine comprises only 0.36 % of the larger river's catchment to a point just downstream of the Longonjo Logistics Facility. The impacts on the main streams passing the mining area can thus be regarded as negligible.

5.3.3.4 Surface Runoff Immediately After Closure

It is expected that surface runoff will be different after closure and rehabilitation than during operations. It is assumed that rehabilitation efforts will result in no standing water (ponds) in all the catchments and that discard dumps and tailing facilities will be grassed and be free draining. It Is further assumed that all pollution control dams will be removed, the area covered with uncontaminated soil, grassed and drained. Thus, surface water runoff from the total original area will occur.

Peak runoff is expected to increase insignificantly for all catchments immediately after closure and rehabilitation. Runoff volume is expected to recover in the long term to be similar that pre-development conditions. It is expected that the MAR will be like pre-development conditions when the water table has risen to pre-development conditions. It is expected that the MAR will be similar to conditions at the end of life of mine. Note that the expected reduction in MAR during mining is only related to surface runoff.

5.3.3.5 Soil Loss Towards End of Life of Mine

Similar to surface stormwater runoff, it is expected that there will be a reduction in soil loss where a large proportion the catchment is contained but an increase where the catchment is disturbed but not contained to a large extend..

Table 5-16 : Soil loss tons/annum towards end of life of mine and % difference from baseline

CATCHMENT NO	OVERLAND SLOPE (%)	WOODS FAIR (ton)	WOOD - GRASS FAIR (ton)	GRASS FAIR (ton)	FARMLANDS GOOD (ton)	RESIDENTIAL ROADS,ETC. (ton)	GRASS POOR (ton)	FALLOW (ton)	TOTAL tons/ annum	DIFFERENCE %	DIFFERENCE RELATED TO LARGER CATCHMENT %
SOIL CLASS		B	B	C	B	C	B	B			
1	10	1025	3075	2870	16167	399	10778	10179	44495	21	0.4
2	5	100	201	477	587	81	587	623	2656	-17	-0.4
3	5	63	75	63	733		469		1403	-77	-1.6
4	10	7484	1640	205	2994	133	719	509	13683	2	0.03
5	1	35	35	37	377	6	11	23	525	-67	-1.4
6	5		13				29	62	104	2	0.01
7	15	837	2511	8372	9780	106489			127989	1	0
TOTAL AREA (1-5)		8707	5027	3653	20858	620	12564	11335	62763	2	0.1
TOTAL AREA (6+7)		837	2524	8372	9780	106489	29	62	128093	1	0

Catchments no 2,3, and 5 indicate a reduction in soil loss due to the large proportion of the catchment being contained or containing a tailing storage facility. The total catchment area of catchment numbers 1 to 5 in the mine's southern operational area forms part of the Luluvile/Cuiva River catchment. The total catchment area towards the end of life of mine comprises only 1.3% of the total catchment of the Luluvile/Cuiva River system up to just downstream of the mining right area. The surface water from the mine's northern operational areas will flow within catchments numbers 6 and 7, which forms part of the river's catchment flowing just north of the proposed Longonjo Logistics Facility (at the railway line). The total catchment area toward the end of life of mine comprises only 0.36 % of the larger river's catchment to a point just downstream of the Longonjo Logistics Facility. The expected effect the development will have on silt yield is depicted in the last column of the table above, which is expected to be negligible.

5.3.3.6 Soil loss Immediately After Closure

It is expected that soil loss will be higher immediately after closure; however, the long run, proper rehabilitation and vegetation management will result in soil loss returning to volumes as per pre-mining conditions.

Table 5-17 : Soil loss tons/annum for conditions immediately post closure and difference to baseline

CATCHMENT NO	OVERLAND SLOPE (%)	WOODS FAIR (ton)	WOOD - GRASS FAIR (ton)	GRASS FAIR (ton)	FARMLANDS GOOD (ton)	RESIDENTIAL ROADS,ETC. (ton)	GRASS POOR (ton)	FALLOW (ton)	TOTAL tons/ annum	DIFFERENCE %	DIFFERENCE RELATED TO LARGER CATCHMENT %
SOIL CLASS		B	B	C	B	C	B	B			
1	10.0	1025	3075	2870	16167	399	28742		52289	42	1.2
2	5.0	100	201	477	587	81	3520		4971	56	1.6
3	5.0	63	75	63	733		10882		11821	90	2.5
4	10.0	7484	1640	205	2994	133	2395		14861	10	0.3
5	1.0	35	35	37	377	6	2208		2700	70	2.0
6	5.0		13				205		223	117	0.4
7	15.0	837	2511	8372	9780	106489			128004	1	0.00
TOTAL AREA (1-5)		8707	5027	3653	20858	620	47747		86642	41	1.2
TOTAL AREA (6+7)		837	2524	8372	9780	106489	205		128227	1	0

It is expected that soil loss will be more significant immediately after closure. However, with careful long term vegetation management, the soil loss should return to volumes as per pre-development conditions. The total catchment area of catchment numbers 1 to 5 in the mine's southern operational area forms part of the Luluvile/Cuiva River catchment. The total catchment area towards the end of life of mine comprises only 2.78%

of the total catchment of the Luluvile/Cuiva River system up to just downstream of the mining lease area. The surface water from the mine’s northern operational areas will flow in catchments numbers 6 and 7, which forms part of the river's catchment flowing just north of the proposed Longonjo Logistics Facility (at the railway line). The total catchment area toward the end of life of mine comprises only 0.38 % of the larger river’s catchment to a point just downstream of the Longonjo Logistics Facility. The expected effect the development will have on silt yield is depicted in the last column of Table 5-17, which is expected to be negligible.

5.3.3.7 Impact assessment

The hydrology impact assessment tables are presented in Table 5-18 to Table 5-23.

Table 5-18: Surface stormwater runoff impact assessment - construction and operational phase

IMPACT	Project phase Construction – C Operation – O; commissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S	Probability Unlikely – U; Low – L Medium – M; High – H	Geographic Reach Site-S Angola Beyond Angola	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R Irreversible – I			
Surface stormwater runoff - construction and operational phase Wet season	C/O	N	L	H	S	M	M	R	Low	▪ During the detailed design stage, the flood capacities of existing culverts, crossings and bridges in the tributaries in the Project footprint (up to the main streams) need to be evaluated and enlarged to accommodate the increased peak runoff, same surety of non-exceedance as before. In addition, any new structure should be designed considering the expected increase runoff for an economically selected probability of non-exceedance.	Negligible
Dry season	CO	N	L	L	S	L	N	R	Negligible		Negligible

Table 5-19: Mean Annual Runoff impact assessment - construction and operational phase

IMPACT	Project phase Construction – C Operation – O; commissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S	Incidence: Probability Unlikely – U; Low – L Medium – M; High – H;	Severity: Geographic Reach Site-S Angola Beyond Angola	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Mean Annual Runoff - construction and operational phase Wet season Dry season	C/O	N	L	H	S	H	M	R	Medium	• The normal flow of tributaries in the Project area (up to the main streams) may be significantly lower. To be confirmed by future Hydrogeological 3D modelling. Should modelling reveal potential impacts to local communities water supply, they should be supplied with alternative water to the same surety of supply as before or compensated.	Negligible

. Therefore, only the possible reduction in the ground-flow (normal flow) portion of the MAR has been considered in the mitigation proposals above.

Table 5-20: Soil loss impact assessment - construction and operational phase

IMPACT	Project phase Construction – C Operation – O: commissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative: P = Positive	Duration Temporary – T: Short term – S	Probability Unlikely – U: Low – L Medium – M: High – H:	Geographic Reach Site-S Angola Beyond Angola	Frequency Low – L: Medium – M; High – H	Magnitude Negligible – N: Low – L: Medium – M: High – H	Reversibility Reversible – R Irreversible – I			
Soil loss - construction and operational phase Wet season	C/O	N	L	H	S	H	M	R	Medium	• All clean water runoff from the mining area shall be diverted to silt traps or swales to trap as much silt as economically possible. The overflows for silt traps and swales shall be so that stormwater is dispersed to avoid erosion. All clean water channels shall be grassed lined or protected against erosion. Temporary contour banks and berms shall be constructed on cleared land and under rehabilitation to minimise erosion.	Low
Dry season	C/O	N	L	L	S	L	L	R	Negligible		Negligible

Table 5-21: Surface stormwater runoff impact assessment - immediately after closure

IMPACT	Project phase Construction – C Operation – O: commissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S	Probability Unlikely – U; Low – L Medium – M; High – H;	Geographic Reach Site-S Angola Beyond Angola	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R Irreversible – I			
Surface stormwater runoff - immediately after closure Wet season	PC	N	M	H	S	H	M	R	Low	• Open pits will be contoured, protected by a berm, and vegetated. Waste rock dumps rehabilitated and TSF (rehabilitation options will include capping - rehabilitation plan to dictate), stockpile areas and removed PCD areas, covered with uncontaminated soil, fertilised and replanted with natural vegetation. Contour banks shall be constructed on rehabilitated land to minimis erosion. Other biodegradable measures to be put in place on rehabilitated land to allow planted natural vegetation to establish pre-development conditions. Swales shall be constructed at contour bank, and channel ends to provide flood attenuation.	Negligible
Dry season	PC	N	M	L	S	L	L	R	Negligible		Negligible

Table 5-22: Mean Annual Runoff impact assessment - immediately after closure

IMPACT		Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
	Project phase Construction – C Operation – O; commissioning – D	Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S	Probability Unlikely – U; Low – L Medium – M; High – H;	Geographic Reach Site-S Angola Beyond Angola	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R Irreversible – I			
Mean Annual Runoff - immediately after closure Wet season	D	N	M	H	S	H	M	R	Medium	• The normal flow of tributaries in the Project area (up to the main streams) may be significantly lower. To be confirmed by future Hydrogeological 3D modelling. Should modelling reveal potential impacts to local communities water supply, they should be supplied with alternative water to the same surety of supply as before or compensated.	Low
Dry season	D	N	M	H	S	H	M	R	High		Medium

Table 5-23 : Soil loss impact assessment post closure

IMPACT	Project phase Construction – C Operation – O: commissioning – D	Incidence Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S	Probability Unlikely – U; Low – L Medium – M; High – H;	Severity Geographic Reach Site-S Angola Beyond Angola	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Soil loss - post closure Wet season	D	N	L	H	S	H	M	R	Medium	• Open pits will be contoured, protected by a berm, and vegetated. Waste rock dumps rehabilitated and TSF (rehabilitation options will include capping - rehabilitation plan to dictate), stockpile areas and removed PCD areas, covered with uncontaminated soil, fertilised and replanted with natural vegetation. Contour banks shall be constructed on rehabilitated land to minimis erosion. Other biodegradable measures to be put in place on rehabilitated land to allow planted natural vegetation to establish pre-development conditions. Swales shall be constructed at contour bank, and channel ends to provide flood attenuation.	Low
Dry season	D	N	L	L	S	L	L	R	Negligible		Negligible

5.3.4 Noise and vibration

Reference

Specialist study 4 – Appendix F

Key specialists

Barend van der Merwe - dB Acoustics via HCV Africa, South Africa

Study objectives

The study objectives of the noise specialist study were as follows:

- Baseline noise measurement[51] surveys to determine existing noise levels at the proposed site boundaries and sensitive receptors;
- Noise intrusion modelling;
- The prediction of the proposed noise regime and resulting impacts outside the proposed boundaries of the site; and
- Recommendation of mitigation methods to minimise impacts on environmental resources and the human environment (i.e. sensitive receptors).

5.3.4.1 Construction phase impacts

The following impacts are anticipated during construction:

- Clearing and grubbing of the plant and ROM footprint – Use of heavy machinery and hauling of topsoil to waste area;
- Construction activities at the plant – Construction of the different sections of the plant such as crushers, screens and conveyors;
- Civil construction activities – Construction of internal roads, stormwater channels, infrastructure and buildings;
- Construction of the integrated waste storage area – Scraping of footprint and lining of the area; and
- Preparation of the open pit area – Scraping and grubbing of the open pit footprint 3-year, 10-year and 25-year pits.

5.3.4.2 Operational Phase Impacts

The following impacts are anticipated during operation:

- Processing plant activities – crushing, screening and water supply to the processing plant;
- ROM activities – handling of material at the ROM with earth-moving equipment;
- Open pit activities – free digging of material with front-end loaders and the loading of hauling vehicles;
- Blasting activities (when the preferred free digging mining method cannot be used 0 – 100kg, 200kg, 300kg and 400kg site mix slurry explosives to be continuously used, per delay;
- Screw Press Plant – Acoustic screening measures in place;
- Siding activities – Tipping of material, loading of wagons with earth-moving equipment;
- Hauling of material to the siding – hauling vehicles between the plant and the siding;
- Integrated waste storage facility – conveying of waste to the waste storage facility;
- Construction camp activities – mechanised activities;
- Earth drilling activities – Drilling rigs to be serviced regularly and all noise sources above 85.0dBA to be screened off;
- Permanent camp activities – mechanical ventilation, traffic, and domestic type activities; and

[51] Using a Brüel&Kjaer Hand-held Analyzer Type 2250, Class 1 instrument.

- Borefield activities – drilling at new exploration areas.

5.3.4.3 Decommissioning / Closure Phase

The following impacts are anticipated during decommissioning / closure:

- Removal of all structures – demolition of all structures at the different mining footprint areas;
- Rehabilitation of disturbed areas – restore the different footprint areas to is natural form; and
- Planting of vegetation – the planting of natural grass in disturbed areas.

5.3.4.4 Impact assessment

The noise and vibration impact assessment table is presented in Table 5–24.

Table 5–24: Environmental noise impact assessment table

IMPACT	Project phase (Construction – C; Operation – O; Decommissioning – D)	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction (N = Negative; P = Positive)	Duration (Temporary – T; Short term – S; Medium term – M; Long term – L)	Probability (Unlikely – U; Low – L; Medium – M; High – H; Definite – D)	Geographic Reach (Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA)	Frequency (Low – L; Medium – M; High – H)	Magnitude (Negligible – N; Low – L; Medium – M; High – H)	Reversibility (Reversible – R; Irreversible – I)			
Increase in the environmental noise levels at the abutting noise receptors - *Clearing and grubbing of the plant and ROM footprint*	C	N	S	M	LSA	M	M	R	Moderate		Low
Increase in the environmental noise levels at the abutting noise receptors - *Construction activities at plant*	C	N	S	M	LSA	M	M	R	Moderate	• Construction activities to be carried during the daytime period as far as practically possible. Machinery and vehicles which will be used must not exceed 85.0dBA during activities.	Low
Increase in the environmental noise levels at the abutting noise receptors - *Civil construction activities*	C	N	S	M	LSA	M	M	R	Moderate		Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Increase in the environmental noise levels at the abutting noise receptors - *Construction of the integrated waste storage area*	C	N	S	M	LSA	M	M	R	Moderate		Low
Increase in the environmental noise levels at the abutting noise receptors - *Construction of Siding infra structure*	C	N	S	M	LSA	M	M	R	Moderate	• Construction activities to be carried during the daytime period as far as practically possible. Machinery and vehicles which will be used must not exceed 85.0dBA during activities.	Low
Increase in the environmental noise levels at the abutting noise receptors - *Preparation of the open pit area*	C	N	S	M	LSA	M	M	R	Moderate		Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Increase in the environmental noise levels at the abutting noise receptors - *Processing plant activities*	O	N	L	M	LSA	M	M	R	Moderate	• Regular noise surveys to be carried out to identify noise sources above 85.0dBA; • Acoustic screening measures must be implemented in a proactive manner.	Moderate
Increase in the environmental noise levels at the abutting noise receptors - *ROM activities*	O	N	L	M	LSA	M	M	R	Moderate		Low
Increase in the environmental noise levels at the abutting noise receptors - *Open pit activities*	O	N	L	M	LSA	M	M	R	Moderate		Moderate

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Increase in the environmental noise levels at the abutting noise receptors - *Siding activities*	O	N	L	M	LSA	M	M	R	Moderate	• Regular noise surveys to be carried out to identify noise sources above 85.0dBA; • Acoustic screening measures must be implemented in a proactive manner.	Low
Increase in the environmental noise levels at the abutting noise receptors - *Hauling of material to the siding*	O	N	L	M	LSA	M	M	R	Moderate	• Trucks to adhere to the speed limit for a mining area of 40km/h in the mine and in residential areas.	Low
Increase in the environmental noise levels at the abutting noise receptors - *waste storage facility*	O	N	L	M	LSA	M	M	R	Moderate	• Regular noise surveys to be carried out to identify noise sources above 85.0dBA; • Acoustic screening measures must be	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Increase in the environmental noise levels at the abutting noise receptors - *Construction camp activities*	O	N	L		LSA	M	M	R	Moderate	implemented in a proactive manner.	Low
Increase in the environmental noise levels at the abutting noise receptors - *Permanent camp activities*	O	N	L		LSA	M	M	R	Moderate	• The prevailing ambient noise level at the boundaries of the camp may not be exceeded at any one time.	Low
Increase in the environmental noise levels at the abutting noise receptors – *Earth drilling activities*	O	N	L		LSA	M	M	R	Moderate	• Regular noise surveys to be carried out to identify noise sources above 85.0dBA; • Acoustic screening measures must be implemented in a proactive manner.	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Increase in the ground vibration levels at the abutting noise receptors – *Blasting activities*	O	N	L	M	LSA	M	M	R	Moderate	• The ground vibration and air pressure levels for a site mix slurry of 100kg. 200kg, 300kg and 400kg per delay to be always used.	Low
Increase in the noise levels at the abutting noise receptors – *Borefield activities*	O	N	L	M	LSA	M	M	R	Moderate	• Drilling to take place during daytime activities and drilling rigs to be serviced on a regular basis.	Low
Increase in the noise levels at the abutting noise receptors – Screw Press Plant	O	N	L	M	LSA	M	M	R	Moderate	• All acoustic screening measures in place and any noise source above 85.0dBA will have to be acoustically screened off.	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Increase in the environmental noise levels at the abutting noise receptors - *Removal of all structures*	D	N	S	M	LSA	M	M	R	Moderate		Low
Increase in the environmental noise levels at the abutting noise receptors - *Rehabilitation of disturbed areas*	D	N	S	M	LSA	M	M	R	Moderate	• Decommissioning activities to be carried during the daytime period. Machinery and vehicles which will be used must not exceed 85.0dBA during activities. •	Low
Increase in the environmental noise levels at the abutting noise receptors - *Planting of vegetation*	D	N	S	M	LSA	M	M	R	Moderate		Low

5.3.5 Soils

Reference

Specialist study 5 – Appendix G

Key specialists

Chris Viljoen - Viljoen Associates via HCV Africa, South Africa

Study objectives

The objectives of the soils specialist study were as follows:

- Classification and mapping of soil types according to the FAO Soil Classification System of the United Nations to 1:10,000 scale;
- Determine the effective depth of the soils;
- Assess the dry land, irrigation agricultural and rehabilitation potential of the soils;
- Assessment of erodibility of the soils in terms of the exchangeable sodium percentage (1N NH_4Ac-extract pH7) exceeding the cation exchange capacity (1N NH_4Ac-extract pH7);
- Assess the current land use and land capability;
- Description of chemical, physical and mineralogical properties of representative soil forms;
- Compilation of soil utilisation guide and plan (stripping and stockpiling); and
- Assess potential impacts on soil and surrounding environment due to stripping and mining, and mitigation.

The environmental impacts associated with soils are presented in the following subsections.

5.3.5.1 Soil Erosion

Heavy equipment may cause soil erosion during construction and operations phases, especially in the mining areas, operational area and stockpiles / waste dump.

5.3.5.2 Change to Soil Properties

Change of soil's physical, chemical and biological properties due to loss of topsoil due to erosion, stockpiling, project activities (stripping, stockpiling, mixing of deep and surface soils during handling, stockpiling and subsequent placement).

5.3.5.3 Dust Generation

Dust will be generated during construction and mining operations, vehicle movement, plant operations and opencast operations (refer to Air Quality in section 5.3.1).

5.3.5.4 Soil Contamination

Contamination of topsoil and stockpiled soil due to hydrocarbon and other chemical spills, oil/fuel handling and storage during construction and mining operations. During construction and production, mining-related chemicals causing acidification and salinisation contaminates soil from a pollution source along preferential seepage pathways.

5.3.5.5 Incorrect Topsoil Stripping and Effective Depth

Loss of topsoil due to stripping, handling and placement of soil associated with pre-construction land clearing and rehabilitation.

5.3.5.6 Erosion of Rehabilitated Areas

Soil erosion can be triggered from rehabilitated areas.

5.3.5.7 Land Use change

Land use will be converted from agricultural and wilderness to mining during the LOM. The land use during operations includes high extraction areas, plant, opencast, overburden, stockpiles, roads, and buildings. Following closure and rehabilitation, land can be returned to wilderness use.

5.3.5.8 Deterioration of Land Capability

The land capability will be affected by mining operations due to loss of topsoil (for surface infrastructure), soil erosion, soil contamination, topography changes, and rehabilitated areas.

5.3.5.9 Mitigation Measures

- Design, implement and update surface water control measures, conduct stockpile maintenance and prevent preferential seepage pathways.
- Manage the soils ‘chemical, physical and mineralogical properties through correct stripping / stockpiling procedures while practising active rehabilitation in mined-out areas and post-mining.
- Minimize dust fallout from mining operations by wet suppression and enforcing the speed limit on unpaved surfaces.
- Prevent soil contamination from spills and hazardous materials, store materials under roof in bunded areas. Make sure that pollution sources are isolated through clean and dirty water separation.
- Monitor potential increasing, static and decreasing contamination anomalies. Remediate soil contamination as soon as possible.
- Develop an emergency spill and clean-up protocol.
- Adhere to stripping guidelines and have qualified supervision.
- Conduct proper planning, undertake rehabilitation measures to reduce soil erosion, improve soil depth and fertility to achieve rehabilitation goals.
- Re-instate wilderness land use that is stable and safe in the long term to avoid legacy issues for Pensana to manage.

5.3.5.10 Impact Assessment

The soils impact assessment rating (pre-and post-mitigation) is presented in Table 5–25.

Table 5–25: Soil impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence Direction N = Negative; P = Positive	Incidence Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity Frequency Low – L; Medium – M; High – H	Severity Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Soil erosion	COD	N	M	H	LSA	M	M	R	Moderate	• Design, implement and update surface water control measures, conduct stockpile maintenance and prevent preferential seepage pathways.	Low
Change of soil's physical, chemical and biological properties due to loss of topsoil due to erosion, stockpiling, mixing of deep and surface soils during handling, stockpiling and subsequent placement.	COD	N	M	H	LSA	M	M	R	Moderate	• Manage the soil's chemical, physical and mineralogical properties through correct stripping and stockpiling procedures and rehabilitation of the closed areas after mining.	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Dust generation	COD	N	M	H	LSA	M	M	R	Moderate	• Also refer to Air Quality in section 5.3.1. Minimize dust fallout from mining operations by wet suppression and enforcing speed limit on unpaved surfaces.	Low
Change of natural surface topography due to reprofiling of surface after stripping.	COD	N	L	H	LSA	L	M	R	Moderate	• Implement surface digital terrain mapping to ensure surface water control measures are implemented to ensure free draining system with minimal soil erosion.	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Soil contamination	COD	N	M	H	LSA	M	M	R	Moderate	• Prevent soil contamination from spills and hazardous materials, store materials under roof in bunded areas. Make sure pollution sources are isolated through clean and dirty water separation. Monitor potential increasing, static and decreasing contamination anomalies. Remediate soil contamination as soon as possible. Develop an emergency spill and clean-up protocol.	Low
Loss of topsoil due to stripping, handling and placement of soil associated with pre-construction land clearing and rehabilitation.	CO	N	M	H	LSA	M	M	R	Moderate	• Strip all usable soil in primary project footprint, irrespective of soil depth. • Adhere to stripping guidelines and have qualified supervision.	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Rehabilitated Areas Erosion	COD	N	M	H	LSA	M	M	R	Moderate	• Undertake rehabilitation measures to reduce soil erosion, improve soil depth and soil fertility	Low
Loss of land with high agricultural potential and land capability.	COD	N	M	H	LSA	M	M	R	Moderate	• Loss of agricultural land due to the establishment of infrastructure is a long term loss, and no mitigation measures exist. Therefore, mitigation is restricted to limiting the extent of impact to the immediate area of impact and minimisation of off-site impacts. • Re-instate wilderness land use that is stable and safe in the long term.	Low

5.3.6 Naturally Occurring Radioactive Materials (NORM)

Reference

Pensana's appointed contractor, integrated into ESIA although conducted independently of HCV Africa – see Appendix P.

Key specialists

Mark Sonter - Radiation protection specialist, Brisbane, via PENSANA

Study objectives

The objectives of the NORM assessment were as follows:

- To review the presence of NORM based on chemical analyses at the Project site to date; and
- To quantify the radiation risk relating to NORM and to recommend mitigation measures.

The environmental impacts associated with NORM are presented in the following subsections.

5.3.6.1 NORM Risks

In its natural state, the ore at Longonjo mine contains radionuclides. Therefore, the grades of uranium (U) and thorium (Th) in the Longonjo concentrate (the export product) are expected to be about 100 ppm U and 4,000 ppm Th (these being equivalent to 1.25 Bq/g of U238 and 16 Bq/g of Th232 in the concentrate).

Table 5-26: Comparison of U and Th activity concentrations for various international rare earth projects

Project	ROM ore	Beneficiated Concentrate
Mt Weld, WA	660 ppmTh (2.64 BqTh/g) 35 ppm U (0.44 BqU/g)	1,500 ppmTh (6 BqTh/g) 30 ppmU (0.37 BqU/g)
Mountain Pass, USA	200 ppmTh (0.8 BqTh/g) 20 ppmU (0.25 BqU/g)	1,000 ppmTh (4 BqTh/g) 100 ppmU (1.25 BqU/g)
Nolans Bore, Northern Territory, Australia	5,000 ppmTh (20 BqTh/g) 200 ppmU (2.5 BqU/g)	10,000 ppmTh (40 BqTh/g) 400 ppmU (5 BqU/g)
Kvanefjeld, Greenland	620 ppmTh (2.5 BqTh/g) 260 ppmU (3.25 BqU/g)	3,500 ppmTh (14 BqTh/g) 1,500 ppmU (18.75 BqU/g)
Browns Range, Western Australia	35 ppmTh (0.14 BqTh/g) 50 ppmU (0.62 BqU/g)	220 ppmTh (0.9 BqTh/g) 620 ppmU (7.7 BqU/g)
Ngualla, Tanzania	50 ppmTh (0.2 BqTh/g) 14 ppmU (0.175 BqU/g)	390 ppmTh (1.56 BqTh/g) 100 ppmU (1.25 BqU/g)
Longonjo, Angola	ca 900 ppmTh (3.6 BqTh/g) ca 27 ppmU (0.3 BqU/g)	4,000 ppmTh (16 BqTh/g) 100 ppmU(1.25 BqU/g)

The overall NORM radioactivity of the Longonjo rare earth concentrate (in terms of summed head-of-chain activity concentration counting both U and Th) is about half of the Greenland REE/U concentrate and a third of the Nolan's Bore RE concentrate.

5.3.6.2 Radioactivity streams on-site

The primary ore is expected to be in secular equilibrium, while the weathered ore may or may not. This might impact the degree of hazard of airborne dust, and Pensana conducted the required tests to determine disequilibrium or otherwise of the weathered ore. Pensana will also conduct tests to determine the equilibrium state of the concentrate, for potential information to customers if requested and for certainty regarding transport labelling. The suites of samples for evaluation will be costed into the detailed engineering phase as part of metallurgical test work and will also be repeated at start-up.

5.3.6.3 Mitigation measures

Although NORM levels are low, Pensana will be obligated through a duty of care and precautionary principles to actively manage NORM to make sure that workers' radiation doses are minimal. NORM will primarily be in the concentrate; thus, it is expected that the tailings and water material dumps would not have NORM levels that are higher than the existing pre-mining geology.

Pensana will comply with the Angolan regulations. During the design process, Pensana obtained guidance from an Australian radiation exper, Mr Mark Sonter. The Wood design team, also from Australia, are considering the Australian guidelines in the ARPANSA 'Code of Practice and Safety Guide for Radiation Protection in Mining and Mineral Processing', aka 'RPS #9'[52].

In terms of RPS#9, Pensana shall develop and submit a formal Radiation Management Plan (RMP) to the regulator for approval. This is well-aligned with the requirements of the IAEA (International Atomic Energy Agency[53]), which also requires a formal Radiation Plan. The RMP will also provide for management of the local and international transport[54] of concentrate. It is expected that the Longonjo concentrate could be classified as DG Class 7 'Radioactive', for transportation (because its 'head-of-chain' (i.e. Th+U) activity concentration of about 17 Bq/g exceeds cut-off for Exemption of 10 Bq/g); it would have the designation UN2912, LSA-1, 'Low Specific Activity' Material, as this is the relevant descriptor for ores and concentrates containing natural radionuclides.

In addition to the above, Pensana (being a UK company) will also comply with the relevant radiation requirements in United Kingdom.

The transportation of the concentrate to the Lobito Port via road and rail in bulker bags, with the subsequent containerization at Lobito, under Pensana supervision, is acceptable in terms of the international standards. The bulker bags will be individually labelled, part of the standard routine following the first batch, during which exact labelling requirements will be confirmed, based on surface and 1-metre dose rates. In addition, sea freight containers will be labelled (details to be determined upon the first shipment), and this will also become routine after the first shipment.

5.3.6.4 Impact assessment

The impact assessment table for NORM risk is presented in Table 5–27.

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[52] https://www.arpansa.gov.au/regulation-and-licensing/regulatory-publications/radiation-protection-series/codes-and-standards/rps9
[53] Occupational Radiation Protection in the Mining and Processing of Raw Materials', RS-G-1.6
[54] IAEA 'International Regulations for Safe Transport of Radioactive Materials' will apply, the latest edition being SSR-6, 2018

Table 5–27: NORM assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
NORM presence in concentrate	O	N	L	M	B RSA	H	L	I	Medium	• Conduct a site baseline NORM survey. • Evaluate NORM in ore and concentrate during subsequent metallurgical test work. • Formulate a Radiation Management Plan (RMP).	Low

5.3.7 Visual intrusion

Reference

Specialist study 6 – Appendix H

Key specialists

Carlo Fourie - HCV Africa, South Africa

Study objectives

The objectives of the visual intrusion specialist study were to:

- Describe the baseline environment in terms of landscape features, most notably land cover / land use, vegetation patterns and landform attributes;
- Identify and describe potential visual receptors in terms of sensitivity, using a combination of satellite imagery and fieldwork;
- Quantify the realistic size and extent of the viewshed, using Geographic Information System (GIS) modelling techniques;
- Identify, describe and assess the potential visual impacts that the receiving environment and potential visual receptors may experience and rate these impacts; and
- Provide recommendations for mitigation to reduce the potential negative visual impacts associated with the Project.

5.3.7.1 Viewshed analysis

The 30m ALOS DEM was used for the viewshed modelling. The modelling used infrastructure heights stipulated in the Visual Impact specialist assessment (Appendix H). The resulting viewshed was constrained to the ZVI of 12 km. The output from the viewshed modelling is shown in. The size of the viewshed categories is shown in Table 5-28.

Table 5-28: Viewshed categories

Distance (m)	Category	Size (km^2)
0 – 2 000	Very high	43.61
2 000 – 3 500	High	40.67
3 500 – 7 000	Moderate	145.92
7 000 – 11 000	Low	203.41
11 000 – 12 000	Very Low	48.69
> 12 000	Negligible	n.a.
Total		**482.30**

The total viewshed area where the Project and associated features will be visible from is 482.30 km2. The size of the viewshed can largely be attributed to the undulating character of the region with no prominent topographical features to limit the size, and the relative absence of higher-growing vegetation. The 'Very High', 'High' and 'Moderate' categories impact the majority of villages in the immediate surroundings, and south, of the Project. This result was expected. Furthermore, the 'Moderate' and 'Low' categories account for over 72% of the entire viewshed but propagate towards the south, southeast, and east. The presence of the Longonjo Carbonatite, and more specifically the resistant fenite ridges on the northern perimeter of the carbonatite, dramatically limits any potential visual impact towards the important north-western corridor.

This modelling represents a worst-case scenario, and only topography was considered during modelling. However, it is highly likely that the woodlands, associated with the more mountainous areas and shown in Figure 5-19, will provide some form of vegetation screening to mitigate the potential visual impact and will, in all likelihood, diminish the 'Moderate' to 'Very Low' categories substantially.

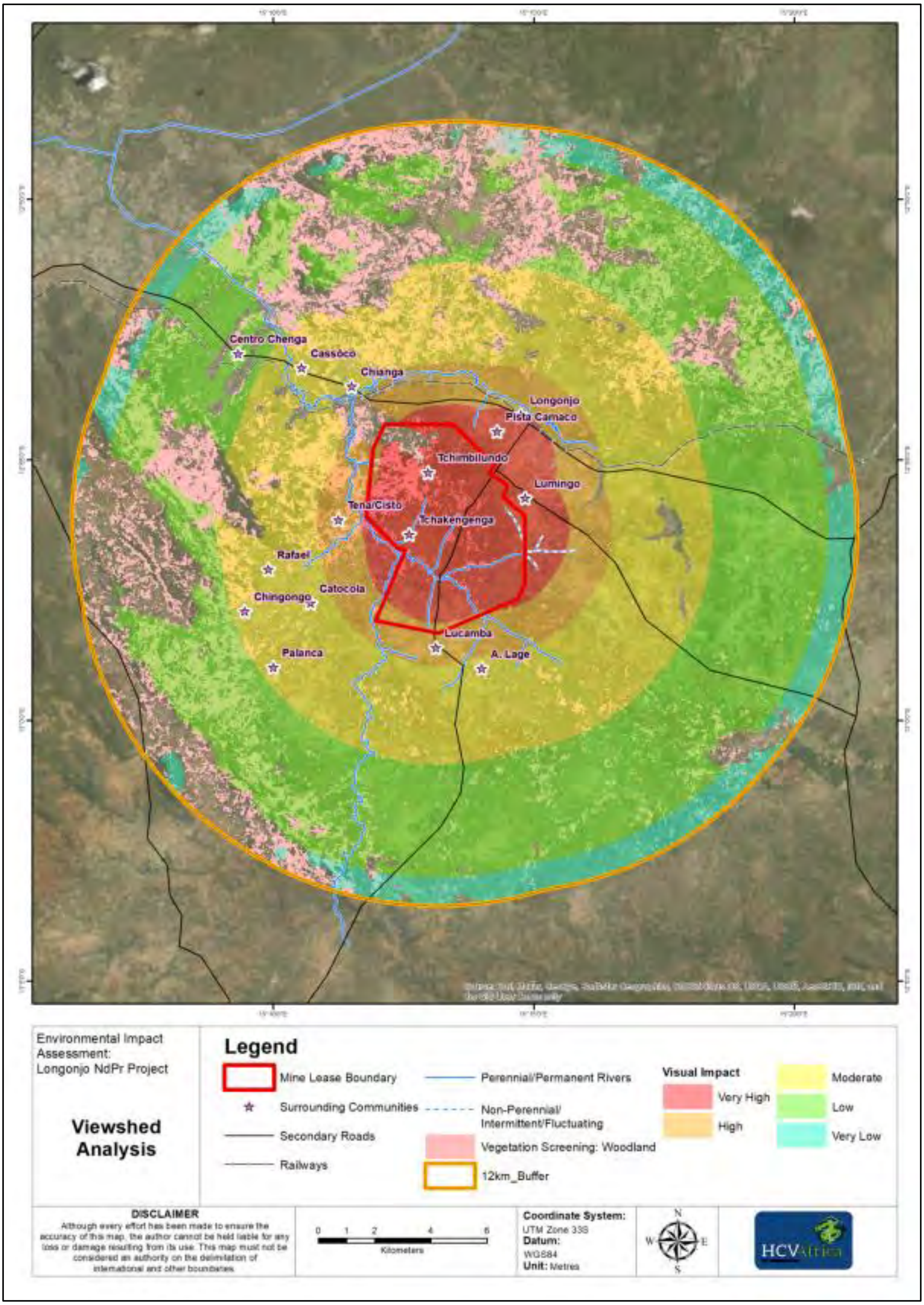

Figure 5-19: Viewshed Analysis of the Longonjo Project

Given the modelling results, the following conclusions can be reached when considering the criteria for VIAs, as shown in Figure 5-20.

- Given the size of the viewshed (482.30 km2), the visibility of the proposed development can be classified as high;
- The footprint and heights of structures of the Project will be substantial, and therefore is envisaged that the Project will exhibit a high visual exposure;
- The visual sensitivity of the area is determined by a combination of topography, vegetation and settlement patterns. This area can be seen as transformed given the abundance of agricultural activities. As a consequence, its sensitivity can be classified as moderate;
- The potential receptors are spread out over a spectrum, ranging from receptors with high (residential areas), moderate (places of work) and low (degraded areas) sensitivity. Therefore, it is safe to classify the visual sensitivity of the receptors as moderate;
- The VAC has been rated in Table 5-20 and is classified as moderate; and
- The compatibility of the proposed development with its surroundings and its impact on the sense of place defines its visual intrusion. Although extensive agriculture activities have already transformed the area, the proposed development will be completely different and significantly larger in scale, making it not congruent with its environment. Furthermore, given the density of villages in the area and the size of the overall viewshed, it can be argued that the Project will exhibit a high visual intrusion.

Visibility of the project – the geographic area from which the project will be visible, or view catchment area. (The actual zone of visual influence of the project may be smaller because of screening by existing trees and buildings). This also relates to the number of receptors affected.

- *High visibility* – visible from a large area (e.g. several square kilometres).
- *Moderate visibility* – visible from an intermediate area (e.g. several hectares).
- *Low visibility* – visible from a small area around the project site.

Visual exposure – based on distance from the project to selected viewpoints. Exposure or visual impact tends to diminish exponentially with distance.

- *High exposure* – dominant or clearly noticeable;
- *Moderate exposure* – recognisable to the viewer;
- *Low exposure* – not particularly noticeable to the viewer;

Visual sensitivity of the area – the inherent visibility of the landscape, usually determined by a combination of topography, landform, vegetation cover and settlement pattern. This translates into visual sensitivity.

- *High visual sensitivity* – highly visible and potentially sensitive areas in the landscape.
- *Moderate visual sensitivity* – moderately visible areas in the landscape.
- *Low visual sensitivity* – minimally visible areas in the landscape.

Visual sensitivity of Receptors – The level of visual impact considered acceptable is dependent on the type of receptors.

- *High sensitivity* – e.g. residential areas, nature reserves and scenic routes or trails;
- *Moderate sensitivity* – e.g. sporting or recreational areas, or places of work;
- *Low sensitivity* – e.g. industrial, mining or degraded areas.

Visual absorption capacity (VAC) - the potential of the landscape to conceal the proposed project, i.e.

- *High VAC* – e.g. effective screening by topography and vegetation;
- *Moderate VAC* - e.g. partial screening by topography and vegetation;
- *Low VAC* - e.g. little screening by topography or vegetation.

Visual intrusion – the level of compatibility or congruence of the project with the particular qualities of the area, or its 'sense of place'. This is related to the idea of context and maintaining the integrity of the landscape or townscape.

- *High visual intrusion* – results in a noticeable change or is discordant with the surroundings;
- *Moderate visual intrusion* – partially fits into the surroundings, but clearly noticeable;
- *Low visual intrusion* – minimal change or blends in well with the surroundings.

Note 1: *These, as well as any additional criteria, may need to be customised for different project assessments.*
Note 2: *Numerical weighting of these criteria should be avoided because of their qualitative nature.*
Note 3: *Various components of the project, such as the structures, lighting or powerlines, may have to be rated separately, as one component may have fewer visual impacts than another. This could have implications when formulating alternatives and mitigations.*

Figure 5-20: Specific Criteria for VIAs

5.3.7.2 TSF, Dumps and Stockpiles

The foundation for constructing the TSF, dumps and stockpiles will be laid during the construction phase, where site clearing, and preparation will be the most significant contributors to visual impacts. Since these features, particularly the TSF, will have a large footprint, the impacts during the construction phase will be noticeable. However, the most significant impact will occur during the operational phase when the mine is fully operational. The visual impact of the TSF and dumps will increase gradually over time, while the stockpiles will fluctuate in size during operations.

5.3.7.2.1 Activities and potential impacts

Activities considered were:

- Clearing of vegetation for the footprints and additional earthworks that may be required to prepare the areas (Construction Phase);
- Construction of the TSF, dumps and stockpiles (Construction and Operational Phase); and
- Increased traffic flow associated with the construction of the features (Construction and Operational Phase).

Visually, the most significant impacts are expected to be:

- A negative visual impact associated with removing of natural vegetation, enhancing soil contrast with the surrounding environment. Uniformity will be interrupted and negatively impact the *sense of place*;
- Height of the features and its visibility to surrounding receptors;
- Dust generation during the clearing operation, and the operational phase. It should be noted that the dust generation is only considered from a visual perspective (refer to the Air Quality impact section 5.3.1); and
- Visual intrusion due to the presence of heavy machinery and using the roads, and the on-site presence of equipment and materials.

The impact ratings and mitigation measures for the TSF, dumps and stockpiles are shown in Table 5-29.

Table 5-29: Impact ratings for the construction and operation of the TSF, Dumps and Stockpiles

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Visual disturbance due to height	C	N	L	D	RSA	H	H	I	High	1. Shaping of TSF and waste dump; 2. Make sure slopes do not exceed a ratio of 1:1.6 to prevent erosion; 3. Not exceeding design heights of infrastructure; and 4. Vegetate the TSF and dumps to minimize the sight of bare soil, and prevent wind and water erosion.	Moderate
Site and road clearing	C	N	L	D	LSA	L	L	R	Moderate	Remove minimum amount of natural vegetation	Low

Dust generation: clearing and dust from TSF / WRD	C; O	N	L	H	LSA	M	L	R	Moderate	Dust suppression techniques	Negligible
On-site machinery, equipment, materials; heavy vehicles using roads	C; O	N	L	D	LSA	H	M	R	Moderate	1. Overnight storage of equipment and materials away from receptors; 2. Make sure that all equipment on-site and general surrounds are maintained; 3. Make sure that that rubble, litter and disused construction materials are managed and removed regularly; 4. Limit pit operations to daylight hours; and 5. Use vegetative screens of indigenous species along roads carrying traffic.	Low
Altering site topography	C	N	L	D	LSA	L	L	I	Low	Make sure that safe storage of excavated overburden and topsoil stockpiles to prevent material loss due to water and wind erosion.	Negligible

5.3.7.3 Opencast Mining

Preparation for the pit will start in the construction phase with site clearing and preparation, including the stripping and storage of topsoil and overburden and the construction of the first benches.

The most significant visual impact from the opencast mining will be during the operational phase.

5.3.7.3.1Activities and Potential Impacts

The clearing of vegetation, increase in traffic, dust generation and altering site topography has already been discussed and rated in the previous section. In addition to these activities, the construction and operation of the pit will exhibit a visual impact. Aspects such as blasting and load-and-haul operations will be associated with the opencast mining in the operational phase.

From a visual perspective, the most significant impacts associated with opencast mining will be the following:

- A negative visual impact associated with removing natural vegetation, enhancing soil contrast with the surrounding environment. Uniformity will be interrupted and negatively impact the *sense of place*;
- Size and magnitude of the pit and its visibility to surrounding receptors; and
- Dust generation during the clearing operation and the operational phase. In this regard, blasting and load-and-haul operations could have a visual impact.

The impact ratings for the opencast mining and mitigation measures are presented in Table 5-30Table 5-30.

Table 5-30: Impact ratings for the construction and operation of the Pit

IMPACT	Project phase (Construction – C; Operation – O; Decommissioning – D)	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction (N = Negative; P = Positive)	Duration (Temporary – T; Short term – S; Medium term – M; Long term – L)	Probability (Unlikely – U; Low – L; Medium – M; High – H; Definite – D)	Geographic Reach (Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA)	Frequency (Low – L; Medium – M; High – H)	Magnitude (Negligible – N; Low – L; Medium – M; High – H)	Reversibility (Reversible – R; Irreversible – I)			
Visual disturbance due to size	O	N	L	D	LSA	H	H	I	High	1. Retain natural vegetation where possible; and 2. Strategic placement of other infrastructure to mask pit operations.	Moderate

5.3.7.4 Infrastructure

This category includes the following: process plant and conveyor belt, buildings, diesel depot and tanks, container handling yard, contractor laydown area and camps, explosives magazine, general landfill site, helipad, substations and the transmission line, roads and parking areas, potable water, raw water tank and booster pump station, reagent handling and storage facility, river pump station, screw press plant infrastructure and wastewater treatment works.

The impacts will commence in the construction phase with clearing the sites and roads and the construction of the various infrastructure features and continue into the operational phase due to mining operation.

5.3.7.4.1 Activities and Potential Impacts

The most significant visual impact of the infrastructure will be the visual intrusion from the structures themselves. Several prominent structures, such as the process plant and conveyor (20 m), and to a lesser degree the some of the buildings and transmission line (6 m), will be considerably higher than any other structures in the immediate area. These features will also affect the area's *sense of place* since no similar operation of this scale is close-by.

Activities considered during the preparation of these areas for the mining activities were as follow:

- Clearing of vegetation for the footprints and additional earthworks that may be required to prepare the areas (Construction Phase);
- Construction of the infrastructure (Construction and Operational Phase); and
- Artificial lighting (Construction and Operational Phase).

The most significant visual impacts associated with these activities will be the following:

- A negative visual impact is with removing of natural vegetation, enhancing soil contrast with the surrounding environment. Uniformity will be interrupted, and negatively impact the *sense of place*;
- Height of the features and its visibility to surrounding receptors;
- Dust generation during the clearing operation;
- Visual intrusion due to the presence of heavy machinery on the site and using the roads, as well as the on-site presence of equipment and materials; and
- Introduction of artificial lighting that will have a significant impact during night-time operations.

The impact ratings for the infrastructure and mitigation measures are presented in Table 5-30. Since a number of similar impacts have already been rated in previous sections, the impact table only considers the physical presence of the infrastructure, and artificial lighting.

Table 5-31: Impact ratings for the construction and operation of the Infrastructure

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Visual disturbance due to presence	C; O	N	L	D	LSA	H	M	R	Moderate	1. Use natural hues and non-reflective material on structures to facilitate them 'blending' in; 2. Use vegetation screens of indigenous species to shield these structures from receptors; 3. Retain taller species of natural vegetation, where possible, as an additional shield; and 4. Limit pit activities to daylight hours.	Low
Artificial Lighting	C; O	N	L	H	LSA	H	M	R	Moderate	1. Make use of down-lighting and low impact lighting; and 2. Avoid tall lights on the periphery and make use of motion sensors.	Low

5.3.8 Waste Management

Volumes of waste streams and waste classification will be finalised during detailed design.

5.3.8.1 Construction phase waste

Waste streams during the construction phase will comprise general, non-hazardous and hazardous materials, for example:

- Plastic;
- Wood pallets, paper and cardboard;
- Oils and lubricants;
- Metals;
- Fluorescent bulbs;
- Batteries;
- Waste concrete, excess building sand and gravel;
- Waste steel and other metals;
- E-waste such as used small electronic equipment;
- Waste electrical cables and associated materials;
- Wood used for machine packaging, concrete shuttering and building works;
- General waste from construction and accommodation camps such as office paper, plastics, food and other related waste; and
- Oily rags, paint and other used containers and filters, used tyres, vehicle parts and other hazardous waste associated with the construction activities such as chemicals, degreasers, paint and coatings, bitumen, herbicides, resins and curing agents.

PENSANA shall set up a waste management system in line with GIIP. Options for managing waste include:

- Appointing a contractor to remove waste from the site if a licensed disposal site can be identified or once an on-site landfill site has been designed and approval for an ESIA for the landfill site approved;
- Reduce the amount of waste being generated (e.g., a system for providing drinking water on-site without using single-use bottles, which are commonly used on remote sites);
- Recycling waste – onsite or through commercial recyclers (e.g., scrap metal dealers);
- Composting – food waste and organic materials (as composting facilities can attract vermin, pest control measures must be included in management plans).
- It is proposed that an engineered facility will be designed and constructed onsite, subject to ESIA approval.

5.3.8.2 Operational waste

During the operation phase, the following wastes will be generated:

- Tailings;
- Waste-rocks from mining;
- Chemicals (will be returned to the process plant);
- Plastic;
- Paper and cardboard;
- Metal;
- Wood and wood pallets;
- Oils, lubricants and oily rags;
- Filters;
- Batteries;
- Fluorescent Bulbs;
- Tyres;
- Medical wastes (hazardous and non-hazardous);

- NORM wastes (these wastes are Naturally Occurring Radioactive Materials that occur when mining, but these will be in small amounts. This type of wastes is covered by specific legislation and will also be covered by a Radiation Management Plan).

Table 5-32: Waste impact ratings for the construction and operation

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Generation of general, hazardous and non-hazardous waste during construction	C	N	S	D	LSA	M	M	R	Moderate	• Appoint a contractor to remove waste from site if a licensed disposal site can be identified; • Reduce the amount of waste being generated (e.g., a system for providing drinking water on-site without using single-use bottles which are commonly used on remote sites); • Recycling waste – onsite or through commercial recyclers (e.g., scrap metal dealers); • Composting – food waste and organic materials (as composting facilities can attract vermin, therefore pest control measures must be included in management plans; • An engineered facility will be designed and constructed onsite. Should a suitable waste disposal facility be available in nearby cities, this will be explored as an option.	Low

Generation of general and non-hazardous waste during operations	O	N	M	H	LSA	M	M	R	Medium	• Appoint a contractor to remove waste from site if a licensed disposal site can be identified; • Reduce the amount of waste being generated (e.g., a system for providing drinking water on-site without using single-use bottles which are commonly used on remote sites); • Recycling waste – onsite or through commercial recyclers (e.g., scrap metal dealers); • Composting – food waste and organic materials (as composting facilities can attract vermin, pest control measures must be included in management plans; • An engineered facility will be designed and constructed onsite. Should a suitable waste disposal facility be available in nearby cities, this will be explored as an option	Low

Generation of hazardous waste during operations	O	N	L	H	LSA	M	M	R	High	• Develop and implement an Integrated Waste Management Plan for the Project, including objectives for the collection, storage, transport, minimization and disposal of all hazardous and non-hazardous wastes generated by the Project; • Demarcated temporary collection/storage areas with suitable and well-marked waste bins for hazardous waste will be provided at strategic places; • Hazardous waste streams will be labelled and stored separately and recycled as far as possible to minimize volumes requiring landfilling; • Where possible hazardous waste will be returned to the suppliers (e.g. empty chemical containers); and • Employees will be educated to make sure that the objectives of the Integrated Waste Management Plan are achieved.	Low

Temporary storage of waste	O	N	L	M	LSA	M	M	R	High	• Development and implementation of an Integrated Waste Management Plan for the Project, including objectives for the collection, storage, transport, minimization and disposal of all hazardous and non-hazardous wastes generated by the Project; • All hazardous waste streams will be identified (inventory) and classified to make sure that toxic components are known and to make sure it is managed and disposed of in a safe manner; • Hazardous waste will be stored in sealed containers constructed of a suitable material and will be labelled clearly; • All hazardous waste will be stored, transported, and disposed of in compliance with the law; • Hazardous and non-hazardous waste storage areas on-site will be positioned away from any stormwater drains and watercourses and away from moving vehicles and equipment to prevent accidental spills; • The temporary storage/sorting site will at least comply with the following: o Accidental spillage of hazardous liquids or materials	Low

										to the soil and groundwater around the temporary storage area shall be prevented; o The site shall be provided with an impervious base to prevent ingress of liquids/leachate; o The hazardous storage area will be provided with a roof; o The facility will be provided with a spill containment sump to accommodate a volume equal to 1.5 times the volume of all containers stored on it as well as the volume of water during a 1-in-25 year storm event, plus the greater of 10% of the aggregate volume of all containers or 100% of the capacity of the largest tank within its boundary, whichever is greater; o Leachate generated at the facility will be stored in a contaminated liquid pond and treated before re-use or being released; o Different and incompatible waste (e.g. such as chlorine and ammonia) will be clearly labelled and stored separately to prevent any chemical reactions such as combustion/fire; o During the rainy season, temporary containment facilities will be covered during non-working days, and before rainfall events. Covered facilities may include use of	

										plastic tarps for small facilities or constructed roofs with overhangs; o Drums will not be overfilled and different wastes types not be mixed; and o Unless watertight, containers of dry waste shall be stored on pallets or similar. • The production or generation of hazardous materials and hazardous waste will be minimized as far as possible; • Containment berms will be provided in fuelling and maintenance areas (including any other areas where the potential for spills is high); • Liquid / semi-liquid hazardous waste shall be kept in appropriate containers (closed drums or similar) and be placed under a roof (or similar structure); • All hazardous waste containers will clearly be labelled with the waste being stored and the starting date of accumulation; • Potentially hazardous waste materials will not be accumulated on the ground; • Empty hazardous containers will be punctured before disposal to prevent it from being re-used (e.g. by community members to	

										collect drinking water from the river); • The original label of liquids and materials will not be removed as it contains important disposal and safety information; • PENSANA will regularly explore the possibility of replacing toxic substances (e.g. certain pesticides) with more environ-friendly substances; • Hazardous waste will be separated and recycled as far as possible to minimize volumes requiring disposal; and • PENSANA will include aspects relating to the Integrated Waste Management Plan, in their regular training curricula.	

Spillage of hazardous waste during transport off-site	O	N	S	L	RSA	L	H	R	H	• All hazardous liquid waste should be returned to the supplier if possible; • Hazardous liquid waste should be placed in suitable sealed containers and appropriately labelled; • Only trained personnel shall handle hazardous waste; • Vehicles transporting waste shall be purposed build and all required Haz-chem signage and emergency contact details should be displayed on these vehicles; • Vehicles shall strictly follow speed limited imposed on the vehicle; • Only trained personnel should transport hazardous wastes; and • Access roads shall be well maintained to facilitate safe passage to and from site.	L

Unauthorised disposal of waste to the environment	O	N	S	L	RSA	L	H	R	H	• An Integrated Waste Management Plan for the Project will be implemented prior to the commencement of the operational phase. This plan shall cover the collection, transport, storage, recycling and disposal of all waste materials. In addition, it shall also provide for regular auditing and the on-going monitoring of all waste management activities; • Corrective actions for non-compliance with the IWMP will be implemented; • Regular environmental audits and inspections of the surrounding area will be undertaken to identify any environmental concerns and take action to rectify them; and • Workers shall be educated and trained to make sure that the environment is kept clean and a reporting system will be implemented to report transgressors.	L

5.3.9 Aquatic Ecology

Reference

Specialist study 7 – Appendix I

Key specialists

Russel Tate – HCV Africa, South Africa

Study objectives

The objectives of the aquatic ecology specialist study were to:

- Determine the baseline aquatic ecological environment associated with the Project;
- Delineate sensitive habitats and assess Critical Habitat Status;
- Identify and quantify the anticipated environmental impacts of the Project; and
- Formulate mitigation and monitoring measures to address impacts.

5.3.9.1 Existing Impacts

The baseline assessment of the various waterbodies associated with the Project indicated large scale historical and current disturbances to these system's ecological status and function.

5.3.9.2 Layout of the Project

The proposed project's layout and sensitive habitats are provided in both Figure 4-72 and Figure 5-21. Although the first direct impact would be attributed to the placement of the TSF in a watercourse, direct loss of riverine habitats can be anticipated in this footprint area (It follows that the stream/river would be diverted around the TSF area – especially during the initial years of the TSF operation. An offset strategy and plan will be required to offset the loss of the stream). No avoidance actions could be achieved with this infrastructure. Mitigation actions to minimise the impact of the proposed TSF is unlikely to be successful owing to the direct footprint/disturbance occurring within the sensitive riverine habitats.

Based on the IFC's mitigation hierarchy and net gain (no-net loss) biodiversity goals, an offset is recommended. In order to achieve this offset, a like for like offset study is recommended.

The second direct impact would be the placement of a yet-to-be-defined weir on the Luluvila River facilitate water abstraction. More information will become available during detailed design relating to the possible weir. An alternative option is also possible, where a floating abstraction point could be constructed, to avoid impacts generally associated with a weir. Aside from the above activities, the proposed development will have a minimal direct impact on local riverine habitats.

5.3.9.3 Construction and operational impacts

Water and habitat quality impacts are anticipated in the river systems in the Project area. As provided in the delineation of the sensitive riverine habitats (Figure 4-72), there will be direct impacts on riverine resources in the perennial streams draining the Project area. In addition, indirect impacts to the downstream Cuiva River system are also anticipated.

The clearing of vegetation and alteration of drainage in a catchment area typically results in mobilising substrates and increased runoff velocity. The resultant impact on local water resources is sedimentation and erosion, which reduce the quality of riverine habitats. In addition, fine sedimentation reduces water quality whereby suspended solid concentrations increase, resulting in the loss of aquatic fauna species that are sediment sensitive.

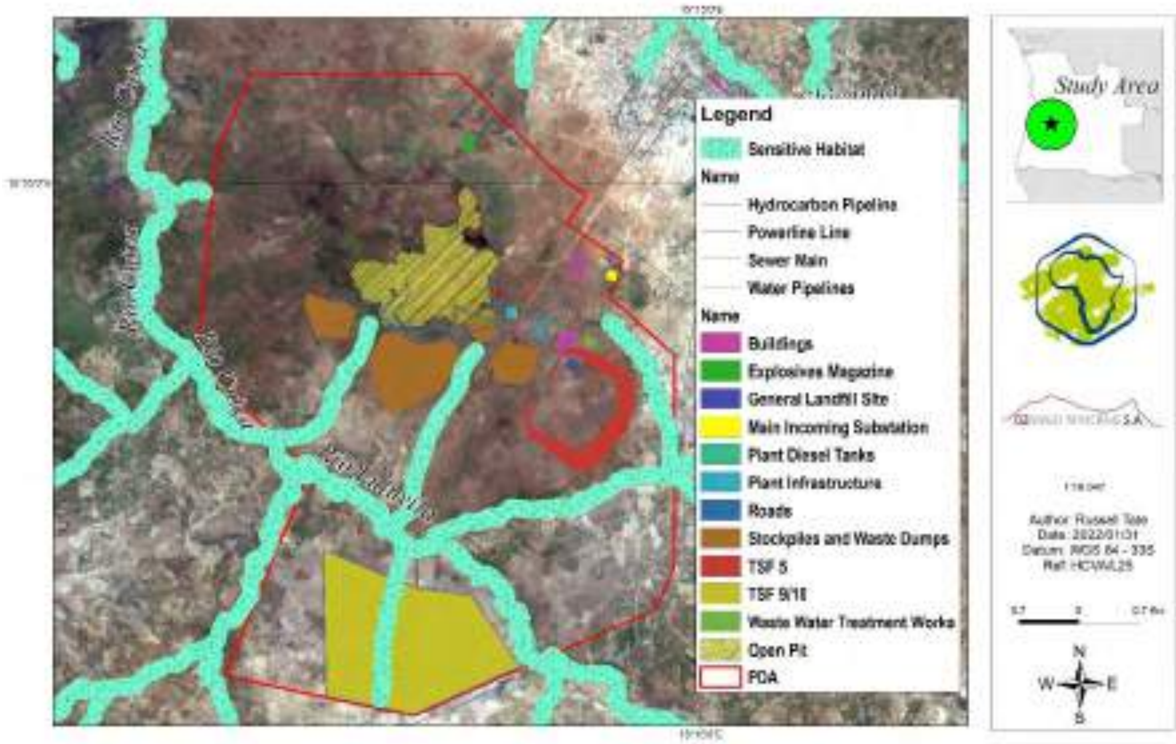

Figure 5-21: IFS stage infrastructure layout in the context of sensitive habitats

Infrastructure presents a risk to local habitat through increased erosion and sedimentation as above, and presents a risk of water quality deterioration through seepage and runoff of construction materials into local waterbodies. These activities may therefore serve to degrade local habitat and water quality.

Linear infrastructure shall facilitate effective crossing over a perennial stream. Crossing points are typically the source of environmental degradation via erosion, obstruction of flow and sedimentation.

Active excavations to remove topsoil and overburden material will alter drainage patterns and local hydrology in the Cuiva River catchment area. Altering the structure of the topography can result in alterations in water volumes in the associated surface water systems. Considering this, the open pit's development will likely alter the local hydrology whereby surface water yields will be reduced in the perennial streams and upper Cuiva River basin. The surface water study associated with the proposed development provides more details on this aspect.

Overburden materials are typically less weathered, and therefore runoff and seepage from these materials contain concentrations of readily dissolvable substances and fine particulate matter, which can alter the water quality in associated downstream river reaches.

The construction and operation of the permanent staff villages and offices present risk to local riverine water quality. Sewage pollution and domestic runoff can increase the concentration of dissolved nutrients in local waterbodies and therefore reduce water quality.

The placement of the TSF will directly alter the respective catchment area and instream conditions resulting in a direct loss to freshwater resources. Other impacts that may be attributed to the TSF material is the potential runoff of TSF material and seepage of contaminated precipitation. These aspects may negatively impact downstream water quality.

The construction of the abstraction impoundment within the Luluvila River will directly impact instream and riparian habitats within the disturbance footprint, upstream of the barrier within the inundation zone and the areas downstream of the impoundment. These impacts would likely negatively affect the overall habitat condition of the Luluvila River.

The current Project infrastructure layout is based on IFS stage design. The following design stage (Detailed Design) will refine the current IFS stage design. The current design shows that some infrastructure falls into the 200m aquatic buffer zone as contemplated by Presidential Decree No. 82/14, Article 110[12].

5.3.9.3.1 Mitigation measures

Infrastructure placement

The placement of the explosives magazine must be relocated outside a drainage line buffer zone. The placement of the proposed weir will likely be in the Luluvila River. The area proposed to be disturbed is recommended in an existing disturbed area, such as immediately downstream or upstream of the existing road-crossing/bridge. More information will become available during the detailed design relating to the possible weir. An alternative option is also possible, where a floating abstraction point could be constructed, to avoid impacts normally associated with a weir.

Open pits, ROM and waste stockpiles, and siding

Standard best practice surface/stormwater water management shall be implemented (e.g. clean and dirty water separation methodologies). See hydrology and hydrogeology sections (5.3.2 and 5.3.3).

Linear infrastructure

See hydrology section (5.3.3) – stormwater runoff shall be channelled into an area where energy dissipation and attenuation occur. Stream crossings shall make use of culverts capable of supporting flows of a 1:50 year flood. Stream crossings must be set in a manner not to disrupt the migration of aquatic fauna in an upstream direction. No gap between the stream substrate and culvert setting should be allowed. Stream crossing banks must be stabilised with appropriate structures that do not result in downstream erosion, including gabions or riprap materials. Sediment screens must also be in place where channelized energy dissipation occurs.

Processing plant, accommodation facilities

Refer to best practice general items in the section below. A detailed water balance must be compiled for the proposed project, including a processing facility and regularly updated. No discharge of process water must take place, and used water must be recycled, attenuated and evaporated. No water abstraction from local river systems must occur without official authorisation and updating the impact assessment. There must be no domestic water discharge; sewage must be treated whereby excess water is recycled through the processing plant. Should sewage water be required to be discharged, water monitoring must be implemented in the river reach associated with the discharge whereby dissolved phosphate, ammonium, and total nitrogen concentrations must be kept to an absolute minimum. The relevant authorities shall officially authorise discharges.

Instream impoundments

The proposed impoundments are required to be in existing disturbed footprints. During the construction of the proposed impoundments, the following recommendations are provided:

- A coffer dam must be constructed upstream of the proposed workings. The coffer dam must convey water to a channel that diverts water around the active workings for the weir (During detailed design, more information will become available relating to the possible weir. An alternative option is also possible, where a floating abstraction point could be constructed to avoid impacts usually associated with a weir.);
- The discharge point of the diversion must not result in erosion;
- A silt trap/screen must be installed downstream of the weir during instream activities (As stated above, a floating abstraction point may also be considered);

- After completing the instream workings, rehabilitation of the affected exposed areas in the riparian habitat must occur; after completion of the instream workings, an audit must ascertain whether this has been achieved;
- Following the completion of the instream workings, no waste material may be left in the river channel. An audit within 30 days of completion of the instream workings must determine whether this has been achieved; and
- If not initially present, no large boulders or material that can alter hydrology must be left in the instream areas. Within 30 days of completion of the instream workings, an audit must ascertain whether this has been achieved.

Tailings Storage Facility

The watercourse at TSF9/10 will be impacted as it is located within the footprint of the TSF facility. In the initial years of the TSF, the stream / channel must be diverted around the TSF footprint. Based on this, an offset strategy for the watercourse must be formulated. The following mitigation actions are recommended for the TSF:

- No water should be discharged from the TSF with all water reporting to a return water impoundment which effectively contains dirty water;
- The TSF must contain all precipitation using berms directed to the return water dam;
- The potential nature of the seepage from the TSF must be investigated further using chemical analysis;
- Standard water quality and aquatic biomonitoring studies must be completed in order to assess the impact to downstream river conditions; and
- Clean water must be diverted around the TSF footprint – especially during the initial years of the TSF operation.

General best practice

The following general actions shall be implemented:

- A stormwater management plan must be implemented;
- A detailed water balance for the entire Project shall be produced and updated regularly in order to manage water resources actively;
- Clean and dirty water management systems to be designed and implemented;
- An alien invasive species management plan must be implemented for all disturbed areas;
- Water quality and aquatic biomonitoring shall be undertaken;
- Following the completion of the construction activities, the impacted areas must be rehabilitated;
- Buffer zones around the delineated areas must be demarcated and avoided by all machinery and vehicles;
- Stockpile areas shall be bermed to reduce runoff into local waterbodies;
- Fuel and oil storage and handling must take place in bunded areas;
- Infrastructure (or any form of disturbance during construction, operation, closure) not be located in 200m of the delineated riparian zone;
- An alien invasive species management plan must be implemented for all disturbed areas;
- Suitable sewage infrastructure and handling which limits risks to local water quality must be in place for all areas;
- Ongoing rehabilitation of disturbed areas during all Project phases;
- Suitably sized culverts must be installed where roadways cross over drainage lines;
- Erosion control measures (gabions or suitable alternative) shall be implemented at all river crossings / culverts;
- Operate the entire mining area as a zero-discharge facility as contemplated in Section 2.13.2;
- Surface run-off from the roads flowing down the embankments often scours the watercourse on the sides of the culvert, causing sedimentation of the channel. This should be catered for with adequate concreted stormwater drainage depressions and channels with energy dissipaters that channel these flows into the river; and

- Implement passive treatment options for contaminated seepage and runoff from the TSF (if any, e.g. during closure when seepage cannot be circulated back to the processing plant).

5.3.9.4 Impact assessment

The aquatic ecology impact assessment is presented in Table 5-33.

Table 5-33: Aquatic Ecology impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S Medium term – M; Long term – L	Probability Unlikely – U; Low – L Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Water and habitat quality degradation during construction	C	N	S	H	LSA	M	M	R	Moderate	• Refer to Section 5.3.9.3.1	Low
Water and habitat quality degradation during operation	O	N	M	H	LSA	M	M	R	High	• Refer to Section 5.3.9.3.1	Moderate
Water and habitat quality degradation during closure / decommissioning	D	N	L	H	LSA	M	M	R	Moderate	• Refer to Section 5.3.9.3.1	Low

5.3.10 Avifauna and Mammals

Reference

Specialist study 8 – Appendix J

Key specialists

Phil Patton – HCV Africa, South Africa
Tyron Clark – HCV Africa, South Africa

Study objectives

The objectives of the avifauna specialist study were to:

- Identify, quantify and describe the habitats likely to host avifauna and mammals in the Project area;
- Dusk and dawn surveys to be conducted where possible and density surveys for certain key terrestrial species;
- Determine behavioural aspects of key species, especially those that would be impacted upon by the Project; and
- Diurnal Point Surveys will also be carried out to estimate spatial and temporal use of the Project site by resident and migrant species;
- Non-lethal trapping methods for mammals – camera traps and Sherman traps;
- Compare species list with the IUCN Red Data Book to determine species of conservation importance and the identification of key species and species of special concern (SSC) (including Angolan statutory requirements); and
- Formulate impact assessment and mitigation measures as applicable to avifauna and mammals.

5.3.10.1 Existing Impacts

Most of the lower-lying areas have been transformed through past and current agricultural practices, wood harvesting and livestock grazing. Although patches of impacted natural woodland and grassland remain, the larger, more intact habitat areas occurring in the hills to the north-west were ranked as being of moderate importance and sensitivity for birds and mammals. As there are no restrictive barriers (e.g. fences or large tar roads and towns) between the Project area and the Chimbilundo Hill, birds and most of the more mobile mammal species will likely move into this habitat during construction and operation.

5.3.10.2 Loss of the Carbonatite Outcrop Habitat (or partially in the 18-year scenario)

Vegetation clearing associated with the excavation of the open pit and subsequent excavation during operation may result in the loss of important high-altitude rocky outcrop, grassland upper wooded gulley habitat that supports SCC bird species, as well as sensitive and essential roost habitat for bat species. It is noted that the open pit excavation during the first ten years of the mining life should not imply the mining of the outcrops, but the likely impact has been retained here, taking the potential life of the Project into account. During the site visit, three natural caves were encountered along the southern side of the outcrop. One of the caves is accessible (through crawling) and opens into a moderately sized chamber followed by two smaller chambers. These chambers, particularly the first, supported a large population of horseshoe bats (ca. >300 individuals). Both visual and acoustic revealed that most of the population is comprised of *Rhinolophus fumigatus,* with *R. lobatus* being considerably less abundant. Although both species are listed as Least Concern because of their large distribution ranges, their population trend is currently unknown. Consequently, significant roost sites such as this, which have been used with great fidelity for many years (based on the height of the guano pile), represent important habitats worth safeguarding. Loss of habitual roost sites can adversely affect the regional population by losing a large proportion of it at once. Additionally, the broken terrain and large boulders in this habitat provide roosting habitat for many crevice roosting species (although none are SCC).

This hilltop habitat also provides suitable habitat for many of the region's higher altitude endemic birdlife. During the 2019 dry season-site visit, a pair of Angola Cave Chats were observed from one of the three caves encountered along with this habitat. The pair was found again at the same locality during the 2021 wet season survey, confirming an all-year resident breeding pair. Another national endemic, namely Angola Lark, was observed in the nearby grasslands. Additionally, it appears that some of the taller cliff / crags may be utilized by cliff-breeding raptors, in the case likely the resident pair of Rock Kestrel. A juvenile Lanner Falcon was seen foraging in this habitat, and it is likely that this species also breeds nearby. However, the cliffs are too low and disturbance levels too high for nesting by any larger raptors such as Verreaux's Eagle (*Aquila verreauxii*) and Cape Vulture (*Gyps coprotheres*). This habitat is classified as being of High Sensitivity for avifauna and mammals. Mining of product on or near this carbonatite steep cliff/crag where the bats and cave chats reside can cause either mortality or extirpation of these important biodiversity features and should be avoided. It is advised that mining of the product exclude the carbonatite steep cliffs/crags and associated cave habitat, and the buffer is always applied and adhered to. The mining pit layout has been updated accordingly in pursuance of this requirement during the ESIA process. Even if avoidance, as stipulated, is effectively achieved, indirect extirpation remains a possibility, and it will be of critical importance that the bats and cave chats be carefully monitored. The proposed area for all other auxiliary infrastructure, dams, weirs and tailings storage facilities (TSFs) is all located outside of this habitat and is not anticipated to negatively affecting this habitat.

5.3.10.3 Loss of Habitats

Clearing vegetation in the pit, tailings and infrastructure footprint areas will result in the loss of avifaunal and mammal habitat. However, much of the lower-lying areas have already been highly transformed through past and current agricultural practices, wood harvesting and livestock grazing. Although patches of natural woodland and grassland remain, they are somewhat impacted, with larger, more intact habitat areas occurring in the hills to the north-west and were ranked as being of Moderate importance and sensitivity for birds and mammals. As there are no restrictive barriers (e.g. fences or large tar roads and towns) between the project area and these hills, birds and most of the more mobile mammal species will likely move into this habitat following construction. Additionally, the proposed southern TSF overlaps a marshy low inundation watercourse. Avoidance of this wetland is said to be unavoidable. As such the loss of these habitats, from a mammal and avifaunal perspective is considered of Moderate significance provided diversion and offsetting measures are implemented.

5.3.10.4 Increased Mortality Risk

The establishment of the Project will invariably result in the mortality of birds and mammals, either directly through vehicle activities and increased incidents of road kills or through indirect means such as increased wildlife harvesting and burn frequency of adjacent areas. During the field surveys, local hunters and their dogs were frequently encountered in the Project area.

5.3.10.5 Sensory Disturbances

Increased noise, vibrations, dust, light pollution and human activity associated with increased traffic as well as construction and operation activities have the potential to adversely affect particular mammal and bird species that are particularly sensitive to sensory disturbances or may interfere with sensitive life history stages (e.g. courtship and rearing of young). The cave and crevice roosting bat species found in the Carbonatite Outcrop are of particular significance in this regard. Subterranean roosting bats have highly developed sensory systems and are highly sensitive to disturbance of their roosting habitat, typically still, dark and quiet (Monadjem *et al*. 2010). Light pollution is another sensory disturbance that may see some of the replacement of more secretive crepuscular / nocturnal mammal and bird species (e.g. *Caprimulgus europaeus*, *Nycteris thebaica*, *Otolemur crassicaudatus*) with more resilient, widespread and commensal species that can capitalize on the increased insect activity (e.g. *Neoromica capensis* and *Tadarida aegyptiaca*). The increased noise and activity levels may also cause the pair of Angola Cave Chats (*Xenocopsychus ansorgei*) and any of the smaller cliff-nesting raptor species to vacate the area. Therefore, monitoring will be required of the bats and cave chats occupying the carbonatite outcrop.

5.3.10.6 Loss of Red-listed Raptor Species Nests

Although the site supports a healthy diversity and abundance of raptors, some of which may be nesting in the Project area, no nests of large-bodied, Red-listed raptors were found in the Project area, nor does there appear to be any suitable nesting habitat in the form of sufficiently tall trees (>5 m) or high undisturbed cliff faces to support nesting by these species. As such, this impact is considered to be of low significance. This includes the large TSF area located in the south, which has extensively searched for large-bodied raptor nests without any success.

5.3.10.7 Potential Exposure to Contaminated Water

Non-optimal placement of tailing (or tailings spills) and waste rock facilities or the inadequate design and / or maintenance of stormwater, grey and sewerage water infrastructure have the potential to contaminate downstream watercourses. This would pose contamination and toxic bioaccumulation hazard to wetland-associated species and all birds or mammals that may drink from these systems. The new southern TSF overlaps a watercourse and therefore poses a risk that can be reduced to Moderate significance if mitigation, diversion and offsetting measures are implemented.

5.3.10.8 Effects of Potential Dewatering of Wetlands

Dewatering of wetlands due to operational activities (e.g. extraction of groundwater from production boreholes that service the mine) can potentially significantly affect wetland integrity (assuming shallow water aquifers are directly connected to wetlands) associated species. Additionally, a reduction in water volume can concentrate any contaminated inputs from the mining activities by reducing the dilution effect.

5.3.10.9 Increase in the Prevalence of Alien and Pest Species

Increased disturbance levels associated with various Project phases increase the spread of alien and invasive plant and animal species. The spread of alien and invasive plants can displace natural vegetation and degrade the quality of remaining habitat, most notably for the site's Red-listed, endemic and / or biome restricted species. No alien or pest bird (e.g. Common Mynah and House Sparrow) or mammal species (e.g. House Rat) were detected during the site visit, but this is likely to change following the establishment of the site with unfavourable consequences for local species.

5.3.10.10 Collision and Electrocution of Birds with New Powerline Infrastructure

Any new powerline infrastructure introduced to the Project's service may pose a collision and electrocution risk to local avifauna. Birds most susceptible to such collision include large ground-dwelling birds (e.g. the potentially occurring Denham's Bustard (*Neotis denhami*)) and raptors (e.g. Bateleur (*Terathopius ecaudatus*) and Auger buzzard (*Buteo augur*)).

5.3.10.11 Impact assessment

The avifauna and mammals impact assessment rating (pre-and post-mitigation) is presented in Table 5–34.

Table 5–34: Avifauna and mammal impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Impacts to the Carbonatite Outcrop Habitat and associated habitat: Consequences for endemic, and / or habitat specific avifauna and bat roosting colonies	COD	N	L	D	RSA	H	M	I	High	• The carbonatite outcrop has effectively been excluded from the pit design. However, this area shall be safeguarded and monitored. • It should be marked as an ecologically sensitive area, and all mining-related activities and general foot-traffic (construction workers and the general public) should be avoided in this area.	Moderate

Loss of other bird and mammal habitats in the Project area	COD	N	L	D	LSA	H	L	I	Moderate	• Avoid clearing vegetation and / or the establishment of mine infrastructure in the watercourses and their associated 200 m buffers. • Place infrastructure close to the access roads where the habitat is considerably more degraded. • Use existing access routes and walking paths. • Areas outside of the footprint denuded during construction need to be re-vegetated with indigenous vegetation. • Rehabilitate all prospecting roads that will no longer be used. • Tailings Option A (Option 2) represents the most favourable option from an avifaunal and mammal perspective.	Moderate-Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Increased mortality risk to birds and mammals	CO	N	M	M	LSA	M	M	I	Moderate	• Experienced, qualified ECO[55] shall identify potential fauna and potential nests directly disturbed and to relocate fauna/flora. • No trapping, killing or poisoning of any wildlife shall be allowed. • Train staff on biodiversity awareness. • Selected staff shall be trained to safely capture and relocate potentially dangerous or injured mammal and bird species. • Speed control enforced to 40km/h.	Low

[55] Environmental control officer

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity: Frequency Low – L; Medium – M; High – H	Severity: Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Sensory disturbance to birds and mammals	CO	N	M	D	LSA	H	M	R	Moderate	• Monitor noise on-site, if possible, attempt to attain readings from the top of the hill as close to the bat roost cave as possible. • Prohibit general access to the carbonatite outcrop and the bat roost cave.	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence Direction N = Negative; P = Positive	Incidence Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity Frequency Low – L; Medium – M; High – H	Severity Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Loss of Red-listed raptor species nests	CO	N	L	L	LSA	L	H	I	Low	• It is not anticipated that any large raptor nests will be encountered on-site. However, if any large nests are encountered, activities within 100m of the nest should be ceased, a picture should be taken and sent to an appropriately qualified avifaunal specialist to assess the situation and advise on the best way forward.	Low
Potential exposure of birds and mammals to contaminated water	COD	N	L	M	RSA	L	H	R	Moderate	• See detailed provisions of the herpetology section (0) on watercourse contamination.	Moderate

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence Direction N = Negative; P = Positive	Incidence Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Severity Frequency Low – L; Medium – M; High – H	Severity Magnitude Negligible – N; Low – L; Medium – M; High – H	Severity Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Effects of potential dewatering of wetlands on birds and mammals	COD	N	L	M	RSA	L	H	R	Moderate	• Use the comprehensive mine water balance to determine maximum abstraction rates.	Low
Increase in the prevalence of alien and pest species	COD	N	L	M	RSA	L	H	R	Moderate	• Implement alien species control plan	Low

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Collision and electrocution of birds with new powerline infrastructure	COD	N	L	M	LSA	L	M	I	Moderate	• Any new powerline infrastructure shall be as far as possible parallel to existing infrastructure. • All new powerlines shall be fitted bird flappers and anti-perch spikes to reduce the risk of collision and electrocution respectively.	Low

5.3.11 Botany

Reference

Specialist study 9 – Appendix K

Key specialists

Llwelyn Coertzen – HCV Africa, South Africa

Study objectives

The objectives of the botany specialist study were to:

- Vegetation classification regarding plant communities in the Project area and sub-communities and variations of these;
- Compilation of a species list for each plant community, including diagnostic and dominant species;
- Describe invasive species (if present) for each plant community;
- Describe exotic species (if present) for each plant community;
- Describe Protected, Red Data and endemic species for each plant community;
- Culturally significant plant species within each community; and
- Conduct an impact assessment and propose mitigation measures.

5.3.11.1 Existing Impacts

The majority of the Project area has been highly transformed through past and current agricultural practices, wood harvesting and livestock grazing. As a result, patches of impacted natural woodland and grassland remain. Areas of higher altitude (e.g. on Chimbilundo Hill) show a less impacted state due to it being less suitable for agriculture.

5.3.11.2 Loss of Existing Habitat Due to Loss of Vegetation

The Project footprint where infrastructure will be located will result in a direct loss of the existing vegetation due to vegetation clearing during site preparation at the onset of the construction phase. In addition, stochastic events such as fire (cooking fires or cigarettes of workers) may result in runaway fires to remove habitat for terrestrial plant species that would otherwise have been available.

Secondary impacts associated with habitat and vegetation removal may include the displacement / loss of flora and fauna (including rare or endangered species). Although the '*Avoided social cost*[56]' - loss of vegetation would reduce the carbon sequestered, the magnitude of this impact cannot be quantified based on the current data collected in the field.

It is also expected that targeted high-value plant species (plants valued e.g. logging and tradable species such as succulents) would increase due to increased access to isolated/fragmented populations in the Project area.

Due to vegetation clearance, the susceptibility to soil erosion will increase, resulting in a decrease in habitat integrity. Vegetation clearance will result in the disruption of the standing biomass and soil, combined with increased human activity, resulting in the likelihood of increased presence and spread of alien and invasive plant species.

5.3.11.3 Alterations in Sedimentation and Chemical Runoff into Aquatic Habitats and Downstream Watercourses

Project-induced impacts resulting in environmental contamination (e.g. hydrocarbon and chemical spills) and environmental degradation (e.g. erosion) can affect local and downstream aquatic habitats. Secondary impacts associated with alterations in sedimentation load and chemical run-off can result in a disruption / alteration of

[56] The concept of the social cost of carbon "tries to add up all the quantifiable costs and benefits of emitting one additional tonne of CO_2, in monetary terms. This value can then be used to weigh the benefits of reduced warming against the costs of cutting emissions." https://www.carbonbrief.org/qa-social-cost-carbon

ecological lifecycles of aquatic plants. Direct mortalities of plant species may also occur due to pollution which may have a detrimental impact on sensitive habitats such as wetlands and rivers. Watercourse also acts as a transporting mechanism to distribute the pollution downstream.

5.3.11.4 Impact assessment

The impact assessment table for botany is presented in Table 5–35.

5.3.11.5 Habitat sensitivity

Each of the natural terrestrial habitats (Figure 5–22) were evaluated in terms of its sensitivity and importance for terrestrial plant species:

- Rocky hillslope grassland – medium to high sensitivity –this habitat unit is fragmented and moderately disturbed within the Project Area. No SCC was recorded within this habitat unit. However, there exists a medium likelihood of the presence of grassland SCC in this habitat unit;
- Woodland – medium to low sensitivity – this habitat is already disturbed and in a constant dynamic flux of different stages of secondary succession. However, two tree SCC were recorded within this habitat: Pterocarpus *angolensis* (VU on Angola Red List) and *Psorospermum febrifugum* (Lr-NT IUCN). Both of these species are still fairly common in the regional landscape;
- Ravine community – medium to low sensitivity – this habitat is already highly disturbed but serves as important fauna habitat within the Project Area; and
- Cliffs and Caves – high to very high sensitivity – the precautionary approach is followed, and this habitat unit is regarded as having unique ecosystem processes and functions. Therefore, it has been excluded from mining operations by avoiding the most recent pit layout..

Table 5–35: Botanical impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – BRSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Loss of existing habitat due to loss of vegetation	C; O; D	N	L	D	LSA	L	H	R	High	• Clearings associated with construction to occur in as small a footprint as possible and limited to the disturbed habitats; • Vegetation clearing on slopes should be minimised, and appropriate stormwater management shall be put in place to limit the erosion potential of exposed soil. This shall include grassed waterways and vegetated strips in and around infrastructure and field borders; • Vegetation establishment shall be promoted after construction in areas outside the final operational footprint through rehabilitation and ecological engineering to re-establish habitats similar to those found in the natural savanna habitats; • Upgrading existing roads/servitudes is preferable and shall prioritise the construction of new roads/servitudes. In addition, if construction of new roads/servitudes are unavoidable, disturbed areas (e.g. old and/or unused agricultural lands) should be prioritized over ecologically intact areas; • An environmental induction for all staff members must be mandatory in which specific issues related to the potential of fire or addressed, e.g. only smoking in designated areas, no open cooking fires etc.	Moderate

Alterations in sedimentation and chemical runoff into aquatic habitats and downstream watercourses	C; O; D	N	L	H	RSA	H	H	R	High	• Mitigation measures mentioned above regarding soil erosion management will reduce the amount of sediment deposition into the wetlands and streams; • Machinery and vehicle service will be conducted away from watercourses / drainage lines; • A dedicated fuel and chemical storage facility according to industry best practice will be constructed away from sensitive habitat types; • Accidental hydrocarbon spills will be cleaned rapidly; • SOP's will be developed and enforced for the handling of hydrocarbons; • Water quality monitoring in accordance with recommendations made by the aquatic specialist will be carried out; • Hydrocarbon collection and separation systems according to industry best practice will be installed at required areas; • Drip trays and oil absorbents will be used on all areas where construction equipment is parked; • Continuous monitoring of water quality coupled with an adaptive management approach to identify risks of potential eco toxicity followed by appropriate actions to reduce or eliminate the risk of eco toxicity; • Mitigation measures mentioned above regarding the control of erosion to reduce the sediment load in the wetlands and streams.	Moderate

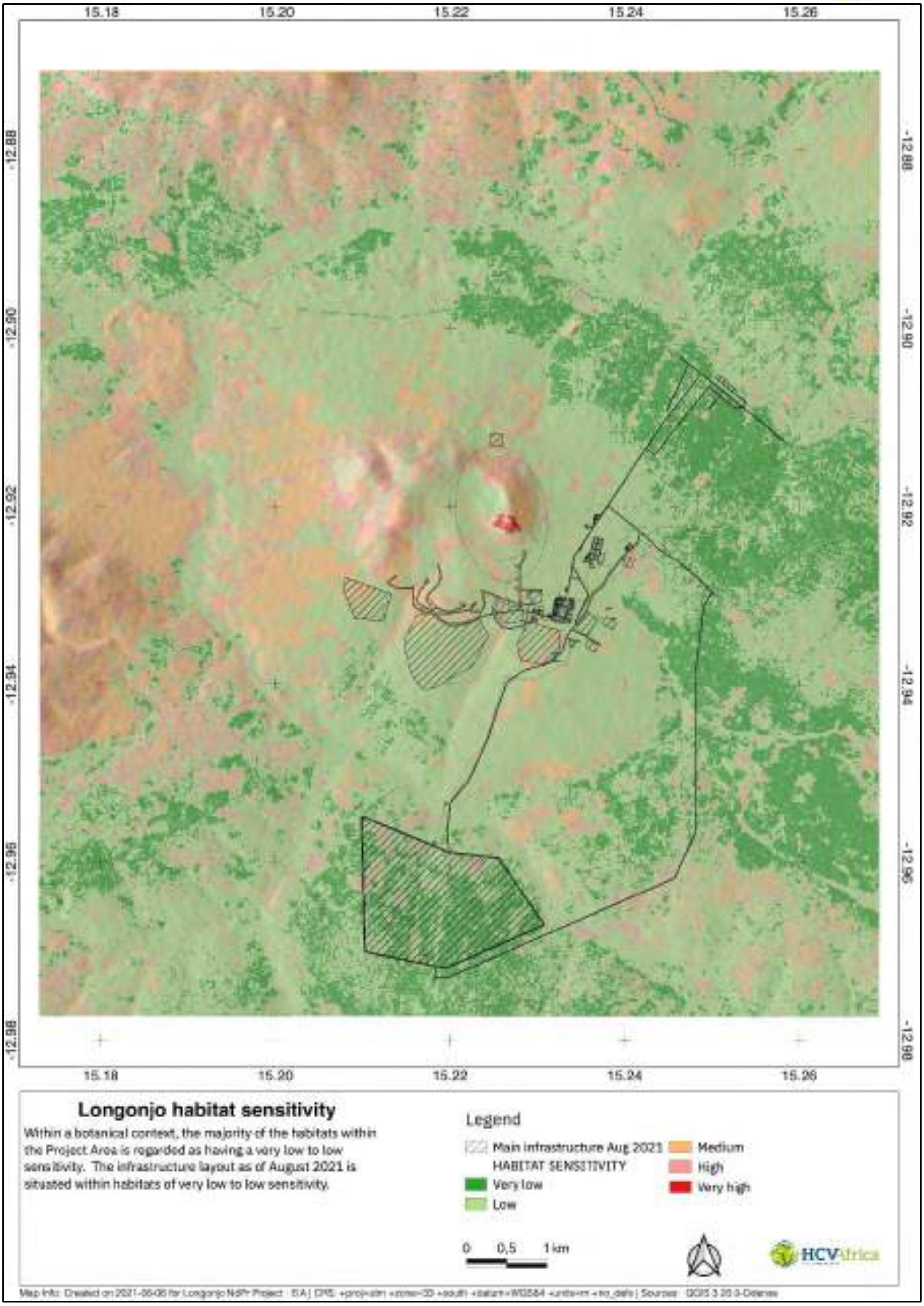

Figure 5–22: Botanical habitat sensitivity

5.3.12 Herpetology

Reference

Specialist study 10a – Appendix L
Specialist study 10b – Appendix M

Key specialists

Tyron Clark – 2021 update – HCV Africa, South Africa
Luke Verburgt 2019/2020 – HCV Africa, South Africa

Study objectives

The objectives of the herpetology specialist study were to:

- Identify, map, quantify and describe the habitats likely to host amphibians and reptiles in the exploration area, in conjunction with the flora survey;
- Conduct night time surveys;
- Determine the occurrence and abundance of amphibians and reptiles in the Project area, using both qualitative and quantitative survey techniques;
- Compare species list with the IUCN Red Data Book and CITES to determine species of conservation importance; and
- Conduct an impact assessment and propose mitigation measures.

The impacts on herpetology and associated mitigation measures are described below.

5.3.12.1 Loss of existing habitat

The rationale behind the impact associated with the mining of the diatreme, as justified in the main herpetofauna report, remains valid and is considered to be of High pre-mitigation and Moderate post-mitigation significance due to alter habitat known to support SCC herpetofauna irreversibly. Regarding the new infrastructure areas, clearing (site preparation) is considered unlikely to have a significant impact on the regions herpetofauna assemblage, considering that these areas are situated away from the diatreme hill and mostly outside of perennial watercourses (with which most of the regions SCC herpetofauna are associated). However, the proposed position of 373quatic373n TSF overlaps with a watercourse, a concern which needs to be addressed through diversion and offsetting. Additionally, the new infrastructure features represent a sizeable addition to the overall footprint area. Therefore, the pre-mitigation rating of High and post-mitigation rating of Moderate is retained provided appropriate diversion and offsetting aimed to demonstrate a net increase in wetland extent and functionality in the project area is successfully implemented. If not, this impact must be considered of very high significance.

5.3.12.2 Direct mortality of herpetofauna due to excavation and traffic

The physical act of removing surface layers of soil and rock for construction and mining using excavators may result in the direct mortality of resident herpetofauna.

Due to the expected increase in vehicle presence throughout the Project area, especially between the plant and the Longonjo railway siding, it is expected that herpetofauna mortality will increase significantly due to trampling by vehicles. Herpetofauna is particularly susceptible to collisions with traffic because they cannot judge the distance or speed of an oncoming vehicle and cannot move away in time. In addition, many species freeze (i.e. become motionless) when approached by a vehicle (due to the substrate vibrations and/or noise) and are therefore rendered even more susceptible to fatal collisions. Finally, amphibians' seasonal abundances and/or migrations are particularly vulnerable to this impact where roads cross aquatic habitats such as rivers and wetlands, especially during the night.

5.3.12.3 Mortality of herpetofauna due to in-migration of people

Direct mortality of herpetofauna is likely to increase as more local people arrive and settle in the surrounding areas seeking employment and the regular presence of staff. Local people hunt large-bodied reptiles to supplement protein intake requirements (especially chelonians[57]), and this occurrence is likely to become more probable and profitable as human densities increase in the area. This is especially concerning for *Kinixys belliana*, a Vulnerable species protected by the Angolan Executive Decree No. 252/18 that has been confirmed to be present on-site and is threatened by collection for bushmeat. In particular, crocodiles, monitor lizards and tortoise/terrapins (data based on specialist interviews with local people) are hunted and collected for consumption and / or trade, with no regard for the sustainability of these practices. As a result, staff will have a relatively high probability of interacting with these species during everyday daily routines during periods of favourable climatic conditions. Generally, the first reaction of untrained people is to attempt to kill any snake, which is highly undesirable from a conservation perspective and increases the likelihood of adverse human / snake interaction (bites / envenomation).

Indirect mortality of herpetofauna is likely to increase in the Project area and surrounding areas due to an influx of people to the area which results in an increased probability of fires and greater utilisation of ecosystem services, as hunting and agriculture.

5.3.12.4 Disruption/alteration of ecological life cycles due to the restriction of species movement (migration/dispersal)

Open excavations can trap herpetofauna and/or disrupt their migration – such as temporary excavations created during the construction phase (e.g. excavations for infrastructure foundations, trenches for the laying of cables and pipelines) and the open pit excavation. Herpetofauna is particularly susceptible to falling into excavations.

Removal / alteration of large areas of natural habitat can cause habitat fragmentation, preventing effective dispersal and migration of adjacent intact herpetofauna populations. The activity in the Project area will not wholly isolate natural vegetation types but may act as a stepping stone for dispersal of rupicolous herpetofauna, although the rupicolous species observed in the Project area are relatively widespread in Angola. The large size and distance of the southern TSF from the rest of the mine infrastructure imply a likely significant contribution to the fragmentation of local habitat.

5.3.12.5 Disruption/alteration of ecological life cycles (breeding, migration, feeding) due to noise, dust and lighting

Rock dumping (stockpiles), activities in the open pit and regular dirt road usage will all contribute to the dust production. Regular dust fallout can cause changes in surface water quality (deposition of dust resulting in the addition of nutrients and siltation), decreased nutrient content of vegetation (reduced effectivity of photosynthesis) and localised reduction of vegetation growth (Hirano *et al*. 1995). The impacts of excessive dust may ultimately result in the direct loss of habitat (removal of vegetation/aquatic habitat) or indirectly through reduced utilisation of dust-coated vegetation/silted aquatic habitats by sensitive fauna and radiation exposure (although this is predicted to be negligible) which can disrupt/alter the ecological life cycles of these species.

The lighting of roads and active sites at night can attract insects that will attract geckos and amphibians, attract snakes (which might be venomous) and increase their interactions with humans and traffic. Loud noises and vibrations during excavation and crushing can disrupt / alter the ecological life cycles of herpetofauna.

[57] turtles, terrapins, or tortoises

5.3.12.6 Introduction of alien flora affecting native herpetofauna assemblages

The introduction and spread of alien flora through the regular movement of vehicles and materials between the site and other areas can alter the habitat structure and processes that can change its suitability for herpetofauna. In addition, heavily infested areas of alien vegetation effectively remove habitat for utilisation by herpetofauna.

5.3.12.7 Erosion from construction, infrastructure and excavations

Erosion can lead to draining wetland systems and siltation of watercourses which can negatively impact herpetofauna with water-specific foraging or breeding requirements.

The risk of habitat degradation for semi-aquatic herpetofauna due to erosion and subsequent sedimentation of watercourses is increased by the proposed position of the southern TSF (TSF9/10) overlaps a perennial watercourse. Therefore, for the eastern TSF, the pre-mitigation impact significance is set at Moderate while the post-mitigation significance is considered Low. For the southern TSF, the pre-mitigation rating is set at High while the post-mitigation risk is considered Moderate provided this facility can be effectively re-aligned to avoid the 100 m buffer on the watercourse; otherwise it should be considered a Moderate significance impact.

5.3.12.8 Watercourse contamination from mine waste (tailings) storage facilities

Tailings are expected to consist of weathered, relatively inert and alkaline material, and therefore the risk of acid mine drainage is low. However, no detailed analysis of the tailing chemical composition has been provided. As such the Precautionary Principle is followed. Radioactivity of the tailings is expected to be negligible due to the ore's very low NORM (Naturally Occurring Radioactive Materials) content, which is further reduced from the tailings during the processing of the concentrate.

The initial impact rating and description for TSF A (TSF5) detailed in the main herpetofauna report are retained. However, the addition of the larger southern TSF (TSF9/10) in the south represents a new risk in this regard and has therefore been separately assessed as an additional impact not previously covered. Although the new TSF is mainly situated in low sensitivity terrestrial habitat and the proposed position of the large southern TSF overlaps a watercourse. As such, the potential impact of the southern TSF on water quality for herpetofauna is considered High without mitigation. The residual impact can be reduced to Moderate if diversion and offsetting are implemented. If these two conditions cannot be met, the residual impact significance should be considered high significance.

5.3.12.9 Watercourse contamination due to chemical spillage

The risk of human operating error (accidental), equipment failure or overflow can lead to chemical spills, e.g. diesel fuel (hydrocarbon). Potential impacts from pollution sources (e.g., chemical storage and use, hydrocarbon use and spills) can effectively "remove" a habitat from utilisation by herpetofauna as well as cause direct mortalities (poisoning). Therefore, it is considered an impact on habitat loss and fauna displacement / mortality. This is of particular concern when sensitive habitats such as wetlands and drainage lines are contaminated.

5.3.12.10 Potential impacts due to water abstraction

Should future 3D hydrogeological modelling results confirm a connection between the shallow aquifer and surface water bodies (Streams), the reduction in flow due to groundwater abstraction can potentially have a significant effect on the herpetofauna community leads to the reduction in aquatic habitat availability. Reduced habitat availability in this context can have severe negative consequences for breeding amphibians and the predators that rely on amphibians as food. Furthermore, a reduction in water volume compounds the impact of contamination from ore extraction chemicals as it effectively reduces the dilution effect and consequently increases the concentration in these systems, making them more toxic. Although Pensana currently plans to abstract only from borefields, should water need to be abstracted from the river or wetland, a separate biodiversity study will be conducted to evaluate this impact.

5.3.12.11 Mitigation measures

- Avoid vegetation removal in sensitive habitats (watercourses, drainage lines, and rivers shall be buffered by 200 m (from the water's edge during the wet season)). The watercourse and its buffer areas should be demarcated, and access restricted prior to construction to exclude the watercourse from development activities; Re-vegetation as part of the rehabilitation phase post-mining is critical to re-establish the baseline environment pre-mining conditions; Perform the majority of vegetation clearing activities during the dry season when herpetofauna migration and activity is reduced, and the likelihood of erosion from rainfall is reduced;
- Minimise the development footprint, where possible. In particular, attempt to preserve a portion of the elevated diatreme wherever possible;
- Consider layout and site alternatives for the proposed development infrastructure as required, which needs to be assessed and compared in order to select the option with the lowest impact;
- Provide any cleared trees to the local community as fuel to maximise utilisation of this resource and prevent acquisition thereof elsewhere;
- Induction for staff regarding the biodiversity on-site, sustainable utilisation of natural resources and the necessity for the conservation thereof – during operations allow herpetofauna to escape instead of intentional killing or to disregards such species;
- All vehicle speeds in the Project area shall be limited to 40 km/h (maximum) and drivers to undergo environmental awareness training;
- Speed humps need to be placed at pre-determined locations especially where roads intersect with drainage lines, wetlands and rivers, to force vehicles to reduce speed;
- Reduce direct mortalities by allowing for herpetofauna to cross the roads. This can be achieved by constructing fauna underpasses (large culverts or large open-ended concrete pipes laid into the raised roads). These underpasses should be used in conjunction with "fauna barriers" which prevent the most susceptible small fauna from crossing the roads on the surface by directing them towards the underpasses where they can cross under the roads safely. It is important to note that utilization of underpasses is strongly dependent on animal body size (larger culverts are more successful) and the surrounding habitat;
- Prohibit unauthorised entry into sensitive areas such as the carbonatite outcrop, watercourses and the surrounding natural areas;
- Vehicles shall not deviate from existing roads;
- No trade in natural resource products and bushmeat shall be allowed in the Project area. Integration with the Security Management Plan and Controls shall be implemented and enforced;
- All staff shall be subjected to an induction training program and regular toolbox talks where appropriate conservation principles, safety procedures, snake bite avoidance and first aid treatment are taught through the use of easy-to-understand study material. This will result in minimal negative interactions with herpetofauna and safe practises regarding to fire e.g. only smoking in designated areas, no open cooking fires etc. Furthermore, no hunting, trapping or trade in any fauna will be allowed in the Project Area and shall be specifically addressed during induction training;
- A qualified herpetologist must train designated staff to be able to capture and relocate potentially dangerous snake species safely;
- The use of Project-specific roads by local inhabitants shall be prevented by appropriate locked gates/ manned booms preventing unauthorized access;
- Where possible, excavations during the construction phase must be left open for as short as possible to avoid trapping herpetofauna and causing habitat fragmentation (open trenches preventing migration/dispersal). This can also be prevented by erecting fences and/or barriers for herpetofauna to make sure that species cannot fall into open trenches;
- All open excavations (especially linear trenches/drainage canals) must have at least one of the long sides constructed so that it slopes with an angle of less than 45° to allow for animals to crawl out. If not possible, then periodic (< 10 m apart) places for herpetofauna to crawl out (soil slopes < 45°) shall be provided temporarily until the excavation is closed;
- Any trapped herpetofauna unable to escape an excavation shall be captured and safely relocated to a suitable nearby habitat away from the construction activities. Staff trained by a qualified herpetologist must carry out the handling of snakes;

- Pathways such as the drainage lines radiating away from the proposed mining activities should serve as corridors to facilitate the safe movement of species across the landscape;
- Refer to dust, noise and visual mitigation measures (Sections 5.3.1, 5.3.4 and 5.3.7);
- Alien flora on-site shall be eradicated pre-construction and shall be actively monitored during the operation phase as part of the management plan (also see Section 5.3.11);
- Erosion control methods (even if only temporary) during the construction phase should be implemented to limit erosion (also see Section 5.3.5);
- Revegetation shall occur for any cleared land no longer being utilised by the mine;
- An effective stormwater management plan should be written and implemented during the construction and operational phases of the Project;
- No construction within the 200m buffer zone around watercourses;
- Construct a shallow channel and earthen berms to separate clean water runoff and prevent contamination from the TSF. Any overflow from the TSF and open pits must be directed into an appropriately lined return water dam (to be designed) with sediment traps;
- Construct a solid barrier fence (can be strong plastic / shade cloth against a wire fence, sunken into the ground for at least 20 cm deep and at least 60 cm high above soil surface) around TSF to prevent access by herpetofauna to the contaminated water. This will prevent direct mortalities and also, mortalities of fauna consuming corpses of contaminated individuals that may result in bio-accumulation of toxins;
- Apply only the minimum chemicals necessary for the task and according to industry best practice;
- Construction vehicles and machinery will be serviced regularly and away from sensitive habitats;
- A dedicated storage facility for all potentially hazardous chemicals will be constructed away from sensitive habitat types according to industry best practice;
- Should 3D hydrogeological modelling have confirmed connectivity between the shallow aquifer and surface water sources, avoid abstracting of ground volumes that would result in flow being reduced to below the ecological reserve limit necessary for the continued functioning of the surrounding rivers and streams.

5.3.12.12 Impact assessment

The herpetology impact assessment table is presented in Table 5–36.

Table 5-36: Herpetofauna impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence Direction N = Negative; P = Positive	 Duration Temporary – T; Short term – S; Medium term – M; Long term – L	 Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	 Frequency Low – L; Medium – M; High – H	 Magnitude Negligible – N; Low – L; Medium – M; High – H	 Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
Loss of existing habitat	COD	N	L	D	LSA	H	M	I	HIGH	See Section 5.3.12.11	MODERATE
Direct mortality of herpetofauna due to excavation and ore processing	CO	N	L	D	LSA	M	M	I	MODERATE	See Section 5.3.12.11	LOW
Direct mortality of herpetofauna due to increased traffic	CO	N	L	D	LSA	H	M	R	MODERATE	See Section 5.3.12.11	LOW
Mortality of herpetofauna due to an influx of people	COD	N	L	D	RSA	M	M	R	MODERATE	See Section 5.3.12.11	LOW
Disruption/alteration of ecological life cycles due to the restriction of species movement (migration/dispersal)	CO	N	L	H	LSA	M	M	R	MODERATE	See Section 5.3.12.11	LOW
Disruption/alteration of ecological life cycles (breeding, migration, feeding) due to noise, dust and lighting	CO	N	L	D	LSA	H	L	R	MODERATE	See Section 5.3.12.11	NEGLIGIBLE
Introduction of alien flora affecting native herpetofauna assemblages	COD	N	L	H	LSA	H	M	R	MODERATE	See Section 5.3.12.11	NEGLIGIBLE
Erosion from construction, infrastructure and excavations	COD	N	L	H	RSA	H	H	R	HIGH	See Section 5.3.12.11	MODERATE

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence Direction N = Negative; P = Positive	 Duration Temporary – T; Short term – S; Medium term – M; Long term – L	 Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	 Frequency Low – L; Medium – M; High – H	 Magnitude Negligible – N; Low – L; Medium – M; High – H	 Reversibility Reversible – R; Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
TSF Option A: Watercourse contamination from mine waste storage facilities	COD	N	L	M	RSA	L	L	R	MODERATE	See Section 5.3.12.11	LOW
Southern TSF: Watercourse contamination from mine waste storage facilities	COD	N	L	H	RSA	H	H	R	HIGH	See Section 5.3.12.11	MODERATE
Waste Dump, TSF Option A and southern TSF: Watercourse contamination due to chemical spillage	CO	N	L	L	RSA	L	H	I	HIGH	See Section 5.3.12.11	MODERATE
Potential impacts due to water abstraction	CO	N	S	H	RSA	H	M	R	MODERATE	See Section 5.3.12.11	NEGLIGIBLE

5.3.13 Critical habitat assessment

Critical Habitat (as defined by IFC PS 6) identification is required to manage risks and avoid, mitigate, and offset impacts to areas with high biodiversity and conservation value. A Critical Habitat Assessment (CHA) for the project area was conducted against the five established criteria as provided below:

- Criterion 1: habitat of significant importance to Critically Endangered (CR) and/or Endangered (EN) species;
- Criterion 2: habitat of significant importance to endemic and/or restricted-range species;
- Criterion 3: habitat supporting significant global concentrations of migratory species and/or congregatory species;
- Criterion 4: highly threatened and/or unique ecosystems; and/or
- Criterion 5: areas associated with key evolutionary processes.

Important habitat potentially classified as critical habitat of relevance to the Project can be simplified as follows: Riparian area and wetlands (aquatic ecosystems) and the fenite rocky outcrops.

5.3.13.1 Aquatic ecosystems

5.3.13.1.1 Critical Habitat Assessment: Criteria 1-3

The Aquatic Ecological specialist concluded that the river reaches relevant to the Project were modified from natural conditions. Through extensive agricultural activities, large-scale modification has resulted in significant flow, bed and channel modification in the assessed rivers. The extent of the transformation has resulted in altering of natural ichthyological and macroinvertebrate communities. No Critically Endangered or Endangered species of aquatic biota were observed or expected, thus not qualifying the Project area as critical habitat under criterion 1. Despite the extent of the modification, in the remaining limited extents of impacted river reaches, endemic, novel and migratory biota were observed, thus triggering Criterion 2 and Criterion 3. When the Project area and its ecological compositions were compared against the thresholds for Criterion 2 Tier 1 and Tier 2, both thresholds were not met, as the habitat assessed does not subjectively contain >1% of their global populations of the endemic and threatened species. Therefore, when the habitats were compared to the thresholds for Criterion 3 species, none of the thresholds was met indicating, that Criterion 3 was not triggered.

5.3.13.1.2 Critical Habitat Assessment: Criterion 4 -5

Limited information about the ecological category of the various waterbodies in Angola is available. However, considering the expansive areas in the study area that are not yet developed, the freshwater ecology in this specific area cannot be constituted as Criterion 4 habitat.

The presence of the Cuiva River cascades has likely created some degree of genetic isolation and, therefore, may support genetically unique subpopulations of various species. However, given the degree of modification in the study area, the considered watercourse cannot be classified under Criterion 5.

5.3.13.2 Terrestrial

Botany

None of the habitats is regarded as critical habitats from a botanical perspective.

Herpetofauna

The carbonatite outcrops and cliffs potentially provide refugia for rupicolous species (e.g. reptiles) and roosting areas to birds and small mammals. However, the outcrop is not typical in the immediate landscape and represents a suitable habitat for the endemic species. It is not considered likely that unknown herpetofauna species of conservation concern would inhabit this diatreme specifically given its small size and connectivity to the surrounding landscape. Therefore, it does not represent a fatal flaw or habitat requiring offset mitigation action for the proposed Project.

Avifauna and Mammals

Results of this avifaunal and mammal survey highlight the Carbonatite Outcrop as supporting a unique and essential avifaunal and mammal assemblage and is of High importance and sensitivity. Although the deep ravines, higher altitude grasslands and miombo woodland habitats associated with the hill also support several rare, SCC and endemic species, these habitats are more widespread and occur in relatively large expanses in the hills to the north-west of the project area and as such are of Moderate importance and sensitivity. All of the other habitats (proposed TSF areas, croplands, infrastructure and other degraded areas) are of low importance / sensitivity and are of little value to local mammal and birdlife and are assigned a Low sensitivity.

This project spans a period in which the IFC PS6 criteria on critical habitat were updated. Until early 2019 the Carbonatite outcrop qualified as a Tier 2 Critical Habitat from an avifaunal perspective. Under Criteria 2 b of the IFC Performance Standard 6 notes on critical habitat assessment which stated that habitat known to sustain ≥ 1 percent but < 95 percent of the global population of an endemic or restricted-range species/subspecies where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgement. However, the June 2019 update to IFC PS 6 excludes the 2b threshold making this point obsolete. Importantly, though, the habitat still qualifies as Critical Habitat under Criterion 3 of the updated version entitled; “International Finance Corporation’s Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, 2019” based on these caves acting as important bat roosts hosting a significant congregation of horseshoe bats[58].

Per IFC PS6 best practice guidelines, the High sensitivity carbonatite outcrop and its bat colony must be avoided. During the formulation of the mitigation measures presented in the ESIA, Pensana amended the mine plan through a change of the mining pit in order to avoid the sensitive carbonatite outcrop altogether. In addition, it is recommended that a robust long term monitoring plan is implemented and an action program to manage risks of adverse impacts on the bat colony. It is further recommended that the pair of cave chats be monitored simultaneously.

5.3.13.3 Conclusion

Impacts to Critical Habitat in the Project area will be limited and have primarily been avoided by changing the mining pit layout. Buffers will be in place to help manage and avoid these areas, as stipulated in the ESMP Section 1.

[58] As per GN77 of the Guidance Note: "Congregatory species are defined as species whose individuals gather in large groups on a cyclical or otherwise regular and/or predictable basis". Examples include the following:

- Species that form colonies;
- Species that form colonies for breeding purposes and/or where large numbers of individuals of a species gather at the same time for non-breeding purposes (for example, foraging and roosting);
- Species that utilize a bottleneck site where significant numbers of individuals of a species occur in a concentrated period of time (for example, for migration);
- Species with large but clumped distributions where a many individuals may be concentrated in a single or a few sites while the rest of the species is largely dispersed; and
- Source populations where certain sites hold populations of species that make an inordinate contribution to recruitment of the species elsewhere (especially important for marine species).

5.3.14 Socio-economic

Reference

Specialist study 11 – Appendix N

Key specialists

Steve Horak – HCV Africa, South Africa
Ana Ramos – Grupo Simples, Angola

Study objectives

The aim of the socio-economic impact assessment (SIA) will be to provide an accurate representation of the social, cultural and economic conditions of the population surrounding the proposed Project, assess the impact on these conditions and provide mitigation measures for any impacts.

5.3.14.1 Summary of the anticipated socio-economic impacts

Every attempt will be made to avoid the physical resettlement of households living in the study area, including mine design changes. However, the most significant socio-economic impact will be the loss of farm land, and access to land to farm and sustain livelihoods and this equates to economic displacement or replacement of the affected households' fields. In the following sections, reference is made to a resettlement plan, and this is not the physical resettlement of communities but the economic resettlement of the subsistence farmers tilling the land in the mining footprint. Adequate analysis and recognition of the potential impacts are crucial to counteract the risk of the impoverishment of these households associated with the livelihood displacement of fields.

The anticipated socio-economic impacts are summarised and described in Table 5–37 below, and where it adds value to the text presented in Table 5–37.

Table 5–37: Positive and Negative Socio-Economic Impacts

Impact identified	Description
POSITIVE IMPACTS	
Local Job Creation.	To be considered sustainable, mining needs to adhere to ecological sustainability, economic vitality, and social equity. With the creation of job opportunities, the mine can create a platform for improving local labour skills. It can allow villagers to (i) access employment, (ii) improve literacy levels, and (iii) improve job security. However, secured income is difficult for residents of the villages surveyed.
Long term employment and economic benefits	Secure employment will increase disposable income and spending power.
Training and skills development opportunities	The mining operation presents the opportunity for training and development. The Project would substantially contribute to the economy in terms of contributions to the development of human capital, particularly at a local scale.
NEGATIVE IMPACTS	
Arrival of construction teams and construction camp	Teams will be housed in a camp that will significantly impact comparing numbers to sizes of villages. In addition, the level of activity for construction will impact the levels of noise and air quality, road use and disturb the generally tranquil setting.
Influx of jobseekers and others looking for opportunities	The Project is highly likely to attract people because unemployment rates are generally high (throughout Angola), with few opportunities. In-migration can result in numerous people arriving and is commonly associated with conflict (cultural norms and values, and even physical conflict), and anxiety. The influx can also result in the establishment and growth of informal settlements.
Impacts on current service and infrastructure	There is precious little infrastructure and services in the LSA and RSA, but in-migration could strain the systems (such as medical supplies at the clinics that do not meet current needs, nor are there sufficient schools).
Loss of access to and use of land	The villages are all land-dependent for their livelihoods and existence, and land is passed from one generation to the next though there are no official papers. Thus, they occupy and use land through tenureship. The extent to villagers farm land has not been determined to date by a land survey. Should the mine be approved and move into the construction phase, this will need to happen. The loss of access to land (through destruction of paths and roads) and loss of land amounts to economic resettlement and all that this entails (loss of productive assets, livelihoods and use of land etc). Assets such as trees that are harvested annually or crops grown annually will need to be compensated for, or alternative land found for villagers.
Impoverishment	The risk of impoverishment for farmers currently farming in the mine footprint is high. The displacement of these farmers interrupts the indigenous production system and the way of life villagers have developed to maintain their livelihoods.
Ecosystem services	Communities are dependent on provisioning services and can be negatively impacted by:

Impact identified	Description
	• Changes to water quality and quantity would be harmful to their welfare and lives; • Loss of trees and vegetation used for fuel and construction; and • Soil – loss of access to new areas or the *nacas* would result in decrease food production and increase food insecurity (which is a pre-existing problem).
Impacts on water resources	Communities are reliant on groundwater and / or surface water, both of which could be impacted by the mine, including: • Quantity – loss of water caused by over-extraction for the Project (lowering of water levels or drying up of rivers, and/or lowering water-table in community wells); • Run-off and effluent associated with the TSF, ROM pads and pollution control dams: o Impacts (and mitigation) on the water are addressed in the hydrology component of the ESIA – section 5.3.3. and 8.15.
Health impacts	There are two main aspects to health – occupational health and safety (OHS) and community health. OHS: risks include • Health risks such as disease caused by working in dusty environments and using hazardous chemicals. • Accidents and injuries – through use of equipment, fatigue, lack of training, working in hazardous areas (such as in excavations), stings / bites from snakes, scorpions and insects, and road traffic accidents. • Outside the ESIA, Pensana / Ozango has a stand-alone H&S Management Strategy, H&S Management Plan and Emergency Response Plan (ERP) to manage health and safety-related risks. See section 8.12. Community health and safety: • Increase in infections through a change of social behaviours (e.g., STIs, HIV/AIDS) and living conditions (e.g., increased tuberculosis). • Accidents and injuries – road traffic accidents, interacting with mine equipment and infrastructure.
Increased food insecurity	Food insecurity is a significant impoverishment risk associated with resettlement (economic displacement). Increasing the risk that affected households will fall into food insecurity. Crops in the study area are predominantly cultivated for household consumption, and farmers are vulnerable to seasonal risks. A failed crop means hunger and starvation for villagers.
Cultural heritage	See section 5.3.15

5.3.14.2 Local job creation and joblessness

IFC PS 5 requires land-based resettlement strategies for physically and economically displaced households previously dependent on land-based livelihoods. The Project will create the opportunity for local jobs directly on the mine and in the local area indirectly through the local economy by supplying of goods and services to the mine. Should the resettlement plan recommend that affected households transition from a land-based livelihood to a wage-based livelihood, then a clear implementation plan would be necessary. This plan needs to consider the current level of skill and language spoken by affected households and indicate how they can be absorbed into the workforce. Best practice for socially responsible resettlement recognises that creating new jobs is difficult and requires substantial investments.

5.3.14.3 Long term employment and economic benefits

There are very few employment opportunities in the local Project area. The mine is planned as a contract mining operation. The mining contractor will provide most of the labour force, mobile mining plant, and all of the required mining infrastructure, for example offices and workshops, stores, diesel and lubricant storage. Ozango will be in charge of the operation of processing facilities, logistics and other relevant areas. It is planned to employ approximately 500 people during the operational phase. Employment of Angolan nationals will take place wherever possible in accordance with the Angolanisation Principle (or the 70% - 30% Ratio Principle), whereby at least 70% of the workforce employed must be Angolan and only 30% may be expatriates. Expatriate candidates will only be considered after the vacancy has been advertised in Angola and if no Angolan national candidate is suitable for the position. . The numbers are preliminary and will be confirmed once the contractors have been selected and appointed. The mine has also committed to purchasing as much of its goods and services from the local economy, which will be of long-term benefit. The local workforce on the mine will also provide local buying power, which will stimulate the local economy.

Mitigation through the optimization of benefits stemming from employment can be achieved by focusing on recruiting locally where this is possible. This should be facilitated by a) supporting the growth of local businesses to make sure that that they are increasingly more capable of supplying the goods and services needed for the Projects and b) the sufficient availability of labour in the local area.

Mitigation in the form of benefit enhancement during both the construction and operation phases should focus on the following areas:

- Targets should preferably be set for how much local labour should be used based on the needs of the mine and the availability of existing skills and people that are willing to undergo training. Opportunities for training unskilled and skilled workers from local communities should be maximised.
- Local sub-contractors should be used where possible, and contractors from outside the local area that tender for work should also be required to meet targets for how many locals are given employment.
- Before the construction phase commences, Ozango should meet with representatives from the local municipality to establish a skills database for the area.
- Where feasible, a training and skills development programme for local workers should be initiated prior to the construction phase.
- The recruitment selection process should seek to promote gender equality and consider the request from stakeholders to involve traditional leaders.
- The local authorities, community representatives and organisations on the interested and affected party database should be informed of the final decision regarding the Projects and the potential job opportunities for locals, and the employment procedures that Ozango intends to follow for the construction and operation phases of the mine.

5.3.14.4 Training and skills development

Residents from the affected communities are farmers by trade with low levels of education and who speak Umbundu as their first language. These residents who will seek a job from the mine to replace their source of income due to the loss of land.

The Project would substantially contribute to the economy and help safeguard against adverse social impacts by contributing to the development of human capital, particularly at a local scale. The staff employed directly by the mine, and the staff employed by contractors, will gain valuable experience leading to the development of the skills base in the municipality concerned. This impact will be especially significant due to the lack of education and training opportunities currently available to the mine communities, and the development of skills that will occur on-the-job.

The potential benefits associated with standard training and skills development can be enhanced in the following ways:

- It would be advantageous for training and skills development programmes to include basic information on financial management, thus allowing qualified technicians to manage their finances well, and potentially manage the finances of any future enterprises they may work to develop.
- Other focus areas could include offering practical short courses on the following:
    - computer literacy;
    - basic electrical training;
    - carpentry;
    - painting;
    - plastering;
    - plumbing;
    - tiling;
    - motor mechanics; and
    - welding and torch-cutting.

5.3.14.5 Landlessness

Landlessness is listed as one of the impoverishment risks associated with economic resettlement. This is because expropriation of land removes the primary foundation upon which households productive system, commercial activities and livelihood are constructed. In addition, land and natural resources are central to the culture and livelihoods of people living in the villages surrounding the mine footprint.

The land is inherited, and the sobas / chiefs have secured user rights.. The villagers, therefore, have land tenure even if this is not supported by formal documentation. The agricultural fields have not been surveyed, which will need to happen before construction starts. This inventory is needed to inform the economic resettlement plan. The World Bank advises that the key to sound resettlement is to adopt a people-centred development policy instead of a property-compensation policy. Due to glaring poverty in the villages affected by the proposed mine, the heart of the resettlement plan would need to be prevention of impoverishment and reconstruction of livelihoods where compensation for lost lands and or allocations of alternative land is a component.

5.3.14.6 Homelessness and 'placelessness'

The mine will create a fundamental change in the sense of place. Currently the communities are isolated and live a simple rural subsistence farming lifestyle. The construction of the mine will create a built environment completely different from what is presently in place, which is predominantly agricultural lands and grazing on the Chimbilundo Hill ("Tchimbilundo"). Once the mine is operational, it will create a semi-industrialised environment with large earth-moving equipment and a processing plant, tailings facility, pollution control dams, open pit mine, accommodation village and offices, and access roads. This is very different from the current rural setting.

5.3.14.7 Marginalization

Marginalisation occurs when affected households cannot fully restore lost economic capacity, and the household is placed on a downward mobility path. For some farmers, loss of access to the more fertile land along the water ways is significant and will result in the loss of higher-yielding crops. There is potentially the risk of gradual marginalisation resulting from the jobs given to the affected farmers proving to be temporary or unsustainable. The resettlement plan needs to consider the profile of each affected farmer and match the reestablishment plan appropriately.

5.3.14.8 Increased morbidity and mortality

The World Bank recognizes that significant decreases in health levels result from displacement-caused social stress, insecurity and psychological traumas. In addition, relocation-related diseases are parasitic and vector-borne, and unsafe water sources heighten vulnerability.

5.3.14.9 Food insecurity

Food insecurity is a significant impoverishment risk associated with resettlement (economic displacement). Forced uprooting increases the risk of affected households falling into chronic undernourishment and food insecurity. Crops in the study area are predominantly cultivated for household consumption, and farmers are vulnerable to seasonal risks. A failed crop means hunger and starvation for a family.

Therefore, the resettlement action plan needs to define support to enable food production at the new allocated farming site.

5.3.14.10 Loss of access to common property

For poor people, particularly landless and asset-less, loss of access to common (non-individual) land represents a significant form of livelihood deterioration. On the other hand, for farmers in the study area, access to the fertile land along the watercourse, hunting in the wooded areas and grazing on the Tchimbilundo hills accounts for a significant contribution to sustaining their livelihoods.

5.3.14.11 Social disintegration

The impact of the unravelling of social networks amongst households farming land in the mining footprint is difficult to define. The impact of economic displacement is the unravelling of these networks and the loss of social capital. These networks, established around a common interest and a place of need, are hard to rebuild.

An anticipated impact is the disarticulation of the cultural heritage and the traditional land allocation by the Soba or Cultural Head of the Village.

The labour influx and camp set up in the local area will impact the social network and community cohesion. Teams will be housed in a camp that will significantly impact the numbers and size of villages into account. The activity level for construction will impact the background levels of noise, air quality and road use and disturb the generally tranquil setting. To fully understand the impact of the labour influx, the Project team needs to understand;

- Size of and skills needed for the construction workforce. (Estimate 300 – 400 jobs available during construction, where half will be available to the local Angolan population. This is subject to the mining contractor appointed. Pensana/Ozango's staff complement will be up to 150 during the construction phase).
- During operation, the number of job opportunities will increase. It is estimated that the Pensana/Ozango staff compliment will be up to 536 during the operational phase, with the contract mining staff members, which is currently unknown as this depends on the appointed mining contractor.
- Company policies to hiring and procurement
- Local socio-economic context drivers – are huge as employment opportunities in the area are limited, and the demand for employment is high.

5.3.14.12 Influx of job-seekers and others looking for opportunities

The Project is highly likely to attract people to the area because unemployment rates are generally high (throughout Angola), and opportunities are few. In-migration can result in numerous people arriving and is commonly associated with conflict (cultural norms and values, and even physical action), and anxiety.

5.3.14.13 Impacts on current service and infrastructure

The influx of job seekers can create added pressure on services and infrastructure, which is already stretched. For example, there are insufficient schools and clinics in the area, and the local administration struggles to meet community service needs. The additional people \ attracted to the area will add to this pressure.

5.3.14.14 Ecosystem services

Communities are dependent on provisioning services and can be negatively impacted by:

- Changes to water quality and quantity would be detrimental to their welfare and lives.
- Loss of trees and vegetation – used for fuel and construction.
- Soil – loss of access to new areas or the "*nacas*" would decrease food production and increase food insecurity (which is already a problem).
- Loss of grazing for cattle and goats.
- Loss of access to land and loss of hunting, which is the source of protein in the diet of many households.

5.3.14.15 Impacts on water resources

The mine could potentially impact water resources both in terms of water quantity due to pit dewatering which will lower the water table and water quality from the processing plant and pollution control dams. The mitigation of these impacts is to make sure that that community boreholes are protected as far as possible, and where they are impacted, to provide an alternative water source. In terms of water quality, the mitigations are to separate clean and dirty water and to make sure that that the pollution control dams are correctly lined and managed. The hydrological specialist study needs to mitigate the water resource impacts.

5.3.14.16 Health impacts

There are two main aspects to health: occupational health and safety (OHS) and community health and safety.

OHS: risks include

- Health risks such as disease caused by working in dusty environments and using hazardous chemicals.
- Accidents and injuries – through use of equipment, fatigue, lack of training, working in hazardous areas (such as in the pit), working in the processing plant and being exposed to processing chemicals, and road traffic accidents.

Community health and safety:

- Increase in infections through a change of social behaviours due to the influx of people (e.g., STIs, HIV/AIDS) and living conditions (e.g., increased tuberculosis);
- Risk of COVID-19; and
- Accidents and injuries – road traffic accidents, interacting with mine equipment and infrastructure.

Impacts applicable to both aspects are:

- Exposure to hazardous substances from the processing plant and pollution control dams (e.g., skin irritations and respiratory tract irritation); and
- Particulate matter from mine equipment and access roads, Run of Mine (ROM) pads, waste rock dumps and tailings facility.

Note that Pensana/Ozango has a stand-alone Safety Health Risk Management Strategy and a Health and Safety Management Plan. Kindly refer to these documents for further information and also section 8.12.

Table 5–38:Socio-economic impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence: Direction N = Negative; P = Positive	Incidence: Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Incidence: Probability – Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Severity: Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Severity: Frequency – Low – L; Medium – M; High – H	Severity: Magnitude – Negligible – N; Low – L; Medium – M; High – H	Severity: Reversibility Reversible – R Irreversible – I	Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
POSITIVE IMPACTS											
Creation of employment and income opportunities (construction)	C O	P	M	D	LSA RSA B-RSA	L	L	R	Low	• Opportunities for the training of unskilled and skilled workers from local communities should be maximized • Promote local procurement of goods and services wherever possible • Develop a local skills database to recruit local labour • Develop a training and skills development programme prior to commencement of construction • Promote gender equality • Engage local leadership	Moderate (positive)
Creation of employment and income opportunities (operation)	C O	P	L	H	B-RSA	H	M	R	Moderate	• Focus training on needs identified in the local economy • Inclusion of training in financial management to improve sustainability	High (positive)

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability – Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency – Low – L; Medium – M; High – H	Magnitude – Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Employment benefits	C O	P	L	H	LSA RSA and B-RSA	H	M	R	Moderate	• Develop employment and hiring policy • Develop key messages to manage expectations and communicate to local communities	High (positive)
Training and skills development opportunities	O	P	L	D	LSA RSA	M	H	R	Moderate	• Focus training on needs identified in the local economy • Inclusion of training in financial management to improve sustainability	High (positive)
Transport, infrastructure and communication	O	P	M-L	H	LSA	L	H	R	Low	• Ozango to engage with authorities and service providers to highlight the Project and potential for increased population, customers and disposable income plus revenues derived from taxes	High (positive)

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability – Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency – Low – L; Medium – M; High – H	Magnitude – Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
NEGATIVE IMPACTS											
Change to sense of place that currently prevails amongst communities	C O	N	L – permanent	H	LSA RSA	H	H	I	High	• Develop policies and management plans for contractors and employees with particular reference to respecting the host communities, their cultural norms and standards • Communicate with villagers throughout all phases of the Project, including pre-construction • Develop a stakeholder engagement plan (SEP) for the life of mine that documents activities, roles and responsibilities	Moderate

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S, Medium term – M; Long term – L	Probability – Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency – Low – L; Medium – M; High – H	Magnitude – Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Arrival of construction teams and construction camp – disruption to local communities	C	N	S	H	LSA	H	H	R	High	• ESMP to be included in contract documents • Contractors to include method statements and update ESMP in their bids • Carry out audits daily during mine establishment and adjust the frequency of audits according to contractors' performance • Included in contracts policies to instruct contractors how to engage with local communities	Moderate
Influx of job-seekers and opportunities	C O	N	T – L	H	LSA	M	M – H	R	Moderate	• Develop an influx management plan • Develop key messages and communicate as widely as possible referring to employment policy • Key messages should include when and where applications from job-seekers are accepted (i.e., not on the site in order to dissuade people from setting up camp on or near the mine)	Moderate

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability – Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency – Low – L; Medium – M; High – H	Magnitude – Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Increased pressure on current services and infrastructure	C O	N	T - L	H	LSA RSA	H	H	R	High	• Influx management plan • Work with regional authorities to identify reasonable measures to support service provision • Work with national government to reinforce services.	Moderate
Loss of land including access to land	C	N	T – permanent	H	LSA	M	H	R	High	• Complete RAP and livelihood restoration plan • Include grievance procedure in SEP	Moderate
Impoverishment	CO	N	L	D	LSA	H	H	R	High	• Develop a livelihood restoration plan	Moderate

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S; Medium term – M; Long term – L	Probability – Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA; Regional – RSA; Beyond RSA – B-RSA	Frequency – Low – L; Medium – M; High – H	Magnitude – Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R; Irreversible – I			
Ecosystem services	C O	N	L	M – H	LSA RSA	M	H	I	Moderate	• Adopt mitigation measures provided in specialist sections (water, aquatic ecology, terrestrial ecology) • Include well protection and water resources in community development plans	Moderate
Impacts on water resources	C O	N	L	M – H	LSA RSA	M	H	R	Moderate	• Adopt mitigation measures provided in specialist reports (water, aquatic ecology, terrestrial ecology)	Moderate
Health impacts	C O	N	L	M	LSA RSA	M	H		High	• Refer to H&S Management Plan • Refer to Occupation Safety Management Plan • Reduce risks by adopting measures in specialist reports including water, air quality, noise	Moderate

5.3.15 Cultural heritage

The Cultural Heritage study identified that the *Serra do Tchimbilundu Chapel's ruin*, has a symbolic value for residents in the Longonjo area. Based on anecdotal evidence, the chapel was built for pilgrimages. The chapel has not been in use for a long time as the Angolan civil war destroyed the chapel and only ruins remain. Nevertheless, the local community still believes in its importance, and it is viewed that its preservation is necessary for symbolic and referential value.

<u>There are eight graves sites located in the Project polygon (as per</u>

Figure 5-23 below). The communities are largely Christian, therefore their tangible assets are churches and graves sites. No monuments or historic sites were identified by the communities during consultation, and they do not have sacred sites. Since the churches are outside the footprint of the Project, they will not be impacted. There are three informal graves sites in the zone of influence of the proposed TSF9/10, where one is within the footprint of TSF9/10. Informal graves sites should be fenced and actively protected by avoiding any mining activity in the vicinity of the graves. If this is not possible, a formal process of grave relocation must be followed, in accordance with the law and with thorough consultation with relevant families and community leadership.

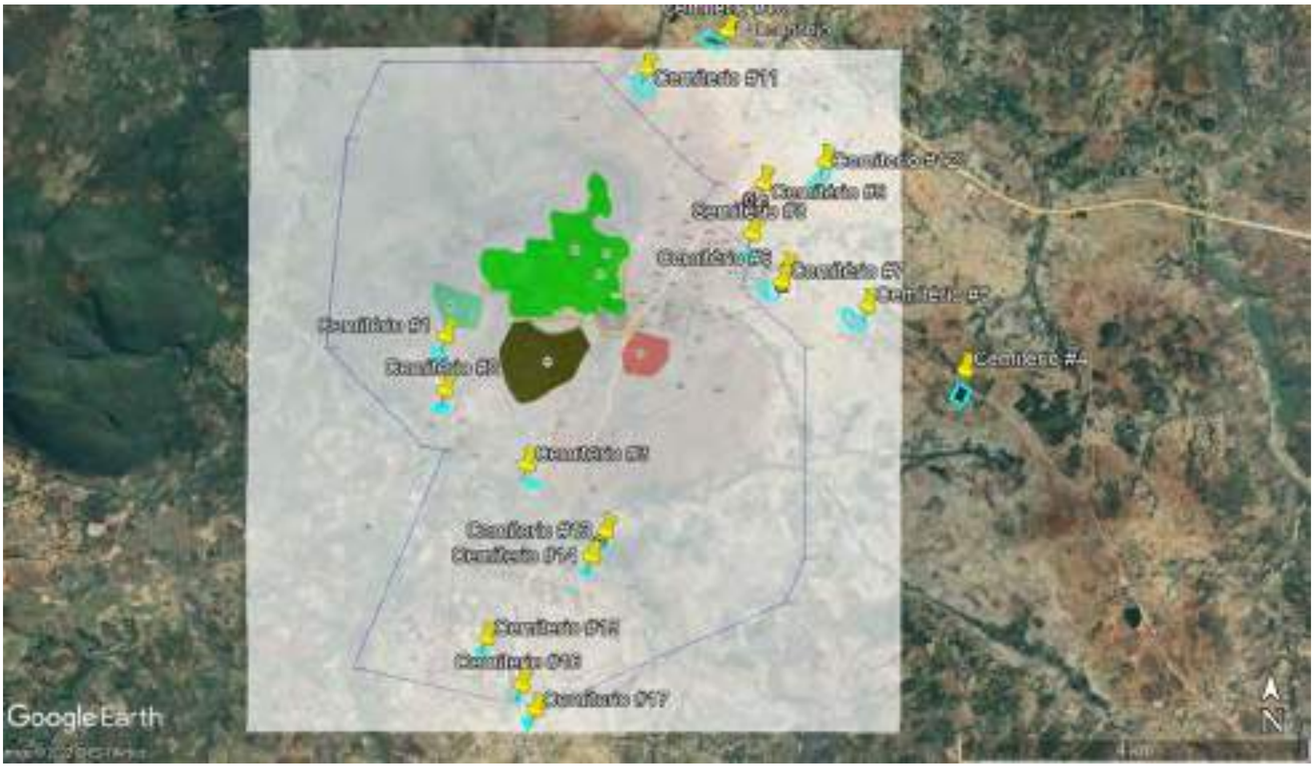

Figure 5-23: Informal graves sites

5.3.15.1 Impact assessment

The cultural heritage impact assessment table is presented in Table 5–39.

Table 5-39: Cultural heritage impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S …	Probability Unlikely – U; Low – L Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R Irreversible – I			
Cultural heritage	C O	N	T	L	LSA	L	L	I	Medium	• The ruins of the Serra do Tchimbilundu Chapel must be left in situ, and the mine activities should not impact this site. Pensana has effectively avoided these ruins by changing the pit layout to avoid the ruins. • Develop a chance-find procedure to manage any artefacts that are uncovered during construction or when excavating ground throughout the life of mine • There are three informal graves sites in the zone of influence of the proposed TSF9/10, where one is within the footprint of TSF9/10. Informal graves sites should be fenced and actively protected by avoiding any mining activity in the vicinity of the informal graves sites. If this is not possible, a formal process of grave relocation must be followed, in accordance with the law and with thorough consultation with relevant families and community leadership.	Low

5.3.16 Traffic

Traffic will increase during the construction phase and remain higher than baseline conditions throughout the operation. Traffic is expected to include the main Longonjo road, access- and haul roads, and the new proposed eastern bypass road. However, it should be noted that the Project may trigger other development in the area and lead to a general increase in traffic volumes over time.

Negative impacts will include air quality, noise, health and safety.

5.3.16.1 Mitigation measures

Mitigation includes:

- Spraying gravel roads with water to suppress dust or using a commercial product to seal surfaces (which is likely to be more costly than using water;
- Maintaining all vehicles to minimise emissions and noise;
- Implement speed control measures (e.g. speedbumps) and appropriate signage to keep speeds to less than 40km/h on all mine roads;
- Induction and training for drivers / operators so they:
  - Take full responsibility for their actions as road-users;
  - Are trained in first-aid;
  - Check that they have spill kits in their vehicles before starting shifts;
  - Do routine checks before driving (check lights, indicators, washers and safety belts);
  - Have a procedure in case of accidents/incidents;
- Put up warning signs at road junctions and in strategic places on-site;
- Enforce speed limits on the Project site, public roads in the vicinity of the Project and close to villages; and
- Develop and implement a traffic management plan prior to the commencement of the construction phase.

5.3.16.2 Impact assessment

The traffic impact assessment table is presented in Table 5–40.

Table 5–40:Traffic impact assessment table

IMPACT	Project phase Construction – C; Operation – O; Decommissioning – D	Incidence			Severity				Environmental and Social Consequence before mitigation	Mitigation Measure(s)	Environmental and Social Consequence after mitigation
		Direction N = Negative; P = Positive	Duration Temporary – T; Short term – S	Probability Unlikely – U; Low – L; Medium – M; High – H; Definite – D	Geographic Reach Site/local – LSA Regional – RSA Beyond RSA – B-RSA	Frequency Low – L; Medium – M; High – H	Magnitude Negligible – N; Low – L; Medium – M; High – H	Reversibility Reversible – R Irreversible – I			
Increase in traffic on the main Longonjo road, access haul roads, and eastern bypass road – health and safety impacts	C,O	N	L	D	LSA	H	H	I	High	• Develop a traffic management plan; • Provide awareness to local communities regarding road safety; • All vehicle speeds in the Project area shall be limited to 40 km/h (maximum); • Speed humps need to be placed at pre-determined locations, especially where roads intersect with drainage lines, wetlands and rivers, to force vehicles to reduce speed; and • All staff operating motor vehicles must undergo safe driving training and environmental induction training courses that include instruction on the need to comply with speed limits, to respect all forms of wildlife (especially terrestrial birds and large mammals) and, wherever possible, prevent accidental road kills of fauna.	Moderate

6 STAKEHOLDER ENGAGEMENT PLAN AND STAKEHOLDER ENGAGEMENT

This section presents the stakeholder engagement plan (SEP) associated with the ESIA and a summary of the stakeholder engagement (or public consultation) undertaken for the Project. Stakeholder engagement (SE) for an ESIA is a separate but parallel process initiated in the scoping phase.

The objective of the SEP is to share information about the Project and obtain comments and feedback from local stakeholders and affected parties. HCV Africa undertakes the Stakeholder Engagement following International Standards (IFC Performance Standards) and in complies with Angolan Legislation. Pensana / Ozango recognises the specific requirements due to the potential of land acquisition and the displacement of communities and households, and the need to safeguard against adverse social impacts.

Stakeholder Engagement was initiated during the reconnaissance visit to the site in 2019. As a result, stakeholders were identified, and the first round of consultation was held during the scoping phase in June 2019. The second round of consultation was undertaken during the Social Impact Assessment in September 2019, updated in 2021.

It should be noted that in Angola, the responsible authorities undertake a separate round of public consultation (defined as a Public Hearing, arranged by the MCTA after the completion of the ESIA) so that the authorities can verify that due process has been followed (i.e., the ESIA process has complied with legislative and regulatory requirements). The findings of the authority public consultation assist them in deciding about whether the Project should go ahead.

6.1 Objectives stakeholder engagement

The objectives of the Stakeholder Engagement Programme are:

- Identification of project stakeholders (who may be directly or indirectly affected by the Project);
- Developing mechanisms for stakeholder feedback and information sharing;
- Consultation at local and national levels throughout the ESIA construction, operation and decommissioning of the site;
- Identification of project impacts and information based on interaction with local stakeholders (local knowledge);
- Identification of acceptable ways to avoid, minimize or offset adverse impacts and optimize benefits;
- Address issues that project stakeholders raise;
- Identify resources required to implement the plan and development of procedures to monitor implementation;
- To identify communities and other stakeholders who will be affected by the Project or have an interest in it;
- To identify issues or concerns;
- To gain local knowledge and experience; and
- Capture / record issues, comments and suggestions that stakeholders have raised.

6.2 Stakeholder engagement plan

The (Stakeholder Engagement Plan) SEP outlined in this section refers to the SE that takes place in parallel with the ESIA technical process. Consultation and stakeholder engagement that will take place **for the life of the Mine** will require a comprehensive, stand-alone SEP produced post-ESIA. The SEP for the ESIA can be used as a foundation for compiling the life-of-mine SEP, which should be incorporated into the Project Environmental and Social Management System (ESMS) as required for IFC Performance Standard 1. This SEP could be revised and updated to reflect the ongoing SE that will continue beyond the ESIA. A SEP is a material requirement for projects that may have significant (negative) impacts and are funded by Equator Principles Funding Institutions (EPFIs) or the IFC.

SE comprises a range of activities and interactions with individuals and groups (stakeholders) including, among other things:

- Identification of project stakeholders (who may be directly or indirectly affected by the Project);
- Developing mechanisms for stakeholder feedback and information sharing;
- Consultation at local and national levels throughout the ESIA construction, operation and decommissioning of the site;
- Identification of project impacts and information based on interaction with local stakeholders (local knowledge);
- Identification of acceptable ways to avoid, minimize or offset adverse impacts and optimize benefits;
- Addressing issues that project stakeholders raise;
- Identification of the resources required to implement the plan and development of procedures to monitor implementation; and
- Developing a r a robust and transparent complaint and grievance mechanism for project stakeholders.

6.2.1 Reasons for stakeholder engagement

Good international industry practice (GIIP) (as per IFC PS1 and International Association of Public Participation (IAP2)) state that a public consultation (aka SE) process creates trust and builds relationships between project proponents and others. SE raises awareness and understanding of projects by sharing project information and involving communities in dialogue, stakeholders include those directly and indirectly affected by a project.

SE is an iterative process that should begin at the conceptual project stage and develop continually as the relationship with stakeholders evolves.

6.2.2 Stakeholder categorisation and identification

Consultation takes place with representatives or spokespeople of different sectors of society, rather than with every individual in a project area. Nevertheless, special efforts are made to obtain the contributions of all people who may be affected directly by the proposed Project, particularly marginalised groups like women and the youth. A stakeholder database will be developed which records details of individuals and organisations.

Stakeholders include:

- National, regional and local government departments;
- Local authorities and traditional leaders;
- Local communities living in the vicinity of the proposed mine, some of whom farm on the footprint of the proposed mine and make use of natural resources (ecosystem services). One village is located in the mine lease area although not located on the mining infrastructure footprint;
- Those whose livelihoods may be affected by the Project;
- Non-governmental organisations (NGOs) and community-based organisations (CBOs);
- Customary institutions and representatives;
- Academic institutes;
- Labour organisations; and
- Media.

6.3 Social context of consultation

There are 5 villages in proximity the Project, and one village, Tchakengenga, is located in the Project polygon – but outside of the Project infrastructure footprint. All 6 villages are rural and depend on agriculture to sustain their households. As obtained from the survey, households vary in size between 2 and 18 members, with the average being 7 per household. The official statistics for the Longonjo commune indicates the average number of people per household to be 4.6.

Most community members were born in the villages, land for agricultural use has been transferred according to local 'cultural' or 'traditional' rules for between 80 to 100 years. Cultivation of crops is similar across all villages, a portion of land is cultivated adjacent to the house and another in the fertile soils alongside the watercourse, known as the '*Nacas*' or '*Onaka*'. These are viewed as valuable assets allowing for cultivation during the dry season. Cultivated crops are cassava, maize, sweet potato, beans, tomatoes, onions and garlic (cassava, maize and beans are the staple crops). Animals are reared in the villages, but villagers rarely eat meat (once or twice a month). Animals are used primarily for trading and raising money, as and when needed. Likewise, eggs are not eaten as they are left to hatch and produce more chickens.

Communities are land-dependent for their livelihood and existence (i.e. ecosystem services are crucial to survival). Cultivated crops are the predominant source of food, and some hunt in the adjacent woodland areas and catch fish as an additional source of protein.

Infrastructure and services are inadequate. There is no electricity supply, energy for cooking is obtained from wood and charcoal, light is provided through kerosene lanterns or fire. Household water supply is from hand pumps and nearby streams. For most villages, except for Tena, the closest Health Facility is the Municipal Hospital in Longonjo. Residents of Tena use the health facility in Chingongo. Walking is the predominant means of getting to fields, schools and neighbouring villages. The roads giving access to the villages are dirt tracks which would be difficult to access during wet seasons.

6.4 Identified project stakeholders

The main stakeholders identified for the Longonjo Project are shown in Table 6–1.

Table 6–1: Stakeholders identified for Longonjo Project

#	Name	Organisation
1	Mr. Bonifácio Vissetaca	Municipal Administrator Longonjo Municipality
2	Mr Leonardo Sapalo	Vice Governor for Technical Services and Infrastructures (Huambo Province)
3	Cidália Odeth B. Gomes	Provincial Director – NGO: Action for Rural Development and Environment (ADRA)
4	Mr Guilherme Dário	Soba Granda
5	Mr. Alberto Carvalho	Soba Camaco Village
6	Mr. Bernardo Nguelengue	Soba Chianga Village
7	Mr Adriano Chivela	Soba Lucamba Village
8	Sr. Maravilho Bongo	Soba Lumingo Village
9	Mr Cajamba	Seculo Lumingo Village
10	Mr Bento Sabino	Soba Tchakengenga Village
11	Mr Cambolo	Soba Tena Village
12	-	Colela Lucamba Farming Association
13	Adalberto Pascoal Lopes	NGO – ADRA (Action for Rural Development and Environment)
14	Joana Lina	Huambo Provincial Governor
15	Angelino Elavoco	Director- Provincial Office for Integrated Economic Development
16	César de Osvaldo Pakissi	Environmentalist- Provincial Office of Environment
18	Abrantes C.S. Carlos	Agronomist Engineer/ Director of the Provincial Office of Agriculture, Livestock and Fisheries
19	Amilcar Cabral Gomes	Geologist/ Head of Mineral Resources Department
20	Celestino Sequendo Essumi	Lawyer/Provincial Government (Huambo)
21	Manuel Vitongue	Agro economist/Provincial Government Office
22	Calunga Quissanga	Architect /Assessor for infrastructure and technical services
23	Benvindo Maria Kalukenhe	Director/Media Office
24	André Buta Neto	National Director of Mineral Resources / MIREMPET

6.5 Schedule and consultation activities

The overall schedule of consultation is presented in Table 6–2.

Table 6–2: Stakeholder engagement per project phase

Stakeholder engagement meetings and activities		
Project Phase	**Date**	**Meeting / Notes**
Scoping Phase – Initial consultation and introduction of the proposed mining development	June 2019	Meeting to introduce the Project and ESIA team to: • Vice Governor for Technical Services and Infrastructures (Huambo Province) • Municipal Administrator (Longonjo) • ADRA (Action for Rural Development and Environment) Provincial Director and representatives of the Social Area (Longonjo) • Traditional authorities (Soba) and general Public • Local Communities (Camaco/ Pista Village, Lumingo Village, Tchakengenga Village, Lucamba Village, Chianga Village)
Baseline Study Phase	June 2019	Engagement with Stakeholders for: • Preliminary identification of issues and aspects relating to land tenure, socio-cultural and livelihoods. • Preliminary discussions with community representatives. Inputs to draft scoping report.
Baseline Study Phase	June 2019	• Undertake fieldwork • Focus group meetings • Participatory mapping • Household questionnaire • Maintain communications / consultation with stakeholders • Collect all questionnaires submitted to the Longonjo Municipality and Huambo Province Offices.
Impact Assessment Phase	September and October 2019	• Report-back on survey results, impact assessment, findings and mitigation – with reference to comments, questions and issues raised during consultation. • Updated information ....
Amendment of the mine lease area and eastern bypass road	June to September 2021	• Inform Sobas of this change to the mine lease area and need for the bypass road. • Engagement with affected households as part of the RAP development engagements

Questions and concerns raised during these consultations have been captured in the Comments and Response Report (CRR) (Annexure I of Appendix N or in Appendix O).

NOTE: The authorities will carry out independent public consultation as part of the decision-making process (for which the proponent will bear the cost).

6.6 Summary of issues raised during consultation

The CRR (Annexure I of Appendix O) contains the details of all the engagements undertaken to date and responds to the issues raised.

The following issues were raised during the consultations to date:

- There is insufficient power for the Project (5MW available), and the Project needs the Government's plan to install a high voltage power transmission line from Laúca that will supply the demand of 15MW.
- There is insufficient infrastructure for villagers, such as schools, water supply, electricity and health centres.
- Traditional midwives do not receive a subsidy from the government, and they do receive a kit that includes food, soap, cooking oil, etc.
- It is important to clarify and explain to the stakeholders all the advantages and disadvantages the Project can bring to the communities.
- Cultural heritage needs to be considered, such as historical sites, monuments, old informal graves sites and sacred sites with old graves.
- In terms of participation, women and youth should be involved during the meetings.
- All negotiations made with the population should be carried out with transparency to avoid unexpected or bad reactions.
- There are no records of conflicts about land in Longonjo.
- ADRA has been involved in exposing villagers to the law, which allows villagers to own their lands legally.
- Villagers wanted to know if they could access fields once the mine was developed.
- It was reported that most of the people in the Tchakengenga community have a field in the greater Project polygon.
- It was mentioned that the Project would bring benefits to the community; therefore, the villagers want the implementation of the Project.
- The community is dissatisfied because they must travel to find a job.
- Job applications should not be organized by the administration but by traditional authorities.
- Farmers wanted to know whether the field owners would be compensated.
- It was reported that there are no job opportunities for the youth in the community.
- It was said that animals are killed on the road and that this could happen to someone in the community.
- People wanted to know which country would benefit from the Project – Angola or others. It was explained that countries such as China and USA use NdPr minerals to manufacture engines for electric cars and other items. Angola will benefit from the sale of the minerals, the province and Longonjo municipality will also benefit.
- The comment was made that lands in Tchimbilundo are more fertile.
- Farmers wanted to know if animals and people would be able to access the area in the future.
- Communities wanted to know if people affected by the Project would be compensated.
- It was mentioned that roads must be rehabilitated.
- Many groups have come to the community, and taken notes of the problems and nothing has changed. The people are tired of promises and non-compliance with these promises.
- There is a lack of fertiliser in the community because the price has increased.
- Crops and cattle depend on the mountain (Chimbilundo Hill). People wanted to know whether the Government would support them because they would not be able to use the mountain.
- Farmers wanted to know whether fields would be taken from the population.
- Villagers said that opportunities are given to people from other areas.
- Women wanted to know whether they would have the opportunity to get a job or only for men and the youth.
- People are worried because they had heard that the community could be transferred elsewhere.
- Communities wanted to know where they could practice agriculture.

Questions and concerns raised during these consultations have been captured in the Comments and Response Report (CRR) (Annexure I of Appendix N or in Appendix O).

7 CUMULATIVE IMPACTS AND COMPLEMENTARY INITIATIVES

PHYSICAL ASPECTS

7.1.1 Air quality

Literature states that adding the peak model concentrations to the background concentrations can result in severe overestimation of the source contribution and that a more realistic method is to add twice the annual mean background concentrations to the peak (or 99.9th percentile) (MINAMB, 2004). Therefore, assuming the $PM_{2.5}$ ground level concentrations provided by the World Bank for 2017 represent the background, the annual and daily cumulative ground level concentrations may increase with a further 32 µg/m³ and 64 µg/m³, respectively.

7.1.2 Hydrogeology

The Longonjo Project is located on the foothills of Chimbilundo Hill. Therefore, upstream projects cannot develop in future. The area's economy will continue to focus on subsistence agriculture for the near future. Overall, and considering the responsible environmental approach PENSANA takes for this Project, the proposed Project will have a minimal contribution to potentially cumulative negative impacts. Note that future 3D hydrogeological modelling results will potentially influence the impact assessment results in this ESIA. Thus, impact assessment might need to be updated.

7.1.3 Hydrology

If the normal flow from tributaries decreases and pollutants end up in the tributaries, the concentration of constituents will be higher. At this stage, it seems as if leachate from the proposed waste rock dump and TSF will not be hazardous. The water table will also be deeper than the depth of the open cast pit during the early stages of the Project; therefore, the normal flow of the tributaries may not be impacted significantly. The cumulative effect will, therefore, not be significant. However, future 3D modelling studies during detailed design will confirm whether this assumption is correct. Therefore, the possibility remains that some of the specialist studies might need to be updated upon completing the 3D modelling study.

The total catchment area investigated for the proposed mining operations in the southern area is only 2.78% up to just downstream of the mining lease area of the total Luluvile/Cuiva River catchment area.

The total catchment area investigated for the proposed mining operations in the northern area is only 0.38% to a point just downstream of the Longonjo Logistics Facility (railway line) of the catchment of the river flowing just north of the proposed Longonjo Logistics Facility.

As it is expected that none of the impacts investigated will be significant, the impacts on the main stream, receiving water from the tributaries within the mining area investigated will be negligible.

7.1.4 Noise

The cumulative noise impact will be from 1.0dBA to 2.6dBA at V4, V5 and V6, which according to the matrix, will be low audibility. The construction phase will only occur during the daytime when the prevailing ambient noise levels are higher at the abutting residential areas. The cumulative impact at the abutting residential areas will be insignificant during the day except at V5 and V6, where the noise intrusion level will be very low. During the night, the noise intrusion noise level will be from 1.8dBA to 7.4dBA. This is because the ambient noise level during the day was higher than during the night. The noise intrusion at V7 will be 3.1dBA and 3.8dBA at V6. This will be created by the Screw Press Plant, which will have to be acoustically screened off to prevent the creation of a noise disturbance during the night-time period at V6. According to the matrix, the cumulative noise impact will be low to medium. The cumulative impact will be less than 1.0dBA, which according to the matrix, will be insignificant. The decommissioning phase will only occur during the daytime when the prevailing ambient noise levels will be higher at the abutting residential areas. Hauling material from the plant to the siding will take place along the existing feeder road between the north and the south. It is expected that the hauling vehicles will result in a maximum noise level of 52.0dBA, which will increase the noise level at a specific point 50m from the road on an intermittent basis (during each haulage trip). There are already construction vehicles that use this road regularly.

7.1.5 Soils and Land Use

The relative isolation of the Project site from other significant development means that it is unlikely that extensive use of the land will occur post-closure. As a result, the landscape could, and should, be returned to a state approximating the pre-development condition. The landscape topographical character can largely be restored and any pre-existing vegetation re-instated. Therefore, the likelihood of a significant residual impact occurring once the site has been fully rehabilitated is limited.

7.1.6 Visual intrusion

No information is currently available indicating that similar industrial projects would occur near the Project site. Furthermore, subsistence agriculture in the Project area already contributes to ambient dust levels, which are already included in the baseline scenario for, e.g. the air quality study. It is therefore expected that cumulative impacts would be limited.

BIOLOGICAL ASPECTS

7.1.7 Avifauna and mammals

The Huambo region supports a wealth of unique and endemic birdlife, most of which are associated with the hills and mountains within the area that provide shelter and refuge in the form of a cooler, moister climate for many species considered relics of a once far more widespread forest environment. The hill in the project area (particularly the Carbonatite outcrop on the crest to the south), albeit somewhat degraded, still serves as one of these refugia and was found to support three national endemics and several biome restricted bird species. Most of this important conservation diversity is associated with the Carbonatite Outcrop and its broken terrain which provides good structural complexity and several unique microhabitats including large boulders, low crags and caves which were found to support a significant roosting population of horseshoe bats. Hilltop refugia such as this are unique and uncommon on a global and national scale (hence the endemic and conservation important status of these species), and the loss of such habitats would contribute to the overall loss of these scarce habitats and further diminish the populations of these already range-restricted and important conservation species. Pensana has already demonstrated its commitment to sustainable development by executing/implementing an effective no-go, safe zone on the carbonatite cliff habitat and its associated buffer. This was mainly achieved by updating the mine plan and pit layout by effectively excluding the entire carbonatite outcrop from the opencast pit. Pensana will also further preserve this feature through long term monitoring of the resident cave chat and maternal bat roost population. These efforts can potentially safeguard the persistence of these important biodiversity features and set a precedence for sustainable and responsible development.

7.1.8 Aquatic ecology

The baseline assessment indicated largely modified riverine ecosystems. Based on the available desktop information, no further large-scale developments were noted to occur upstream of the Project area. Considering that the dominant existing impact in the catchment is sedimentation, the proposed Project can increase current sedimentation levels via exposed materials and altered catchment surfaces. However, should mitigation prove to be successful, these incidences of additional sedimentation arising from the Project is limited. Thus, should sedimentation be managed effectively, a negligible cumulative impact is anticipated.

7.1.9 Botanical

Landscape and regional scale impacts need to be considered for a project of this magnitude. In addition, impacts associated with activities external and non-related to the project have to be seen in context with those of the project to mitigate against potential cumulative impacts. Biodiversity within the Project Area has already been heavily influenced by past and present activities and will inevitably be influenced positively and negatively by anticipated future changes.

The cumulative loss of the vegetation through transformation of land within the Project Area and the SCC found within it should be considered proactively. Despite the anticipated impacts of activities external to the project, this is likely to have low to moderately negative consequences on regional ecosystem functioning and flora and fauna communities.

IFC PS6 standards (IFC, 2012) require that projects adhere to a "no net loss" of natural habitats and a "net positive gain" in critical habitats. Natural habitats will be lost because of the project. However, based on the current findings and knowledge of the Project Area, none of the habitats is regarded as critical habitats from a botanical perspective. However, based on the current layout designs, most of the infrastructure will not be situated within the natural habitats within the Project Area. Instead, based on the current layout designs most of the infrastructure will be situated in the habitats classified as Transformed, Bare Soil and Agricultural Field.

To meet the financing requirements of IFC PS6 (2012), an offset strategy will need to be developed by the project proponent to compensate for the predicted loss and degradation of natural habitats in the area of influence.

7.1.10 Herpetofauna

Given the rural nature of the Project Area location, relatively few obvious large-scale developments exist (as viewed from satellite imagery) contributing to severe negative impacts on the herpetofauna community at the regional scale. Probably the most significant concern for herpetofauna in the region is the cumulative impacts of abstraction of water and the cumulative pollution of water sources.

Large scale subsistence agriculture is widespread in the region, and increasing populations are likely applying additional pressure on the remaining natural habitat. The structural change resulting from the removal of shrubs and trees and the seasonal burning habits of local subsistence farmers will affect herpetofauna communities. This may result in large, connected areas of cultivation that are unsuitable for some herpetofauna groups, and it results in island habitats where vulnerable herpetofauna populations are isolated. Although the proposed mine covers a relatively small area, the diatreme afforded some protection from agriculture and thus removes habitat that may have remained relatively natural and accessible to herpetofauna in the foreseeable future. Mine planning should avoid as much of the elevated rocky areas as possible to retain the habitat function of these areas.

As mentioned above, abstraction of water from shallow aquifers feeding these systems has the potential to alter or remove crucial habitat for aquatic and semi-aquatic herpetofauna, as well as reduce the dilution of any chemicals or eroded material that enter these systems. In the regional context, careful management of this resource will be required to reduce regional-scale impacts on the aquatic and semi aquatic herpetofauna community. Therefore, the current Project will need to perform regular water volume and water chemistry monitoring at all upstream and downstream sites to monitor the Projects' influence on these systems. All other projects in the region should ideally be performing similar monitoring so that the relevant governmental competent authority can collate this data and periodically assess the cumulative impacts (and possibly assign legal water abstraction quotas) on these aquatic systems.

The large size and disjunction nature of the southern TSF do increase the overall cumulative effect of habitat loss and fragmentation in the area. Furthermore, the proposed position of this TSF overlaps a watercourse. Should the ESMP mitigation measures be implemented insufficiently during construction and operation, the TSF can have far wider-ranging effects than only the project area through the deterioration of water quality. Following the 2021 survey, it is now confirmed that Nile Crocodile inhabits the Cuiva River bordering the project area to the west and, it is SCC herpetofauna such as this that are known to be particularly susceptible to mining-induced changes to in-stream water quality and quantity. This impact should be addressed through watercourse diversion during the early stages of the TSF construction. In line with IFC PS6 international best practice, the loss of this watercourse which classifies as High sensitivity Natural Habitat, must be appropriately offset to demonstrate a no net loss / net gain in wetland extent and functionality in the project area. A comprehensive wetland delineation baseline study followed by a detailed wetland rehabilitation and offset strategy must be compiled by a suitably qualified ecological specialist. Under these circumstances, the impact is considered moderate residual significance.

SOCIO-ECONOMIC ASPECTS

7.1.11 Socio-economic Impacts

There are no anticipated social cumulative impacts that are considered negative. Positive cumulative impacts could be from the mine stimulating economic development in the local area through the support of local business through procurement policies that favour local business providing goods and services. This will provide a stimulus to grow the local economy. The long-term employment of people will also provide positive cumulative impacts.

8 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (DETAILS OF MITIGATION)

8.1 Approach

The Environmental and Social Management Plan (ESMP) will support PENSANA[59] and their appointed contractor(s) to meet the requirements of Angolan legislation and international standards requirements throughout the life of the Project. The ESMP describes actions that will be required and assigns roles and responsibilities for staff responsible for implementing the ESMP. Mitigation is specific, measurable, achievable, relevant, and time-bound (SMART) enabling staff to have clear instructions and enabling auditors to document the level of success in implementing the ESMP.

Post-ESIA, this ESMP will be a stand-alone document that should be included in contract documentation and other tender documents sent to contractors and suppliers and updated annually (section 8.5). All contractors and suppliers should be obliged to submit method statements to PENSANA for review and sign-off before they begin work; a practical option is to include method statements in documentation when bidding for contracts.

8.2 Objectives of the ESMP

The key objectives of the ESMP are to:

- Facilitate compliance with applicable acts, projects specific Legal Register, regulations, and guidelines;
- Recognise that social responsibility and environmental management are among the highest corporate priorities;
- Assign clear accountability and responsibility for environmental protection, safety and social responsibility to management and employees;
- Facilitate environmental and social planning throughout the Project life cycle;
- Provide a process for achieving targeted performance levels;
- Provide appropriate and sufficient resources, including training, to achieve targeted performance levels on an ongoing basis; and
- Evaluate environmental and social performance against PENSANAs Health Safety and Environmental policy, other policies, objectives, and targets and seek improvement where appropriate.

8.3 Visibility of the ESMP

ESMP shall be made visible to all parties involved in the construction and operational phases of the Project. In addition, a complete copy of the ESMP shall be available and maintained at the site at all times.

8.4 General duty of care

PENSANA shall comply with the general duty of care principles in terms of good international industry practice (GIIP).

Although the principles were considered during the formulation of this ESMP and included in the ESMP where relevant, the ultimate duty of care throughout the Project lifespan remains with PENSANA.

Duty of care requires that PENSANA is responsible for managing environmental, health and safety-related impacts throughout the lifespan of the Project (and in some instances after that). Therefore, PENSANA shall take reasonable and practical steps to prevent harm to the receiving environment (biological, physical, social).

There are three general aspects of the duty of care principle:

- sustainable use of natural resources;
- conservation of biological diversity; and

[59] All references to PENSANA automatically also imply Ozango and *vice versa*

- avoidance of harm to people.

Therefore, a duty of care requires that PENSANA take reasonable measures to prevent, minimise, and rectify pollution and environmental degradation.

8.5 Revisions of the ESMP

An ESMP is a "living document" and needs to be revised as the Project develops throughout its lifetime. At a minimum, it is good practice to review an ESMP annually.

The findings and recommendations by internal / external auditors or specialists will be used to update the ESMP. As a result, the ESMP will be included as part of the environmental and social management system (ESMS).

8.5.1 Performance management

Periodic audits and inspections will be undertaken using the ESMP as the main reference document. The frequency of audits will be geared to each working section of the operation; it is commonplace for internal inspections to be undertaken by section heads / managers, with the ECO providing guidance and support for training and corrective action planning. In addition, annual audits by independent auditors enable overall performance to be documented.

The ESMP audit report typically comprises at least the following:

- Audit scope and assessment period applicable;
- Summary of the assessment procedure followed;
- Evaluation criteria used during the assessment;
- The results of the assessment including monitoring results and trends revealed by the monitoring activities; and
- Recommendations to improve performance, how and by when non-compliances or environmental and social management deficiencies shall be resolved.

PENSANAs senior management shall review the ESMP annually to maintain continual improvement, suitability, and effectiveness of the ESMP and review its performance. PENSANA shall formally document the management review and retain proof (e.g. meeting minutes and decision signed by the responsible / authorised person).

8.5.2 Timing and proponent responsibility

To make sure that the ESMP remains time-bound and measurable, the ESMP utilises activity-based planning that is triggered by appropriate future events/milestones. By utilising this approach, all management/mitigation plans will be developed and implemented relative to the timing of the actual activities in the overall Project schedule. The timing of the triggers will be adjusted over time (whether earlier or later) to match the progress of the Project.

PLAN	RESPONSIBILITY AND REPORTING ROLE	TIMING
SEP for life of the Project	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Training and Induction Plan	PENSANA	Before the start of construction.
Biodiversity Action Plan	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Environmental Complaints Plan (Grievance mechanism)	PENSANA delegated to a competent third party	Through the life of the Project.
Environmental Auditing and Inspection Plan (including non-conformance process)	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.

PLAN	RESPONSIBILITY AND REPORTING ROLE	TIMING
Air Quality Management Plan (incl. dust, odours and fugitive emissions)	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Noise Management Plan	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Water Management Plan	PENSANA delegated to a competent third party	Before the start of construction. Separate detailed WMP for operations, to be formulated prior to operation commencement.
Soil Erosion and Sedimentation Management Plan	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Materials Management Plan	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Chemical and Hazardous Materials (including contaminated soils/material) Management Plan	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Traffic Management Plan	PENSANA delegated to a competent third party	Before the start of construction. Separate detailed TMP for operations, to be formulated prior to operation commencement.
Waste Management Plan	PENSANA delegated to a competent third party	Waste management plan already completed according to MCTA template and to be submitted along with the ESIA to the MCTA. As part of the ESMS, the Waste Management Plan will be updated when project specifics become available during detailed design and be in place before the onset of construction. Plan will address construction and operation.
Resource Use Plan (including water and energy use)	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Pollution Prevention Plan	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Emergency Preparedness and Response Plan	PENSANA delegated to a competent third party	Before the start of construction. To be maintained during operation.
Environmental Monitoring Plan	PENSANA delegated to a competent third party	Refer to Section 9 of the ESIA. The monitoring plan will be executed before the commencement of construction to expand the baseline data collected during the ESIA seasonal surveys.
Archaeology and Cultural Heritage Plan (including chance find procedure)	PENSANA delegated to a competent third party	Before the start of construction.
Offset strategy and Offset management plan	PENSANA delegated to a competent third party	Before the start of construction of the TSF (TSF 9/10).

8.5.3 Roles and responsibilities

8.5.3.1 The MCTA

The MCTA will typically:

- Review and approve the regulatory ESMP as part of the Regulatory ESIA; and
- At their discretion, the MCTA may carry out site inspections to verify PENSANA and the appointed contractors' compliance with the provisions of the ESMP.

8.5.3.2 Project proponent – PENSANA

As a proponent (also see section 8.5.1), PENSANA will:

- Be responsible for the implementation of the ESMP;
- Oversee the performance of appointed contractors and suppliers through internal audits to gauge conformance with all procedures and environmental obligations in this ESMP; and
- Develop training programmes for training all staff in environmental and social aspects of their work.

8.5.3.3 Contractors and suppliers

The appointed contractors will be required to do the following prior to the commencement of construction activities:

- Issue method statements to PENSANA for approval;
- Comply with all of the requirements of the ESMP;
- Appointment of an HSE Manager (acceptable to and approved by PENSANA), who will be assigned responsibility for the implementation of the ESMP as applicable to the specific contractors' activities; and
- All ESMP related documentation/control procedures must be submitted to PENSANA for review and approval.

8.5.3.4 PENSANA HSE manager

The PENSANA HSE Manager will be responsible for:

- Induction of staff at all levels regarding environmental and social aspects of their roles;
- Staff training through departmental meetings and toolbox talks – this may include delegating responsibility to section managers for task-specific training;
- Developing training tools;
- Providing weekly updates at management meetings on environmental and social performance;
- Carrying out formal and informal site inspections to gauge overall performance;
- Assisting with developing method statements, action plans, and corrective actions, as needed;
- Responding to environmental incidents and overseeing corrective actions such as clean-ups;
- Developing management plans (e.g., emergency preparedness and response plans, waste management plans, health and safety procedures);
- Overseeing PPE supplies and use of PPE;
- Maintaining a register of incidents and grievances; and
- Proposing practical mitigation, management and monitoring for inclusion in the ESMP.

8.6 Project phases and resources

PENSANA will ensure the availability of the human and financial resources needed to conduct all environmental and social management, mitigation and monitoring activities at the mine throughout the construction, operation, closure and post-closure phases. As necessary, but primarily during construction, this will include capital investment to make sure that environmental and social mitigation measures such as pollution control equipment are integrated into various project components. This will also include providing the resources needed to implement the Closure Plan and to discharge post-closure long-term care and maintenance obligations.

8.7 Grievance mechanism and Stakeholder Engagement Plan (SEP)

The purpose of a grievance mechanism is to demonstrate responsiveness to stakeholder needs. A clear and widely publicised grievance mechanism improves stakeholder management by making sure that grievances are documented in writing and clearly understood. All stakeholders are encouraged to submit written grievances to the PENSANA Community Liaison Officer (CLO), and stakeholders should be reassured that written submissions will not be used in any way to intimidate those submitting the complaints. The SEP is a live document and will be continuously updated and used for ongoing stakeholder consultation throughout the life of the Project.

Key elements of a grievance mechanism include:

- Clear instructions on how grievances are submitted and handled after submission, including a maximum period that a stakeholder must wait to receive a reply;
- Alternatives for submitting a grievance in-person to a staff member if a stakeholder is not able to or comfortable submitting a grievance in writing; and
- Grievances are regularly summarized in a grievance log, and anyone submitting a grievance will automatically be included in the overall stakeholder log and electronic database.

The following sections explain the PENSANA grievance mechanism.

8.7.1 Purpose of grievance mechanism

The grievance mechanism is a method through which communities and individuals affected by PENSANA's activities can formally communicate their concerns and grievances to the company and facilitate mutually acceptable resolutions within a reasonable timeframe. A grievance process is a management tool designed to help address stakeholder concerns promptly and facilitate a trustworthy and constructive relationship. Anyone may use the grievance procedure may be used by anyone at no cost and without fear of retribution.

8.7.2 PENSANA as custodian of the grievance mechanism

The CLO is the PENSANA staff member responsible for coordinating of stakeholder engagement activities and managing the corporate grievance procedure. This person does not have the authority to resolve grievances but instead works with a team of managers to collect accurate information about a given issue, share it with appropriate senior management, and communicate the resolution back to the person submitting the grievance.

The CLO shall report to the HSE manager (or equivalent), who will assume ultimate responsibility for managing the entire grievance mechanism process. In addition, the HSE manager shall report on grievance statistics (resolutions, residual issues, associated risks) to PENSANA executive management for decision-making purposes as and when needed.

8.7.3 Confidentiality statement

PENSANA will treat all personal information provided by the complainant with the strictest confidentiality. No details of the complainant will be provided to other organisations or individuals without prior written permission. PENSANA may use the information provided for monitoring and reporting without disclosing personal data.

8.7.4 Fair and transparent process

PENSANA's complaints procedure is designed to be readily understandable, accessible and culturally appropriate for people in Longonjo and the surrounding area. Where a complaint needs an interpreter or translation, this will be made available by PENSANA.

8.7.5 Publicity and accessibility

As part of the overall stakeholder engagement process and encouraging local communities to engage with the work of the Project, PENSANA will publicise the complaints procedure through a notice board, newsletter, meetings and other events.

8.7.6 Grievance submission mechanism

Grievances should be submitted using the contact information of the CLO.

- Grievances may be submitted by telephone, in writing or in person at the company offices, or verbally through the external relations staff, who will put the grievance in writing for management purposes;
- All grievances will be documented. The importance of documenting all grievances is to make sure problems are accurately understood and handled appropriately;
- All formal grievances shall receive a formal reply within two weeks (10 working days). The formal response will provide additional information or, if appropriate, further instructions on proposed measures to resolve the issues;
- Documented grievances will not be used in any way to intimidate the person or organisation submitting the complaint;
- As a general rule, names of persons submitting a grievance will be kept confidential unless a grievance is made in a public meeting;
- Only the number of grievances and the general nature of complaints will be regularly reported. This information will be summarised in a grievance log, but personal information will be kept confidential;
- Grievances received anonymously will be treated as comments or issues and recorded, but no formal response will be issued; and
- While efforts will be made to resolve all grievances amicably, if a grievance/complaint cannot be resolved, PENSANA will seek to involve other external experts, neutral parties or local and regional authorities, as appropriate.

Grievances that are submitted in writing (whether by letter, fax or email) may be submitted stating:

- Name and surname;
- Organisation and position, if relevant;
- Address;
- Telephone/Fax and e-mail;
- Most effective means to send a response; and
- Details of the grievance (any important details; date of the incident, location, etc.).

Due to the rural location of the Project in the Longonjo municipal area, communities have limited access to electronic communication mechanisms. It is suggested that the CLO provide basic grievance forms, in hard copy, to the relevant community leaders (e.g. sobas) so that community members may submit their grievances via such forms. An electronic database of this information shall be kept up to date continuously by the CLO – and even by dedicated site personnel before construction commences to bridge the gap between the current and when the first CLO is formally appointed.

8.7.7 Record keeping system of grievances

PENSANA shall establish a grievance mechanism / record-keeping system / log. T The CLO shall maintain this system / log to capture the information listed in the section above. The CLO will track how issues are resolved until the issue is closed out. The system / log shall summarise the grievance in the following manner:

- Grievance number;
- Date the grievance was submitted;
- Complainant’s name and contact details (as per section above);
- Complaint type (e.g., water, air quality, noise, traffic);
- Action taken to address the grievance; and
- Date of close-out of grievance.

8.7.8 Internal grievances

PENSANA shall develop an internal grievance procedure as part of its HR procedures. The internal grievance mechanism will be aligned with the mechanism proposed above with relevant changes to make it more relevant to the employee and contractor context.

8.7.9 Stakeholder Engagement Plan (SEP) for the life of the Project

Ongoing consultation will be the subject of the SEP for the life of the Project (i.e., for all phases of mining following the completion of the ESIA). Therefore, the SEP for the ESIA and the information gathered during consultation and the RAP process will be incorporated into the SEP for the life of the Project.

Generally, the SEP for the life of the Project will focus on building a proactive relationship with the neighbouring communities. The permanently appointed CLO will be a key role player in this process. CLO will meet regularly with community leadership (e.g. monthly). Where feasible, a community engagement forum will be established where regular engagement can be facilitated. A complete database of engagement activities will be maintained and reported on periodically.

The SEP will specify the frequency of engagement of the CLO with the respective stakeholders. A general recommended approach will be for the CLO to have monthly meetings with the sobas in the relevant villages, while the CLO will have quarterly meetings with the provincial authorities. The frequencies will be amended as needed when the SEP (for the life of the Project) is updated periodically to adjust to the operator’s needs and the village leadership.

8.8 Social responsibility

During the project implementation phases (construction and operation), PENSANA should communicate their strategy toward social investment in Angola particularly, in regions and local communities potentially affected by the Project. This strategy should emphasise the distinction between social investment offered as philanthropic goodwill to support community needs and “mitigation” required to reduce negative impacts. This distinction should be combined with efforts to align ongoing communication processes between the CLO and the local communities. Women shall be a key focus in the social responsibility initiatives.

8.9 Environmental and Social Management System (ESMS)

IFC PS 1 requires that PENSANA consider developing and implementing an ESMS to a recognised standard (i.e., IFC PSs and external certification such as ISO 14001 and OHSAS 18001), under in-house environmental policies and lender/financier requirements. A framework ESMS was developed for Pensana as part of the ESIA process. The ESMS shall be managed as a live system along with the ESMP.

8.10 Legal register

PENSANA shall maintain and update a legal register for the Project. The legal register shall be independently audited annually by a suitably qualified professional.

8.11 Health & Safety and Environmental and Social Policies

PENSANA has an HSE policy (Appendix A) in place. This policy shall be reviewed and signed every second year, and copies will be placed on all relevant notice boards throughout the mining operation. The policy and updates thereof shall stipulate:

- Compliance with and where possible exceedance of the relevant statutory requirements;

- Compliance with the PENSANA Corporate Governance policy as it relates to e.g. IFC Environmental and Social Performance Standards, appropriate industry guidelines and relevant Lender requirements/covenants;
- Social commitments (no child labour, gender equality, non-discrimination etc.);
- Identification of environmental impacts, potential hazards and appropriate corrective action to reduce the risk to an acceptable level; and
- Roles and responsibilities within PENSANA management structures to execute the content of the HSE policy.

In addition, PENSANA shall formulate an HSE Manual, available for use by employees and contractors / subcontractors.

8.12 Health & Safety and Occupational Health and Hygiene

Pensana has an Occupational Health and Hygiene policy in place and a Safety Policy in place. A tailored Safety, Health and Risk Management Strategy has been formulated for the mine and implemented. A Risk Register has been populated during the design process based on input from numerous project stakeholders. The Risk Register will be updated regularly and is used as a live tool to address risk.

8.13 Emergency planning and response

Environmental incidents relating to the Project shall be dealt with according to an emergency and response plan.

All emergencies must be handled according to a defined Emergency Response Plan. The Emergency Response Team must provide an immediate response to any significant incident. Examples of general incidents that may occur and the emergency responses required are as follows:

- Fire in the Project area, a vehicle, or the surrounding vegetation – The Project area emergency response team will take immediate action appropriate to the nature and extent of the fire, and alert the local authority as appropriate; and
- Spillage of chemicals and hydrocarbons – Any pooling hydrocarbons will be soaked up with a fit-for-purpose commercial absorbent material. The absorbent material and soil will be removed for bio-remediation.

Personnel will be designated and trained to activate and implement the Emergency Preparedness and Response Plan in reaction to onsite and offsite emergencies or other environmental emergencies that may occur. In addition to the Operations Manager, who will be the designated Incident Coordinator or his designated deputy, and Emergency Response Team members, other key staff involved in implementing the Emergency Preparedness and Response Plan shall include the Operations, Environmental, Safety and Security supervisory personnel. Contractors performing work for PENSANA will also be required to be appropriately trained and have ready access to equipment and supplies that would allow them to contain and control an accidental release until the arrival of an emergency Response Team.

8.14 Specific legal requirements / authorisations

Table 8–1 summarises the legal requirements PENSANA shall comply with.

Table 8–1: Legal requirements

Item	Requirement	Status
Decree No.117/20 on General Regulation for Environmental Impact Assessment and Environmental Licensing Procedure (Revoked Decree No. 51/04 on Environmental Impact Assessment)	In terms of Article 26, any activity requiring an EIA must apply for an Environmental License, which the MCTA issues.	Done – Regulatory ESIA completed for the Project
Decree No.117/20 on General Regulation for Environmental Impact Assessment and Environmental Licensing Procedure (revoked Decree No. 59/07 on Environmental Licensing)	Article 42 indicates that only technicians associated with companies registered as Environmental Consultancy Societies can carry out Environmental Impact Studies in Angola under the terms of the legislation in force.	In compliance with this decree, PENSANA through OZANGO appointed GSO to submit the ESIA to MCTA as GSO holds a valid registration to do so.
Decree No. 96/09 on Environmental Licensing Fees	A fee needs to be paid by PENSANA at the end of the ESIA, to acquire an Environmental License (both installation and operation licenses) for the proposed activities, based on the project's investment.	Done – Regulatory ESIA completed for the Project
Executive Decree No. 87/12 on Public Consultation for Projects Subject to Environmental Impact Assessment	PENSANA will be required to carry the cost of any public consultation after the ESIA as required by the authorities and to make sure that the information presented at such public consultation meetings comply with the requirements of this decree.	Post ESIA
Decree No. 92/12 on the Terms of Reference for Environmental Impact Studies	In terms of this executive decree, the proponent must complete and submit the required forms in Annexes I and II to register its projects and ensure that the EIS complies with the minimum content requirements set out in Annex III.	These forms were submitted to MINAMB (now MCTA) in September 2018, MINAMB then requested additional information to finalise the submission. The additional information was then submitted to MINAMB and MINAMB responded on 9 November 2018 with their comments.
Law No. 6/17, General Framework Law on Forests and Wildlife	PENSANA shall apply for authorization to fell trees / deforesting from the Forest Department.	Typically, this takes place outside of the ESIA process.
Decree No 201/16 on Animals that may not be hunted	PENSANA shall enforce a zero-hunting policy on all of their employees and contractors' employees during the lifetime of the Project.	Through the ESMP and company polies.
Water Law No. 6/02	PENSANA shall apply for a license for the Project and also a license to abstract surface water and discharge wastewater (if relevant).	Typically, this takes place outside of the ESIA process
Presidential Decree No. 26/20 (National Biodiversity Strategy and Action Plan 2019-2025)	PENSANA shall comply with the requirements of this decree in terms of conservation and sustainable use of biological diversity and the fair and equitable distribution of biological resources in favour of all	Through the ESMP

Item	Requirement	Status
(revoked Resolution No. 42/06 on the National Biodiversity Strategy and Action Plan (NBSAP))	Angolans into policies and development programmes.	
Decree No. 194/11 on Liability on Environmental Damage	PENSANA to note that the company will be liable for environmental damage.	PENSANA to implement all requirements of the ESMP.
Decree No. 261/11 on water quality	Presidential Decree No. 261/11 serves as an addition to the national Water Law No. 6/02, dealing specifically with water quality. It establishes the roles within the Angolan governmental administration for overseeing water quality issues and addressing the water quality standards relating to human consumption and wastewater. The decree also lists the role of water quality monitoring and the standard parameters for drinking water, surface waters and emissions limits for wastewater discharge (in Annex VI).	PENSANA to implement all requirements of the ESMP to avoid Project-induced water quality impacts.
Decree No. 190/12, on Waste Management	Waste Management Plan shall be drafted and be submitted to the Waste National Agency for approval.	To be submitted when the ESIA is submitted.
Decree No. 17/13 on Construction and Demolition Waste Management	PENSANA shall comply with the requirements of this decree.	Through the ESMP
Decree No. 82/14, on the General Use of Water Resources	Article 110 requires that PENSANA shall consider a 200m buffer zone as follows: "areas of protection of water resources, the water course beds, river banks and water courses adjacent zones of up to a distance of 200 metres. ' Article 17 requires that PENSANA shall apply for water use and discharge.	PENSANA shall consider the design of the Project and avoid disturbances or the placement of infrastructure within the buffer zones.
Presidential Decree No. 203/19, Approves the Regulation on Landfills	Regulations provide for the disposal of waste in landfills and the requirements to be observed in the design, construction, operation, closure and post-closure of landfills. In addition, the landfill operation is subject to licensing, covering the design, construction, operation, closure, and post-closure phases of the landfill.	Once detailed design on the landfill is available, PENSANA shall apply for authorisation of the landfill site based on relevant baseline information collected specifically for the purposes of the landfill site (e.g. hydrogeology, geotechnical etc.)
	Incineration was listed as a solution for waste streams produced. When the design of the incineration plant becomes available, the Air Quality Dispersion Model and impact assessment shall be updated to account for this additional air pollution source. At the time of finalisation of the ESIA and specifically the Air Quality Dispersion Model and impact assessment, the processing plant (e.g. MRES plant) emission details (e.g. stack heights, vents, emission flow rates, emission compositions etc.) was not available.	Pensana shall confirm what local authorisations may be required to license air emission sources.

8.15 ESMP: Construction and Operation[60]

The specific requirements of the ESMP for construction and operation are presented below in Table 8-2.
In many cases additional mitigation measures or detailed stipulations thereof, are presented after Table 8–2 in sections 8.15.1 to 8.15.10.

[60] In some cases, measures for Decommissioning are stipulated in the ESMP. These are non-exhaustive and a detailed Decommissioning ESMP shall be formulated during the operational phase of the Project.

Table 8–2: Environmental and Social Management Plan

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Air Quality and GHG					
Construction and Operation	Fugitive and traffic air pollutant emissions	• Implement an equipment and vehicle maintenance schedule to keep them operating at optimal levels • All vehicles to be fully licensed according to Angolan traffic regulations (e.g. annual licencing and subsequent periodic inspection required by law).	PENSANA Environmental Manager	• AQ Management plan • Equipment maintenance schedule	• No visible signs of excessive smoke/soot emitted from equipment and vehicles
Construction and Operation	Fugitive dust emissions potentially impacting human receptors as well as fauna and flora	• Water or dust control agents shall be applied to suppress dust in working areas and regularly used roads where necessary. • Should grievances be submitted, these will be investigated. Should complaints be warranted, further action shall be considered e.g. a dust monitoring system (e.g., dust buckets in the vicinity of receptors located close to the Project boundary).	PENSANA Environmental Manager	• AQ Management plan • Grievance mechanism	• Dust levels not exceeding WHO standards
Aquatic ecology / Riverine ecology					
Construction phase	Erosion and Sedimentation	• Erosion control measures at all surface infrastructure, implementation of the surface/stormwater management plan	ECO	• Monthly audits of surface infrastructure between the months of September and May. • Monthly water quality sampling and bi-annual aquatic biomonitoring.	• No evidence of erosion or sedimentation attributed to the activities.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction Phase	Contaminated runoff/seepage	• Implementation of dirty and clean water separation. Storage of hydrocarbons and process materials in bunded areas.	ECO	• Monthly water quality sampling and bi-annual aquatic biomonitoring.	• No evidence for water quality impairment and biological degradation.
Construction Phase	Alien vegetation establishment	• Implementation of the alien invasive management plan.	ECO	• Quarterly assessments of alien vegetation associated with surface infrastructure	• No development of alien vegetation communities.
Construction Phase	Water loss from headwater streams	• Implementation of groundwater study mitigation actions	ECO	• See groundwater study	• No significant loss of water volume in surface water bodies.
Construction Phase	Instream habitat modification through the construction of the impoundments	A coffer dam must be constructed upstream of the proposed workings. The coffer dam must convey water to a channel that diverts water around the active workings of the weir. The discharge point of the diversion must not result in erosion. A silt trap/screen must be installed downstream of the weir during instream activities. Following completion of the instream workings, rehabilitation of the affected exposed areas in the riparian habitat must occur; after completion of the instream workings, an audit must ascertain whether this has been achieved. More information will become available during detailed design relating to the possible weir. An alternative option is also possible, where a floating abstraction point could be constructed to avoid the anticipated impacts. Mitigation measures should then be adapted at that point as necessary.	ECO	Monthly water quality sampling and bi-annual aquatic biomonitoring.	• No evidence for water quality impairment and biological degradation.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		A diversion of the stream on the footprint of the TSF is required to divert the flow around the TSF – especially during the initial years of the TSF operation. An offset strategy and plan will be required to offset the loss of the stream. • Following the completion of the instream workings, no waste material can be left within the river channel. Within 30 days of completion of the instream workings, an audit must ascertain whether this has been achieved. If not originally present, no large boulders or material that can alter hydrology must be left within the instream areas.			
Operation phase	Erosion and Sedimentation	Erosion control measures at all surface infrastructure, implementation of the surface/stormwater management plan	ECO	• Monthly audits of surface infrastructure between the months of September and May. • Monthly water quality sampling and bi-annual aquatic biomonitoring.	• No evidence of erosion or sedimentation attributed to the activities.
Operation phase	Contaminated runoff/seepage	Implementation of dirt and clean water separation. Storage of hydrocarbons and process materials in bunded areas.	ECO	• Monthly water quality sampling and bi-annual aquatic biomonitoring.	• No evidence for water quality impairment and biological degradation.
Operation phase	Alien vegetation establishment	Implementation of the alien invasive management plan.	ECO	• Quarterly assessments of alien vegetation associated with surface infrastructure	• No development of alien vegetation communities.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Operation phase	Instream habitat degradation	The implementation of the sediment management programme and environmental releases	ECO	• Monthly water quality sampling and bi-annual aquatic biomonitoring.	• No evidence for water quality impairment and biological degradation
Decommissioning phase	Contaminated runoff/seepage	Implementation of dirt and clean water separation. Storage of hydrocarbons and process materials in bunded areas.	ECO	• Monthly water quality sampling and bi-annual aquatic biomonitoring.	• No evidence for water quality impairment and biological degradation.
Decommissioning phase	Alien vegetation establishment	Implementation of the alien invasive management plan.	ECO	• Quarterly assessments of alien vegetation associated with surface infrastructure	• No development of alien vegetation communities.
Avifauna and Mammals					
Construction, Operation and Decommissioning	Loss of the Carbonatite Outcrop and Associated Habitats: Consequences for Endemic, and / or Habitat Specific Avifauna and Roosting Bat Colonies.	Refer to 8.15.3	Pensana and ECO	• Refer to 9.2	• A map produced annually showing the development of the mine infrastructure and disturbance footprint in relation to the High sensitivity habitats. Data must be available in georeferenced shapefile format
Construction and Operation	Increased mortality risk to birds and mammals	Refer to 8.15.3	Pensana and ECO	• Refer to 9.2	• Visible and maintained biodiversity awareness signs and posters. • Annual report highlighting the actions taken to reduce wildlife mortalities by highlighting (a) increase awareness and the

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
					training undertaken by staff (b) a map showing the location of all roadkill incidents and measures taken to reduce incidents (e.g. signs or speed humps) (c) the numbers and photographs of removed traps and snares and (d) the number of wildlife encounters / rescued and relocated individuals.
Construction and Operation	Sensory disturbance to birds and mammals	Refer to 8.15.3	Pensana and ECO	• Refer to 9.2	• Annual report on (a) the number of bats counted from photos taken of the main roost huddle, (b) noise levels recorded near the top of the hill preferably near the roost cave, (c) dust bucket levels and (d) static point photography of the site from the top of the hill at night to illustrate the increase in light pollution levels over the years and what could be done to minimise it.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
					• A monthly report including recorded dust levels; • An annual report including noise levels; • ECO to report on the location of lights attracting animals so that lighting can be amended to reduce attraction, or these areas can be avoided with regards to light placement.
Construction and operation	Loss of Red-listed raptor species nests	Refer to 8.15.3	Pensana	• Refer to 9.2	• The report dealing with faunal mortalities should include a section detailing any large raptor nests encountered and the action taken and correspondence with relevant experts. An inventory should be kept of the locations of all raptor nests encountered, the species occupying the nest and the status of that nest.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Operation and De-commissioning	Exposure of birds and mammals to contaminated water downstream of the mine and reduced flow due to water abstraction	Refer to 8.15.3	Pensana	• Refer to 9.2	• Water chemistry management – refer to Hydrology section; • Water levels – refer to Hydrology section; • Water intakes – clean, clear and intact sieves. No obvious fauna mortalities.
Construction, Operation and Decommissioning	Introduction of alien flora affecting native herpetofauna assemblages	Refer to 8.15.3	Pensana and ECO	• Refer to 9.2	• Compilation of an alien and invasive plant control plan that is reviewed on an annual basis. This report should include spatial (GIS) analysis and mapping of the extent and intensity of alien vegetation across the Project Area as well as areas that have been cleared and areas that are prioritized for clearing that year. The report should also detail all alien control action to date (e.g. man hours, cost, the location, date and species eradicated).

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction, Operation and Decommissiong	Collision and electrocution of birds with new powerline infrastructure	Refer to 8.15.3	Pensana and ECO	• Refer to 9.2	• Include in the annual report notes of any bird collisions or electrocutions with powerline or other infrastructure (or the lack thereof)
Botany					
Construction; Operation; De-commissioning	Physical Modification of Habitat & Reduction in Connectivity	**Sample variables:** Area (ha) and locations of detectable changes. **Sampling method:** • Web based monitoring (remote sensing) of medium resolution (10-20 m) satellite imagery using a change detection algorithm • Basic descriptions of dominant plant species and structure should be noted when in-field investigations are required using the timed meander method. **Data analysis:** • Newly acquired aerial/satellite imagery should be programmatically compared to the original baseline imagery as well as the most recently acquired imagery data set using GIS. All detected areas of change (infrastructure, vegetation clearing etc) should be mapped and categorised. Areas of vegetation change not attributable to Project-related	Environmen-tal manager and/or environment-tal control officer	• Contiguous patches of vegetation change up to 500 m outside of specific Project related activities with a footprint area of > 0.5 ha should be investigated in-field. Cumulative changes in area > 20% from the original contiguous cluster of a certain vegetation type requires further investigation into the origin of the disturbance(s) so that vegetation disturbance due to Project related activities (both directly and indirectly) can be quantified. • Annual reporting indicating areas of change expressed as percentage change (%) in area for each contiguous cluster of a certain vegetation type (this could be done remotely and doesn't require field verification).Any changes reported need to differentiate	Performance will be indicated through No Net Loss (NNL): • No net reduction in the diversity within and among baseline species and the vegetation types;

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		infrastructure development should be flagged and investigated on foot to determine their cause. Georeferenced photographs should be taken to document any changes observed in the field and assist with the characterisation of the observed vegetation community. **Sampling frequency:** • Annual monitoring using remote sensing imagery (this could be done remotely and doesn't require field verification), • Ad hoc on-site photo-based evaluations in response to areas of vegetation change detected through remote sensing, • Biennial in-field vegetation monitoring using the timed meander method **Sampling area:** • Entire Project Area including 500m buffer		between natural background fluctuations in vegetation changes and include an error matrix to report on accuracy of any changes observed. • Specific reporting on areas of change not directly attributable to Project activities (e.g. construction site clearing) and their cause (this could be done remotely and doesn't require field verification). Any changes reported need to differentiate between natural background fluctuations in vegetation changes and include an error matrix to report on accuracy of any changes observed. • All reporting to be accompanied by GIS shapefiles and any original georeferenced photographs. Detailed reporting to be done on areas with cumulative changes >20%. • Additional action may be required to halt or prevent certain activities from continuing in order to maintain compliance (e.g. clearing activities for roads within natural areas). •	

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction; Operation; De-commissioning	Establishment of alien/invasive species (AIS)	**Sampling variables:** • Date, location, species, density estimate, size of establishment (area) **Sampling method:** • Visual inspection on foot and by vehicle (for road verges) of all construction and operation areas, particularly where vegetation clearing has occurred, and establishment of pioneer plant species is possible/evident. • Visual inspection on foot of all vehicle washing stations as specified by Environmental & Social Impact Assessment. • Evaluation of the effectiveness of AIS control measures implemented. • Areas of infestation should be sampled using the timed meander method to determine the number and frequency of AIS species. The extent of an infested area should be mapped out by traversing the periphery of the AIS population whilst capturing/ recording the spatial data using a GPS device. The density of individuals within an infested area should be estimated by counting the number of individuals within a quadrat. • NOTE: the timed meander during the biennial in-field vegetation monitoring will also allow for the recording of AIS	Environmental manager and/or environmental control officer	• Annual reporting summarising the collected data and recommending corrective actions where required	• Decrease in number of AIS species detected across the AOI; • Decrease in total density and extent of an infested area

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		plants within natural habitats. These areas can then be further sampled to determine the density and extent of these AIS populations. • Data analysis: • Graphical inspection of summary statistics (e.g. #species detected, total extent of infested area etc.). Geospatial analysis of AIS infestations to determine targeted eradication actions and implementation of controls to minimise spread. Specific analysis taking into account seed dispersal mechanisms (e.g. wind/water) required to predict future spreading patterns and implement proactive measures to prevent this. • Sampling area: • All infrastructure sites, roads and roadsides including a 50 m buffer around these. • Sampling frequency: • Biennial together with the vegetation monitoring			
Cultural heritage					
Construction and operation	Damage to the Serra do Tchimbilundu ruins.	• The ruins of the Serra do Tchimbilundu Chapel are to be left in situ, and the mine activities should not impact this site. Pensana has effectively avoided	Environmental manager and/or environmental control officer	• Monitor whether access restriction to no-go areas (e.g. Mount Tchimbilundu) is adhered to.	• Zero damage to cultural heritage resources

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		these ruins by changing the pit layout to avoid the ruins.		• Authorised local community members may still gain free access to the Serra do Tchimbilundu ruins. Community members shall inform the mine when they would like to visit the ruins so that correct H&S protocols can be followed to avoid any injury to the community members in the mining area. Pensana will maintain a footpath leading up the mountain to the ruins of the chapel.	
Construction and operation	Damage to cultural heritage resources during civil works and open pit mining.	• Develop a chance-find procedure to manage any artefacts that are uncovered during construction or when excavating ground throughout the life of Project • The risk is low as there are no historic buildings, and communities do not have sacred sites other than churches and grave sites. • There are three informal graves sites in the zone of influence of the proposed TSF9/10, where one is within the footprint of TSF9/10. Informal graves sites should be fenced and actively protected by avoiding any mining activity in the vicinity of the graves. If this is not possible, a formal process of grave relocation must be followed, in accordance with the law and with	Pensana and environmental manager	• Photographic records of areas that are excavated and engage with communities during excavations (to ask opinions on previous land use) • Monitor implementation of chance find procedure	• Chance find procedure in place

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		thorough consultation with relevant families and community leadership. • Engage with authorities so that the chance-find procedure includes names and contact details in case there are artefacts uncovered and the authorities are needed to help			
Herpetofauna					
Construction, Operation and Decommission	Loss of existing habitat	• Avoid removal of vegetation in sensitive habitats: all watercourses, drainage lines, and rivers shall be buffered by 200 m (from the water's edge during the wet season) from all infrastructure, including the processing plants and waste storage facilities. The watercourse and its buffer areas should be demarcated and access restricted prior to construction to exclude the watercourse from development activities; • Minimise the development footprint, where possible. In particular, attempt to preserve a portion of the elevated diatreme wherever possible; • Consider layout and site alternatives for the proposed development infrastructure, which needs to be assessed and compared in order to select the option with the lowest impact;	Pensana and ECO	• Refer to section 9.5.1	• Annual spatial (GIS) analysis and mapping of vegetation clearing activities in relation to buffered sensitive areas during the construction and operation phases; • Annual ECO report on monitoring mechanism described during construction phase and operation phases.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		• Re-vegetation as part of the rehabilitation phase post-mining is critical to re-establish the baseline environment pre-mining conditions; • Perform the majority of vegetation clearing activities during the dry season when herpetofauna migration and activity is reduced, and the likelihood of erosion from rainfall is reduced; and • Provide any cleared trees to the local community as fuel to maximise utilisation of this resource and prevent acquisition elsewhere.			
Construction and Operation	Direct mortality of herpetofauna due to excavation and ore processing	• Wherever possible, removal of vegetation and topsoil should be performed predictably and systematically (e.g. start from a pre-determined area and move in a single direction) that allows time for fauna to become aware and move away from the disturbance; • Staff performing vegetation clearing and excavation activities shall be appropriately trained to avoid interacting with wildlife and allow all fauna encountered during vegetation clearing activities to escape (where possible); and • Induction for staff regarding the biodiversity on-site, sustainable utilisation of natural resources and the	Pensana and ECO	• Refer to section 9.5.2	• Annual report indicating appropriate metrics to demonstrate the degree of investment in education of staff.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		necessity for the conservation thereof – during operations allow herpetofauna to escape instead of intentional killing or totally disregarding such species.			
Construction, Operation and Decommission	Direct mortality of herpetofauna due to increased traffic	• All vehicle speeds in the Project Area shall be limited to 40 km/h (maximum); • Speed humps need to be placed at pre-determined locations, especially where roads intersect with drainage lines, wetlands and rivers, to force vehicles to reduce speed; • Reduce direct mortalities by allowing for herpetofauna to cross the roads. This can be achieved by constructing fauna underpasses (large culverts or large open-ended concrete pipes laid into the raised roads). These underpasses should be used in conjunction with "fauna barriers", which prevent the most susceptible small fauna from crossing the roads on the surface by directing them towards the underpasses where they can cross under the roads safely. It is important to note that utilization of underpasses is strongly dependent on animal body size (larger culverts are more successful) and the surrounding habitat; • All staff operating motor vehicles must undergo environmental induction training courses that include instruction on the need to comply with speed	Pensana and ECO	• Refer to section 9.5.3	• Annual spatial analysis of roadkill hotspots and comparison of roadkill incidence before and after implementation of measures to reduce mortalities (mitigation measures to be clearly described); • # staff operating motor vehicles trained regarding prevention of road mortalities in relation to the # staff hired to operate motor vehicles (aim is for 100 % subjection to training).

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		limits, to respect all forms of wildlife (especially reptiles and amphibians) and, wherever possible, prevent accidental road kills of fauna, particularly where the roads cross a sensitive natural habitat (e.g. streams or rivers); • The use of Project-specific roads by local inhabitants shall be prevented by appropriate locked gates / manned booms preventing unauthorized access with a vehicle; • Prohibit unauthorised entry into sensitive areas such as watercourses and the surrounding natural areas; and • Vehicles shall not deviate from existing roads.			
Construction, Operation and Decommission	Mortality of herpetofauna due to an in-migration of people	This impact is difficult to mitigate against directly as Pensana does not control the surrounding local inhabitants. Instead, Pensana shall make sure that their staff do not engage in activities that exacerbate wildlife trade. • No trade in natural resource products and bushmeat shall be allowed in the Project Area. Integration with the Security Management Plan and Controls shall be implemented and enforced; • All staff shall be subjected to an induction training program and regular toolbox talks where appropriate	Pensana and ECO	• Refer to section 9.5.4	• # staff trained regarding sustainable utilisation of natural resources and the necessity for the conservation thereof in relation to the # staff hired (aim is for 100 % subjection to training); • # snares/ traps observed; # captured individuals observed; • # staff requiring disciplinary action due

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		conservation principles, safety procedures, snake bite avoidance and first aid treatment are taught using easy-to-understand study material. This will result in minimal negative interactions with herpetofauna and safe practices regarding fire, e.g. only smoking in designated areas, no open cooking fires, etc. Furthermore, no hunting, trapping or trade in any fauna will be allowed in the Project Area and shall be addressed explicitly during induction training; • Immediate dismissal and expulsion from the Project Area shall be enforced for infringing staff members; • Designated staff must be trained by a qualified herpetologist to capture and relocate potentially dangerous snake species safely; and • The use of Project-specific roads by local inhabitants shall be prevented by appropriate locked gates/ manned booms preventing unauthorized access.			to non-compliance with bushmeat regulations; • # fires in in the Project Area and the total area burnt; • # of snakes to be relocated from premises; and • # snake bites [including near-misses].
Construction and Operation	Disruption/alteration of ecological life cycles due to the restriction of species movement (migration/dispersal)	• Where possible, excavations during the construction phase must be left open for as short as possible to avoid trapping herpetofauna and causing habitat fragmentation (open trenches preventing migration/dispersal). This can also be prevented by erecting fences and / or barriers for	Pensana and ECO	Refer to section 9.5.5	• # of herpetofauna observed and rescued from excavations; • # non-compliant excavations. •

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		herpetofauna to make sure that species cannot fall into open trenches; • All open excavations (especially linear trenches/drainage canals) must have at least one of the long sides constructed in such a way that it slopes with an angle of less than 45° to allow for animals to crawl out. If not possible, then periodic (< 10 m apart) places for herpetofauna to crawl out (soil slopes < 45°) shall be provided temporarily until the excavation is closed; • Any trapped herpetofauna unable to escape an excavation shall be captured and safely relocated to a suitable nearby habitat away from the construction activities. It is critical that staff trained by a qualified herpetologist carry out the handling of snakes; and • Pathways such as the drainage lines radiating away from the proposed mining activities should serve as corridors to facilitate the safe movement of species across the landscape.			
Construction and Operation	Disruption/alteration of ecological life cycles (breeding, migration, feeding) due to noise, dust and lighting	• Equipment with low noise emissions (i.e. noise suppressors) must be used; • A dust monitoring system should be implemented during the construction and operational phase. Dust suppression techniques (spraying water	Pensana and ECO	Refer to section 9.5.6	• A monthly report including recorded dust levels; • An annual report including noise levels;

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		or other dust control agents with a water tanker) shall be used in areas where dust is generated, e.g. pit, stockpiles, haul roads, as required for radiation management to the Australian standards as well as international best practice standards; • Use down-lighting and low impact lighting (by selecting appropriate light fittings), avoid tall lights on the periphery, and use motion sensors where possible. Down-lighting shall be from non-UV lights where possible, as the light emitted at one wavelength will attract fewer insects. This will reduce the likelihood of attracting insects and their predators (i.e. herpetofauna); • Keep noise levels low as per best practice standards; • Dust impacts on the watercourses must be avoided through mitigation measures explained above; and • A comprehensive monitoring program on amphibians as indicator class must be implemented on a seasonal basis for life of mine.			• ECO to report on the location of lights attracting animals so that lighting can be amended to reduce attraction, or these areas can be avoided with regards to light placement.
Construction, Operation and Decommission	Introduction of alien flora affecting native herpetofauna assemblages	• Alien flora on-site shall be eradicated pre-construction and shall be actively monitored during the operation phase as part of the management plan;	Pensana and ECO	Refer to section 9.5.7	• Annual spatial (GIS) analysis and mapping of alien vegetation spread in the Project Area.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		• Disturbance of natural areas not part of the development footprint shall be avoided, and the spread of alien flora into natural areas shall be prevented; • Continuous monitoring of the growth and spread of alien flora coupled with an adaptive management approach to identify suitable control mechanisms, preferably mechanical, for small infestations. Chemical control should only take place in predetermined areas away from watercourses and should be approved by the ECO and competent authority beforehand; • Alien invasive species shall not be planted as part of landscaping. Only trees indigenous to the vegetation unit and endemic to the area may be planted, even if for visual purposes only. This should be indicated prior to development and approved by the competent authority; • Discard stockpiles to be vegetated if possible, with suitable indigenous species to prevent erosion and establishment of alien and invasive flora; and • Rehabilitation of post-mining operations shall include an alien and invasive species monitoring and eradication action plan to make sure that the			• Annual ECO report on monitoring and control mechanism applied during construction, operation and decommissioning phases. Report to include the man hours, the location, the date and the alien species during any alien clearing.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		spread and establishment of alien and invasive species are controlled and monitored (starting from the operational phase of the mine) and that disturbances post-mining are minimal and mitigated where necessary. Where possible, the site needs to be restored to its previous condition / land-use, which excludes alien and invasive species.			
Construction, Operation and Decommission	Erosion from construction, infrastructure and excavations	• Earthworks and vegetation clearing should be left open for as short a time as possible during the construction phase, and where possible, the bulk of these activities should be performed during the dry season; • Erosion control methods (even if only temporary) during the construction phase should be implemented to limit erosion; • Revegetation shall occur for any cleared land no longer being utilised by the mine; • An effective stormwater management plan should be written and implemented during the construction and operational phases of the project; and • Construction close to watercourse should be limited and preferentially avoided.	Pensana and ECO	Refer to section 9.5.8	• Channel, berm and pollution control dam integrity and functionality; • Continued sediment trap and silt fence functionality; • Water chemistry → See Hydrology Report. • Annual report demonstrating any detectable effect of mining activities (chemicals, sedimentation, etc.) on the442quaticc and semi-aquatic herpetofauna communities with proposed remedial actions (where necessary). Species composition and relative

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
					abundances to be provided in tabular format for comparison and statistical analysis.
Operation and Decommissioning	Watercourse contamination from mine waste storage facilities	• The waste storage facility must adhere to industry best practice standards, and appropriate containment technology (e.g. HDPE liner) must be used in the tailings dam to prevent leaching / seepage for the life of mine based on the initial geotechnical site investigation findings; • Construct a shallow channel and earthen berms to separate clean water runoff and prevent contamination from the TSF. Any overflow from the TSF and open pits must be directed into an appropriately lined return water dam (to be designed) with sediment traps. Separation of clean and dirty water is essential; • Construct a solid barrier fence (can be strong plastic / shade cloth against a wire fence, sunken into the ground for at least 20 cm deep and at least 60 cm high above soil surface) around TSF to prevent access by herpetofauna to the contaminated water. This will prevent direct mortalities and also, mortalities of fauna consuming corpses of contaminated individuals that may result in bio-accumulation of toxins;	Pensana	Refer to 9.5.9	• Current water quality and indications of tailings overflow or leaching; • Annual report on solid barrier perimeter integrity around tailings facility and any observed herpetofauna mortalities or living specimens in the tailings water; • Channel, berm and tailing dams' integrity and functionality; • Annual report demonstrating any detectable effect of mining activities (chemicals, sedimentation, etc.) on the443quaticc and semi-aquatic herpetofauna communities with proposed remedial actions (where necessary). Species composition and relative

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		• Safe Operating Procedures (SOP's) shall be developed and enforced for handling of mine waste spillages; • If extensive contamination has occurred, the affected area must be rehabilitated appropriately. This will require consultation with experts in the relevant field specializing in the rehabilitation of polluted habitats (terrestrial or aquatic); and • The return water dam (or pollution control dam) has not been included in the layout as it is still being designed. Impacts regarding its placement will need to be assessed once the layout has been finalised.			abundances to be provided in tabular format for comparison and statistical analysis.
Operation	Watercourse contamination due to chemical spillage	• Apply only the minimum chemicals necessary for the task and according to industry best practice; • Construction vehicles and machinery will be serviced regularly and away from sensitive habitats; • A dedicated storage facility for all potentially hazardous chemicals will be constructed away from sensitive habitat types according to industry best practice; • Accidental hydrocarbon spills will be cleaned immediately. Chemical spill clean-up kits must be stationed at all sites where spills are probable,	Pensana and ECO	Refer to 9.5.10	• Channel, berm and pollution control dam integrity and functionality; • Annual report demonstrating any detectable effect of mining activities (chemicals, sedimentation, etc.) on the444quaticc and semi-aquatic herpetofauna communities with proposed remedial actions (where

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		especially in conjunction with sensitive habitats such as close proximity to aquatic habitats. Several staff shall be trained in the chemical clean-up procedure, and at least one member of this unit must be on duty at all times; • Safe Operating Procedures (SOP's) shall be developed and enforced for handling of hydrocarbons; • A zero-tolerance approach for hydrocarbon spillage next to the watercourse shall be communicated to staff and contractors; • No vehicles or machinery shall be allowed in the buffer areas of watercourses except where crossing over bridges is required. Predetermined areas shall be indicated / demarcated where vehicles and machinery are to be stored, repaired and re-fuelled; • Drip trays shall be positioned under stationary vehicles and plant machinery that are not actively moving around the plant, to collect hydrocarbon spills; and • If extensive spills have occurred, the area must be rehabilitated appropriately. This will require consultation with an ecologist and soil scientist specializing in the rehabilitation of polluted habitats. This will further decrease the magnitude of the			necessary). Species composition and relative abundances to be provided in tabular format for comparison and statistical analysis.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		anticipated impacts arising from accidental spills.			
Operation and Decommissioning	Potential impacts due to Water abstraction	• Avoid abstraction of ground and surface water volumes to levels that would result in flow being reduced to below the ecological reserve limit necessary for the continued functioning of the surrounding rivers and streams; and • In event of a chemical spill, limit abstraction volumes to achieve sufficient dilution of chemicals in rivers and streams to reduce toxicity.	Pensana	Refer to 9.5.11	• Water chemistry → See Hydrology Report; and • Water levels → See Hydrology and Aquatic Ecology reports. •
Hydrogeology					
Site prep and Construction	Waste generated from maintenance and refuelling of plant and machinery	• Establish designated areas in which activities that can produce contaminated hydrocarbon waste can take place (filling station) • Use impervious surfaces for all the workshop areas and refuelling bays; • Construct adequate drainage structures to collect of contaminated wastewater and use oil/water separators; • Remove and treat any contaminated soil on an impervious layer as soon as possible (spill kits).	PENSANA Construction Manager or Project Manager	Prevent contaminants such engine oil, used oil, diesel and other hydrocarbon based fluids to infiltrate into the groundwater.	• Good house- keeping and limited or no spillages
Site prep and Construction	Generation of sanitary wastewater discharge	• Provide portable sanitary facilities at the site for the construction workers or adequately designed septic tank systems;	PENSANA Construction Manager or Project Manager	Prevent sanitary wastewater to enter groundwater stream.	• No spillage of wastewater

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		• Manage and dispose of the sanitation waste generated during the construction period; and • Implement a policy to monitor and report any leakages observed.			
Site prep and Construction	Hydrocarbon contamination of groundwater from accidental spills	• Use impervious surfaces for all storage areas; • Train staff in the management and clean-up of hydrocarbons • Construct bounded perimeters for all storage areas; • Implement spill response strategy; and • Treat contaminated soil in-situ from accidental spills If not successful, remove and dispose of the soil	PENSANA Construction Manager or Project Manager	No hydrocarbon contamination	• Lack of hydrocarbon related contamination and adequate spill response
Operational Phase – Plant and Production Facilities	Accidents/ spillage during storage and transport of potential contaminants.	• All storage areas as well as the pipe routes to be constructed with impervious floors to avoid losses to the environment; • All storage areas must have bunded perimeters; • All storage areas must drainage systems to a collector or containment structure fitted with oil/water separators and grease traps; • The drainage system at the storage facilities must not be connected to the stormwater collection system; and	PENSANA Mining and Plant Manager	Routine monitoring of all water resources	• To make sure adequate intervention practices are in place and to prevent groundwater contamination from accidental spillages

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		• Accident response procedure must be in place.			
Operational Phase – Plant and Production Facilities	Infiltration of contaminants into the groundwater system as a result of inadequate drainage management and failure to maintain the drainage system	• Monitor drainage volumes and ability of the system to handle peak volumes; • Maintain separators and grease traps regularly; • Dispose of the volumes in the separators and traps regularly; • Runoff from processes and storage areas should be separated from potentially less contaminated runoff; and • Augment the drainage and capture of contaminated runoff as required.	PENSANA Mining and Plant Manager	Routine monitoring of all water resources	• To make sure adequate drainage system and maintenance practices and avoid infiltration of contaminants into the groundwater system
Operational Phase – Plant and Production Facilities	Infiltration of contaminants into the groundwater system as a result of unforeseen releases of hazardous materials or as a result of accidents during production process	• Preparation and implementation of Standard Operating Procedures (SOP's); • Implement Hazardous Material Management Plan; • Carry out regular inspections of hazardous material handling; and • Institute spill response procedures.	PENSANA Mining and Plant Manager	Environmental audits and routine monitoring	• To prevent contamination of groundwater with hazardous materials
Operation of Waste Rock Dumps	Leachate generation and seepage infiltration into the groundwater system	• Use the readily available low permeability materials in the construction design; • Construct a drainage system to capture seepage and potential leachate; and • Implement a Waste Management Plan.	PENSANA Mining Manager at Pit Super-intendent	Environmental audits and routine monitoring	• To prevent contamination of groundwater with seepage from the waste dump

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Operation of TSF and related infra-structure	Leachate generation and seepage infiltration into the groundwater system	• Use the readily available low permeability materials in the construction design; • Construct a drainage system to capture seepage and potential leachate; and • Drill adequate monitoring borehole and implement a routine monitoring programme • Construct shallow interception trench system down-gradient of the TSF • Model seepages from the TSF into the groundwater environment and predict movement of contaminants	PENSANA Mining Manager and TSF Supervisor	Environmental audits and routine monitoring	• Prevent contamination of groundwater with seepage from the TSF and any related infrastructure
Operation of Pit and related infra-structure	Dewatering of local aquifer systems	• Model water inflows in order to understand volumes and chemistry; • Monitor inflows, outflows and groundwater; and • Remediate contamination sources and treat water if necessary.	PENSANA Mine Manager and Pit Supervisor	Routine monitoring and update of ground-water models	• Reduce water use and optimise mine dewatering strategy
Mine Decom-missioning and Closure activities	Temporary storage of materials and equipment	• Establish a designated area for temporary storage until decommissioning is complete; • Limit the storage time; and • Remediate (remove) any contaminated soil after the removal of equipment and materials	PENSANA Mine closure team	Environmental audits and routine monitoring	• Prevent contamination of groundwater by hydro- carbons and other solvents

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Mine Decom-missioning and Closure activities	Closure of the Pit and associated infrastructure	• Model flows prior to closure to understand volumes and chemistry; • Monitor inflows, outflows and groundwater; and • Remediate contamination sources and treat water if necessary.	PENSANA Mine closure team	Environmental audits and routine monitoring	• Limit decant and seepage of dirty /contaminated water
Hydrology					
Stormwater runoff					
Design and Construction Phase	Increased surface flood water runoff magnitude may cause submergence of existing culverts and bridges for tributaries in catchments.	• The flood capacities of existing culverts, crossings and bridges in the tributaries within the area to be developed up to the main streams need to be evaluated and enlarged to accommodate the increased peak runoff, to the same surety of non-exceedance as before. Considering the expected increased runoff, any new structure should be designed for an economically selected probability of non-exceedance.	PENSANA Civil Design Engineer and Mine	Environment Control Officer (ECO) to confirm from Designers that culvert and bridges have been designed for flood return periods as agreed. Designers to supervise construction.	• Designs to be done in accordance with international practices for agreed flood probabilities
Operational phase	Increased surface flood water runoff magnitude may cause submergence of existing culverts and bridges for tributaries in catchments.	• Culverts and bridges to be kept free of debris and silt. Erosion damage to be repaired immediately.	PENSANA and Environmental Manager	Environmental Manager to inspect culverts and bridges at least on a quarterly basis especially at the beginning of the rainy season in order to ensure it is kept free of debris and silt to prevent erosion due to overtopping of drainage structures. Mine Management shall inspect bridges and culverts after every storm event.	• Flood water must not flood existing culverts and bridges for the design flood magnitudes as agreed upon. Only limited erosion to be allowed to take place with no downstream built up of silt and debris and no debris or silt blocking upstream sides.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Post closure	Increased surface flood water runoff magnitude may cause submergence of culverts and bridges within the investigated area	• Culverts and bridges to be kept free of debris and silt. Erosion damage to be repaired immediately.	Land owners or Local Authority	Land owners or Local Authority to inspect culverts and bridges at least on a quarterly basis especially at the beginning of the rainy season in order to ensure it is kept free of debris and silt to prevent erosion due to overtopping of drainage structures.	• Flood water must not flood existing culverts and bridges for the design flood magnitudes as agreed upon. Only limited erosion to be allowed to take place with no downstream built up of silt and debris and no debris or silt blocking upstream sides.
Mean annual runoff					
Design and Construction Phase	Decreased normal and environmental flow in tributaries within the project area. Potential to be confirmed by the geohydrology specialist.	• Should water be used for domestic and other purposes by the local people, and they should be supplied with alternative water to the same surety of supply as before or compensated. Should detailed environmental studies about aquatic life in the tributaries indicate that it is important to sustain the pre-development condition, water from another source shall be supplied to the tributaries equal to a minimum amount which is required to sustain the ecology, all depending on the outcome of the geohydrology and study environmental study about aquatic life in the tributaries.	PENSANA Civil Design Engineer and Mine	Environment Control Officer (ECO) to confirm from Designers that the necessary means have been put in place to achieve the required replenishment of normal stream flow and water requirement of local people using water from the tributaries	• Designs to be done in accordance with international standards for environmental maintenance flow requirements and for domestic water supply as well as for agreed other water demands of existing water users.
Operational phase	Decreased normal and environmental flow in tributaries within the project area. Potential	• Water supply for domestic and other purposes by local people must be maintained and environmental maintenance flow.	PENSANA and Environmental Manager	PENSANA and Environmental Manager to read water flow measuring devices	• Domestic and other water demands of local people using water from the tributaries and

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
	to be confirmed by the geohydrology specialist				environmental flow volumes must be met as agreed and designed.
Post closure	Decreased normal and environmental flow in tributaries within the project area. Potential to be confirmed by the geohydrology specialist	• Water supply for domestic and other purposes by local people must be maintained and well as environmental maintenance flow			• Domestic and other water demands of local people using water from the tributaries and environmental flow volumes must be met as agreed and designed.
Soil loss					
Design and Construction phase	Increased soil loss, except for catchment number 2,3 and 5 with a reduction in soil loss due to the large proportion of the catchment being undisturbed or containing a tailing storage facility.	• All clean water runoff from the mining area shall be diverted to silt traps or swales to trap as much silt as economically possible. The overflows for silt traps and swales shall be so that stormwater is dispersed to avoid erosion. All clean water channels shall be grassed lined or protected otherwise against erosion. Temporary contour banks and berms shall be constructed on cleared land and under rehabilitation to minimize erosion. Pit backfilling is to be done continuously from the onset and the surface rehabilitated to pre-development conditions.	PENSANA Civil Design Engineer and Mine	Environment Control Officer (ECO) to confirm from Designers that the necessary means have been put in place to minimise erosion and to trap as much as possible silt	• Designs to be done in accordance with international practices for controlling soil erosion and trapping of silt
Operational phase	Increased soil loss, except for catchment number 2,3 and 5 with a reduction in soil loss due to the large proportion of the catchment being	• Grass cover in clean water runoff channels shall be maintained in good condition, and any erosion that took place must be addressed by re-grassing or other methods. Silt shall be removed from silt traps and swales and disposed	PENSANA and Environmental Manager	PENSANA and Environmental Manager must visually inspect vegetation establishment on rehabilitated land, channels and silt traps/swales on a regular basis and after each flood event.	• Clean water channels must not be eroded or silted up. Silt traps and swales must not be silted up and maintained empty. Grass and other

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
	undisturbed or containing a tailing storage facility.	of at suitable, allowed places. Temporary contour banks upstream of pits must be maintained. Backfilled pits to be rehabilitated as mining progresses			vegetation established on rehabilitated land must improve on an annual basis.
Post Closure	Increased soil loss	• Grass cover in clean water runoff channels shall be maintained in good condition, and any erosion that took place must be addressed by re-grassing or other methods. Silt shall be removed from swales and disposed of at suitable, allowed places. Contour banks on rehabilitated land to be maintained	Land owners	Land owners to visually inspect progress of vegetation establishment on rehabilitated land, channels for erosion, grass cover in channels and swales on a regular basis and immediately after flood events	• Clean water channels must not be eroded or silted up. Swales must not be silted up and maintained empty. Grass and other vegetation established on rehabilitated land must improve on an annual basis.
Noise and vibration					
Construction phase	Increase in the prevailing ambient noise levels – 3dB above the prevailing ambient noise level – see Table 3.2	• The Environmental, Health and Safety Guidelines of the IFC of the World Bank shall be taken into consideration during the construction phase of the Project: • Selecting equipment with lower sound power levels; • Installing silencers for fans; • Installing suitable mufflers on engine exhausts and compressor components; • Installing acoustic enclosures for equipment causing radiating noise; • Installing vibration isolation for mechanical equipment – care;	The PENSANA, Project engineer and ECO	• Noise monitoring to be done on a monthly basis at the measuring points given in Figure 10-1. • Noise monitoring to be done with a Class 1 Noise Level Meter. • Calibration of the instrument to be done at an accredited laboratory on an annual basis. • Noise monitoring to be done in terms of the requirements of the Health and Safety Requirements of the IFC, World Bank.	• The prevailing ambient noise levels may not be exceeded by more than 3.0dBA at the boundary of the mining area – see Legal section 3.5.8.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		• Re-locate noise sources to less noise-sensitive areas to take advantage of distance and natural shielding; • Taking advantage during the design stage of natural topography as a noise buffer; • Develop a mechanism to record and respond to complaints (grievance mechanism); and • Construction activities to be done during daytime only.			
Operational phase – Noise	Increase in the prevailing ambient noise levels – 3dB above the prevailing ambient noise level – see Table 3.2 which may result in sleeping loss for residents in the vicinity of the mining operations.	• Feedback to the Chief Engineer once the prevailing ambient noise level is exceeded by more than 3.0dBA (mining-related noise only); • Records of environmental noise to be kept for three (3) years; • Acoustic mitigatory measures to be implemented at noise sources more than 85.0dBA or when the ambient noise level is exceeded by more than 3.0dBA; • Environmental noise monitoring to be done in the vicinity of the mining boundary at least annually; and • Develop a mechanism to record and respond to complaints.	Pensana and ECO	• Environmental noise monitoring to be done on a monthly basis for the first two years after which the frequency can change to a quarterly basis; • Noise monitoring to be done on a monthly basis at the measuring points given in Figure 10.1. • Noise monitoring to be done with a Class 1 Noise Level Meter. • Calibration of the instrument to be done at an accredited laboratory on an annual basis. • Noise monitoring to be done in terms of the requirements of the Health and Safety Requirements of the IFC, World Bank.	• The prevailing ambient noise levels may not be exceeded by more than 3.0dBA at the boundary of the mining area – see Legal section 3.5.8. • The threshold value of 12.5mm/s for poorly constructed buildings and 25mm/s for modern type buildings not to be exceeded at the residential areas abutting the mining area.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Operational – Blasting	Increase in the prevailing ground vibration and/or air pressure levels during blasting activities at the pit.	• Feedback to the Chief Engineer once the prevailing ground vibration levels exceeds the threshold levels of 12,5mm/s (clay huts) and 25.0mm/s (modern type buildings) and the air pressure levels 140dBL; • Records of ground vibration monitoring per blast to be kept for three (3) years; • The site mix slurry explosives may not exceed 400kg per delay during the blast; • A 500m blast zone to be maintained around the opencast pit; • Ground vibration monitoring and air pressure levels to be measured during each blast at the blasting site and at the mining boundary the nearest to the blast; and • Develop a mechanism to record and respond to complaints.	The PENSANA, Project engineer	• Vibration monitoring to determine prevailing ground vibration levels exceeds the threshold levels of 12,5mm/s (clay huts) and 25.0mm/s (modern type buildings) and the air pressure levels 140dBL • Vibration monitoring in the 500m blast zone • Inspection of community households in proximity to the mine to identify vibration impacts	• No exceedance of threshold values
Decommissioning phase	As above	• Demolition activities and maintenance activities to be done during daytime periods only.	The PENSANA, Project engineer and ECO	• Noise monitoring to be done on a monthly basis at the measuring points given in Figure 10.1. • Noise monitoring to be done with a Class 1 Noise Level Meter. • Calibration of the instrument to be done at an accredited laboratory on an annual basis. • Noise monitoring to be done in terms of the requirements of the	• The prevailing ambient noise levels may not be exceeded by more than 3.0dBA at the boundary of the mining area – see Legal section 3.5.9.

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
				Health and Safety Requirements of the IFC, World Bank.	
Socio-economic					
Construction and operation	Training and development	• Develop training materials and training register • Develop a policy for selecting trainees – work in cooperation with local communities so that policy is understood and agreed to • Develop a schedule of training cycles and create a database of those who opt for training • Set targets for trainees so that there are clear expectations about achievements • Maintain a training register	Pensana – human resources	• Completion of training and achieving qualification • Records of meetings regarding development of trainee policy with comments and responses • Include trainee policy in SEP for life of Mine • Include environmental and H&S policies in training • Include critical aspects of ESMP in training – induction as well as periodic training	• Numbers enrolled; number who complete course to gauge success of employment policy
Construction and operation	Employment and economic benefit	• Employment policy geared to employing local people (who have skills required) • Develop employment and hiring policy • Develop key messages to manage expectations and communicate to local communities	Pensana – human resources	Record-keeping of numbers employed from the local area, national areas and expat; set targets and objectives for numbers	• Internal audits and record-keeping to compare numbers to targets and objectives
Construction and operation	Foreign exchange gains and less dependence on imports	• Promote local procurement of goods and services wherever possible • Beneficiation at the local level • Develop procurement policy • Community relations team to assess potential suppliers of goods and services in LSA	Pensana – human resources	• Database of service providers • Keep records of quality of goods available locally, as part of the database	• Local companies increasingly able to fulfil mines needs

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction and operation	Transport, infrastructure and communication	• Pensana to engage with authorities and service providers to highlight project and potential for increased population, customers and disposable income plus revenues derived from taxes	Pensana – human resources	• Improved access to services such as cell phone coverage monitored through community relations team • Increased transport network	• There may be an increase in the number of motorbike taxis as more money flows through communities enabling entrepreneurs to invest in vehicles • Increase in number of cars and minibus taxis
Construction and operation	Change to sense of place that currently prevails amongst communities	• Develop policies and management plans for contractors and employees with reference to respecting the host communities, their cultural norms and standards • Communicate with villagers throughout all phases of the Project, including pre-construction • Develop a stakeholder engagement plan (SEP) for the life of the Project that documents activities, roles and responsibilities	Pensana – human resources	• Audits to assess conformance with policies and plans • Through the SEP actions, develop neighbourly relations and assess their attitudes and concerns • Educate the communities on the grievance procedure, its purpose and how to register issues	• There is not an increasing trend of grievances submitted, good neighbourly relations are maintained and is evident through community meetings and engagement
Construction	Arrival of construction teams and camp – disruption to local communities	• ESMP to be included in contract documents • Contractors to include method statements and update ESMP in their bids • Carry out audits daily during set-up and adjust the frequency of audits according to contractors' performance	Pensana – finance manager	Contractor audits	• No findings against contractors

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction and operation	Influx of job-seekers and others seeking opportunities	• Develop an influx management plan • Develop key messages and communicate as widely as possible referring to employment policy • Key messages should include when and where applications from job-seekers are accepted (i.e., not on the site in order to dissuade people from setting up camp on or near the mine)	Pensana – human resources	• Map areas that are subject to influx and analyse results (why people choose certain areas and how this impacts the socio-economic and biophysical environments), Engage with authorities regarding influx in RSA	• No evidence of disruption of social cohesion
Construction and operation	Increased pressure on current services and infrastructure	• Influx management plan • Work with regional authorities to identify reasonable measures to support service providers • Work with the national government to reinforce	Pensana – human resources	• Engage with service providers as part of the SEP	Services do not deteriorate •
Construction and operation	Loss of land including access to land	• Complete RAP and livelihood restoration plan • Include grievance procedure in SEP	Pensana – human resources	Details to be provided in the RAP	• As per RAP – post ESIA
Construction and operation	Disruption of ecosystem services	• Adopt mitigation measures provided in specialist sections in ESIA (water, aquatic ecology, terrestrial ecology) • Include well protection and water resources in community development plans	Pensana and environmental manager	As per specialist management and monitoring plans	• As per specialist management and monitoring plans
Construction and operation	Impacts on water resources	• Adopt mitigation measures provided in specialist studies (water, aquatic ecology, terrestrial ecology)	Pensana and environmental manager	• As per the respective specialist management and monitoring plans	• As per specialist management and monitoring plans

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction and operation	Health impacts	• Develop a health and safety management plan for employees, contractors and communities • Develop occupational health and safety monitoring plans for the farm and at key receptors • Reduce risks by adopting measures in specialist reports including water, air quality, noise • Analyse health impacts records and update management plans accordingly (e.g., through education and training; share learnings between departments, with contractors and communities)	Pensana – health and safety manager	• Develop database of records of incidents, accidents, and occupational health to identify trends	• Statistics show health does not deteriorate (occupational) and in communities
Construction and operation	Cultural heritage	• Develop a chance-find procedure to manage any artefacts that are uncovered during construction or when excavating ground throughout the life of Project • The risk is low as there are no historic buildings, and communities do not have sacred sites other than churches and grave sites • Engage with authorities so that the chance-find procedure includes names and contact details in case there are artefacts uncovered and the authorities are needed to help	Pensana and environmental manager	Photographic records of areas that are excavated and engage with communities during excavations (to ask opinions on previous land use)	• Chance find procedure in place

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Soil					
Construction Phase, Operational Phase	Soil Erosion	• Appropriately designed stormwater run-off measures • Establish soil stabilistation in problem areas e.g. vegetation or 'gabions'(rock baskets)	Engineer, Environmental Manager	Monthly inspections to verify occurrence of soil erosion. Particular attention to be given to stormwater channels, down-gradient areas where irrigation is taking place, verges of Project roads etc.	• No sediment loss at problem areas and silting up of down stream areas
Construction Phase	Deterioration of Soil Properties	• Correct stripping and stockpiling of topsoil and correct reconstruction of soil during rehabilitation	Project Manager, Environmental Manager	Inspect daily stripping, stockpiling and rehabilitation activities	• No intermixing of certain diagnostic soil layers as set out in the topsoil stripping and stockpiling documents. The same is applicable during rehabilitation when the soils are being reconstructed.
Construction Phase, Operational Phase	Dust generation	• Prevent excess dust forming during construction and operational activities	Environmental Manager	See Air Quality mitigation and monitoring requirements	• See Air Quality mitigation and monitoring requirements
Construction Phase, Operational Phase	Contamination	• Chemical, hydrocarbon and other storage areas to be under cover (i.e. roofed) to prevent contaminated waterflow, which would facilitate the transport of the pollutants to soils and to water bodies. • Design and construct bunds around storage areas to facilitate containment. • Implement a spill and leak protocol.	Environmental Manager	ECO shall on a weekly basis inspect all hydrocarbon and chemical storage areas, including areas where hydrocarbons and chemicals are used (e.g. maintenance yard, vehicle fuelling area, workshops, laboratories) for evidence of spillages.	• Visual assessment of spillages, accident reports of incidents

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction Phase	Topsoil Stripping	• Conduct topsoil stripping on a specified protocol to make sure that diagnostic soil horizons are not intermixed to be used optimally later for rehabilitation purposes	Project Manager, Engineer, Environmental Manager	Working carefully with earthmoving machinery from a digital terrain map. Making sure horizons identified are not mixed	• Visual inspection, monitoring and logging where different stockpiles are placed containing diagnostic horizons stockpiled together.
Construction Phase, Operational Phase, Closure Phase	Surface Development	• Prevent loss of topsoil where there are any planned or unplanned surface development	Project Manager, Engineer, Environmental Manager	Conduct visual inspections on a weekly basis.	• Visual inspections no topsoil is lost from disturbed areas
Operational Phase, Closure Phase	Rehabilitated Areas Erosion	• Prevent poor surface control measures to make sure that no erosion takes place	Environmental Manager, Engineer	Implement proper water control measures.	• No sediment loss should occur
Closure Phase	Effective Depth	• Make sure that during reconstruction of the soil profile considering compaction and potential subsidence the effective depth should not be <300mm @ BD 1,275kg/m³.	Environmental Manager/Engineer	Measure effective depth after soil reconstruction	• Monitor plant growth and water holding capacity on reconstructed soil profiles.
Construction Phase, Operational Phase, Closure Phase	Land Use/Land Capability	• Land use will be altered during life of the mine and will be reverted back to wilderness during closure.	Engineer, Environmental Manager	Make sure that proper soil reconstruction in terms of different soil layers takes place.	• No sediment loss, soil chemical + physical + mechanical properties are within required standards for stable landscape.
Traffic					
Construction and operation	Traffic – health and safety	• A traffic management plan (with community awareness programme)	Pensana – health and	• Record accidents and incidents pertaining to mine traffic	• Zero traffic incidents annually

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		• Design and implement training for drivers • Include traffic in the over-arching health and safety plan • Air quality: reduce risks by implementing an air quality management plan • Put up traffic signs at junctions and strategic places • Set and enforce speed limits (speeds should not exceed 30km/hour through villages on main and access roads) • Monitor and record traffic incidents and accidents – Project traffic (Project traffic) • Record and share learnings from traffic incidents and accidents involving third parties (to raise safety awareness and where risks may be encountered, amongst all employees and contractors)	safety manager		
Visual					
Construction; Operation	TSF, dumps and stockpiles	• Shaping of TSF and waste dump; • Ensuring slopes do not exceed a ratio of 1:1.6 to prevent erosion; • Not exceeding heights as specified in Table 2.1; and • Vegetate the TSF and dumps to minimize the sight of bare soil and prevent wind and water erosion	The PENSANA, Project engineer and ECO	• Audits during construction by the mine and third-party auditors	Following approved engineering drawings

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction	Site and road clearing	• Remove the minimum amount of natural vegetation; • Retain taller vegetation species where possible	The PENSANA, Project engineer and ECO	• Audits during construction by the mine / contractor and botanist	Following pre-determined plans based on vegetation patterns
Construction; Operation	Dust generation: clearing, blasting, load-and-haul operations	• Dust suppression techniques – see Air Quality mitigation measures in section 8.15.1.1	The PENSANA, Project engineer and ECO	• Audits in conjunction with air quality requirements – see Air Quality mitigation measures in section 8.15.1.1	Audit recommendations
Construction; Operation	On-site machinery, equipment, materials; heavy vehicles using roads; increased traffic flow	• Overnight storage of equipment and materials away from receptors; • Regular maintenance of equipment and general surrounds • Regular removal of rubble and litter; • Limit pit operations to daylight hours; • Use of vegetation screens on-site and along roads to shield operations	The PENSANA, Project engineer and ECO	• Audits during construction by the mine / contractor and third-party auditors	Following audited and approved standard operating procedures
Construction; Operation	Artificial lighting	• Use down-lighting and low impact lighting; • Avoid tall lights on the periphery and make use of motion sensors	The PENSANA, Project engineer and ECO	• Audits during construction by the mine / contractor and third-party auditors	Following approved engineering drawings
Construction; Operation	Constructed infrastructure	• Use natural hues and non-reflective material on structures; • Use vegetation screens to shield structures from receptors; • Retain taller species as additional shielding; • Limit pit activities to daylight hours	The PENSANA, Project engineer and ECO	• Audits during construction by the mine / contractor and third-party auditors	Following approved engineering drawings

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction	Altering site topography	• Make sure that safe storage of excavated overburden and topsoil stockpiles to prevent material loss due to water and wind erosion.	The PENSANA, Project engineer and ECO	• Audits during construction by the mine / contractor and biophysical specialists	Following approved biophysical recommendations
Construction	Pit	• Retain natural vegetation where possible • Strategic placement of other infrastructure to mask pit operations	The PENSANA, Project engineer and ECO	• Audits during construction by the mine / contractor and third-party auditors	Following approved engineering drawings
Waste management					
Construction; Operation	Generation of general and non-hazardous waste during construction and operation	• An engineered facility will be designed and constructed onsite; • Reduce the amount of waste being generated (e.g., a system for providing drinking water on-site without using single-use bottles, which are commonly used on remote sites); • Recycling waste – onsite or through commercial recyclers (e.g., scrap metal dealers); • Composting onsite – food waste and organic materials (as composting facilities can attract vermin, therefore pest control measures must be included in management plans); • Medical waste will be collected and stored safely and sent to the nearest hospital for incineration.	PENSANA and environmental manager	• Monthly waste storage- and disposal facility audits • Waste volume database kept and trends indicating stable / reducing waste volumes	• Minimum non-compliances noted during audits • Non-compliances resolved with immediate effect or management plans put in place or adjusted to remedy non-compliance

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction and Operation	Generation of hazardous waste during construction and operations	• Develop and implement a Waste Management Plan for the Project, including objectives for the collection, storage, transport, minimization and disposal of all hazardous and non-hazardous wastes generated by the Project; • Demarcated temporary collection/storage areas with suitable and well-marked waste bins for hazardous waste will be provided at strategic places; • Hazardous waste streams will be labelled and stored separately and recycled as far as possible to minimize volumes requiring landfilling; • Where possible hazardous waste will be returned to the suppliers (e.g. empty chemical containers); and • Employees will be educated to make sure that the objectives of the Waste Management Plan are achieved.	PENSANA and environmental manager	• Waste Management Plan implementation • Monthly waste storage- and disposal facility audits • Waste volume database kept and trends indicating stable / reducing waste volumes	• Waste Management Plan implementation • Minimum non-compliances noted during audits • Non-compliances resolved with immediate effect or management plans put in place or adjusted to remedy non-compliance
Construction and Operation	Temporary storage of waste	• Development and implementation of a Waste Management Plan for the Project, including objectives for the collection, storage, transport, minimization and disposal of all hazardous and non-hazardous wastes generated by the Project; • All hazardous waste streams shall be identified (inventory) and classified to	PENSANA and environmental manager	• Waste Management Plan implementation • Monthly waste storage- and disposal facility audits • Waste volume database kept and trends indicating stable / reducing waste volumes	• Waste Management Plan implementation • Minimum non-compliances noted during audits • Non-compliances resolved with immediate effect or management

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		make sure that toxic components are known and to make sure it is managed and disposed of in a safe manner; • Hazardous waste will be stored in sealed containers, where relevant, constructed of a suitable material and will be labelled clearly; • All hazardous waste will be stored, transported, and disposed of in compliance with the law; • Hazardous and non-hazardous waste storage areas on-site will be positioned away from any stormwater drains and watercourses and away from moving vehicles and equipment to prevent accidental spills; • The temporary storage/sorting site will at least comply with the following: o Accidental spillage of hazardous liquids or materials to the soil and groundwater around the temporary storage area shall be prevented; o The site shall be provided with an impervious base to prevent ingress of liquids/leachate; o The hazardous storage area will be provided with a roof; o The facility will be provided with a spill containment bunded area to accommodate a volume equal to 1.1 times the volume of all containers stored on it as well as the volume of			plans put in place or adjusted to remedy non-compliance

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		water during a 1-in-25 year storm event, plus the greater of 10% of the aggregate volume of all containers or 100% of the capacity of the largest tank within its boundary, whichever is greater; o Leachate generated at the facility will be stored in a contaminated liquid pond and treated before re-use or being released; o Different and incompatible waste (e.g. such as chlorine and ammonia) will be clearly labelled and stored separately to prevent any chemical reactions such as combustion/fire; o During the rainy season, temporary containment facilities will be covered during non-working days and before rainfall events. Covered facilities may include the use of plastic tarps for small facilities or constructed roofs with overhangs; o Drums will not be over-filled, and different wastes types not be mixed; and o Unless watertight, containers of dry waste shall be stored on pallets or similar. • The production or generation of hazardous materials and hazardous waste will be minimized as far as possible; • Containment bunds will be provided in fuelling and maintenance areas			

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		(including any other areas where the potential for spills is high); • Liquid / semi-liquid hazardous waste shall be kept in appropriate containers (closed drums or similar) and be placed under a roof (or similar structure); • All hazardous waste containers will clearly be labelled with the waste being stored and the starting date of accumulation; • Potentially hazardous waste materials will not be accumulated on the ground; • Empty hazardous containers will be punctured before disposal to prevent it from being re-used (e.g. by community members to collect drinking water from the river); • The original label of liquids and materials will not be removed as it contains important disposal and safety information; • Material Safety Data Sheets (MSDS) will be kept (i) on file in the place of storage (e.g. chemical stores, and (ii) at the location where the chemical in question is being used (e.g. a copy of the MSDS for a pesticide must also be available in the vehicle that it transporting the pesticide to the area of application); • PENSANA will regularly explore the possibility of replacing toxic substances			

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
		(e.g. certain pesticides) with more environ-friendly substances; • Hazardous waste will be separated and recycled as far as possible to minimize volumes requiring disposal; and • PENSANA will include aspects relating to the Waste Management Plan in the regular training curricula for staff plus contractors.			
Construction and Operation	Spillage of hazardous waste during transport off-site	• All hazardous liquid waste should be returned to the supplier if possible; • Hazardous liquid waste should be placed in suitable sealed containers and appropriately labelled; • Only trained personnel shall handle hazardous waste; • PENSANA will appoint a suitably qualified waste contractor company with vehicles transporting the waste, being purposed built and all required Haz-chem signage and emergency contact details should be displayed on these vehicles; • Vehicles shall strictly adhere to the speed limit imposed on the vehicle; • Only trained personnel should transport hazardous wastes; and • Access roads shall be well maintained to facilitate safe passage to and from the site.	Contractor and PENSANA ("Cradle to grave" principle requiring PENSANA to make sure that waste is safely disposed of at final destination.	• Waste Management Plan implementation • Monthly waste storage- and disposal facility audits • Waste volume database kept and trends indicating stable / reducing waste volumes	• Waste Management Plan implementation • Minimum non-compliances noted during audits • Non-compliances resolved with immediate effect or management plans put in place or adjusted to remedy non-compliance

Project phase	Potential impact	Detailed actions	Responsible person/ entity	Monitoring mechanism	Indicator / performance criteria
Construction and Operation	Unauthorised disposal of waste to the environment	• A Waste Management Plan for the Project will be implemented prior to the commencement of the operational phase. This plan shall cover the collection, transport, storage, recycling and disposal of all waste materials. In addition, it shall also provide for regular auditing and the ongoing monitoring of all waste management activities; • Corrective actions for non-compliance with the WMP will be implemented; • Regular environmental audits and inspections of the surrounding area will be undertaken to identify any environmental concerns and take action to rectify them; and • Workers shall be educated and trained to make sure that the environment is kept clean, and a reporting system will be implemented to report transgressors.	PENSANA and environmental manager	• Waste Management Plan implementation • Monthly waste storage- and disposal facility audits • Waste volume database kept and trends indicating stable / reducing waste volumes	• Waste Management Plan implementation • Minimum non-compliances noted during audits • Non-compliances resolved with immediate effect or management plans put in place or adjusted to remedy non-compliance

8.15.1 Air quality – additional mitigation measures

8.15.1.1 Dust Management Plan

8.15.1.1.1 Site Specific Management Objectives

The main objective of Air Quality Management measures for the Longonjo Mine Project is to make sure that the performance of all operations remains within ambient air quality criteria. Particulates were identified as the main pollutant of concern from the proposed mining project operations.

The ranking of sources serves to confirm or, where necessary, revise, the current understanding of the significance of specific sources, and evaluate the emission reduction potentials required for each. Sources of emissions for the proposed project may be ranked based on:

- emissions - based on the comprehensive emissions inventory established for the operations, and,
- impacts - based on the predicted ambient inhalable and respirable particulate concentrations.

Source ranking based on emissions was undertaken for source groups reflecting proposed operations with no control measures. The ranking of uncontrolled sources indicates the relative significance of each source. This also allows the assessment of the suitability of controls. In addition, ranking according to emissions and impacts facilitates the identification of sources requiring further controls.

8.15.1.1.2 Ranking of Sources by Emissions

Quantified particulate emissions due to the proposed project operations were provided in section 5.3.1. The emissions were divided into point sources and fugitive particulate sources, including TSP, PM_{10} and $PM_{2.5}$ per operation category.

The most significant contribution of total particulate emissions due to proposed unmitigated operations is vehicle entrainment.

8.15.1.2 Project-Specific Management Measures

The air quality assessment found that the acceptability of proposed operations in terms of World Bank guidelines necessitates implementing an effective local dust management plan. Given the potential dust impacts from operations, it is considered “good practice” that dust control measures are implemented throughout the project's life, and it is recommended that the project proponent commit itself to dust management planning. The main contributing sources of particulate emissions have been identified and quantified.

8.15.1.3 Estimation of Dust Control Efficiencies

The main sources of fugitive dust emissions from the proposed project were identified to be:

- Vehicle entrainment on unpaved road surfaces

The impacts from vehicle entrainment are directly linked to vehicular activity. The impacts from unpaved road surfaces may be mitigated with water sprayers (assuring ~75% control efficiency). It is recommended that, as a minimum, the access road and onsite haul roads be mitigated with water sprayers in order to reduce the particulate impacts on the surrounding communities.

8.15.1.4 Identification of Suitable Pollution Abatement Measures

Suitable abatement measures have been discussed in detail in the Air Quality Specialist Study (Appendix C). The main mitigation measures for dust on haul- and general mining road surfaces include:

- Regular water spraying;
- Spraying with any of several chemical palliative products, including hygroscopic salts, lignosulfonates, petroleum resins, polymer emulsions; and

- Monitoring climatic conditions and visual monitoring of dust emissions.

8.15.1.4.1 Specification of Source-Based Performance Indicators

Source-based performance indicators for proposed routine operations for the project would include the following:

- Dustfall immediately downwind of the tailings and waste rock piles to be < 1200 mg/m²/day and dustfall at sensitive receptors to be < 600 mg/m²/day.
- Crushing and screening plant: The absence of visible dust plume at all tipping points and outside the crushers during crushing operations would be the best indicator of effective control equipment in place. In addition, the dustfall near various sources should be <1 200 mg/m^2/day and dustfall at sensitive receptors to be < 600 mg/m²/day.

8.15.1.4.2 Record-keeping, Environmental Reporting and Community Liaison

8.15.1.4.2.1 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly) during rehabilitation, with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be considered in the inspections and audits must be made transparent by way of minimum requirement checklists included in the Environmental Management Plan.

Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that the quarterly/annual reviews indicate progress towards targets to be unsatisfactory.

8.15.1.4.2.2 Liaison Strategy for Communication with Interested and Affected Parties (I&APs)

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. EMPs should stipulate specific intervals at which forums will be held and provide information on how people will be notified of such meetings. For operations for which un-rehabilitated or party rehabilitated impoundments are located near (within 3 km) residential areas, it is recommended that such meetings be scheduled and held at least on a bi-annual basis.

8.15.1.4.3 Financial Provision (Budget)

The budget should indicate the capital and annual maintenance costs associated with dust control measures and dust monitoring plans. It may be necessary to make assumptions about the duration of aftercare prior to obtaining closure. This assumption must be made explicit about assessing the financial plan within this framework. Costs related to inspections, audits, environmental reporting and interested and affected parties (I&AP) liaison should also be indicated where applicable. Provision should also be made for capital and running costs associated with dust control contingency measures and security measures.

The financial plan should be audited by an independent consultant, with reviews conducted annually.

8.15.1.5 Summary of Dust Management Plan

A summary of the air quality management objectives is provided in Table 8-3. The management and monitoring of all operations at the mine should be evaluated daily, and appropriate actions should be taken to minimise dust generation and impacts.

Table 8-3: Air Quality Management Plan for the proposed project operations

Aspect	Impact	Management Actions/Objectives	Target Date
Vehicle entrainment on unpaved road surfaces	PM_{10} and $PM_{2.5}$ concentrations and dustfall rates	• Various management measures may be implemented, including: • Water sprayers provide ~75% control efficiency • Chemical suppressants provide 80%-90% control efficiency. *Due to the proximity of sensitive receptors to the proposed project activities, it is recommended that the access road and onsite haul roads be mitigated through watering, as a minimum, to achieve a control efficiency of 75%.*	Duration of operations
Crushing operations	PM_{10} and $PM_{2.5}$ concentrations and dustfall rates	• Various management measures may be implemented, including: • Telescopic chute with water sprays provide ~75% control efficiency • Water sprayers on crushing activities provide ~50% control efficiency • Hoods with scrubbers provide up to 75% control efficiency • Enclosure of scrubbers and screens would provide up to 100% control efficiency • Hooding with fabric filters can result in control efficiencies of 83%. *Visual observations of the crusher should be undertaken daily. If visible plumes of particulate matter are observed, water sprayers on the crushing activities should be implemented to control the emission of this source by 50%.*	Duration of operations
Wind erosion from the TSF	PM_{10} and $PM_{2.5}$ concentrations and dustfall rates	*Given the proximity of sensitive receptors to the preferred TSF option, it is recommended that the sidewalls of the tailings dam be vegetated. The vegetation cover should ensure at least 80% control efficiency.* *The top surface area should have a 40% wet area (if feasible).* Other control measures that may be implemented (depending on the practicality) is to introduce a water spraying system on the surface of the tailings dam covering the outer perimeter of the dam, spraying water when the wind exceeds 5.4 m/s.	Duration of operations and post-operational phase
Ambient Monitoring	PM_{10} concentrations and dustfall rates	• A proposed dust fallout sampling network (comprising seven single dust buckets), is recommended, as provided in Section 5.2.3. Dust fallout rates to be below 1200 mg/m²/day in non-residential areas and 600 mg/m2/day in residential areas averaged over 30 days. • One PM10 sampling campaign is recommended at the closest sensitive receptors (north east of operations) once proposed mitigated operations take place to ensure minimum impacts from the project on the surrounding communities.	Duration of operations

8.15.2 Aquatic ecology – additional mitigation measures

Based on the outcomes of the assessment, the following additional studies have been recommended:

- Waste classification to determine the nature of the proposed lining at the TSF;
- Detailed water balance during detailed design to derive the volumes of water required for the operation of the project;
- Additional studies on the levels of endemicity and description of fish species in the Area of Influence;
- Water and aquatic biomonitoring; and
- During the initial years of the TSF operation, the stream within the footprint of the TSF shall be diverted until the progressive construction of the TSF covers the entire stream. An offset strategy and plan will be required to offset the loss of the stream. An Offset study is required for the direct impacts to delineated riverine habitats.

8.15.3 Avifauna and Mammals

8.15.3.1 Loss of the Carbonatite Outcrop and Associated Habitats: Consequences for Endemic, and / or habitat Specific Avifauna and Roosting Bat Colonies.

- Attempt to safeguard a portion of the diatreme hill, specifically, the Carbonatite Outcrop and associated habitats situated on the southern crest. This area has been designated as highly sensitivity (see sensitivity map) as it supports a unique and diverse avifaunal and mammal assemblage.
- This area should be marked as an ecologically sensitive area and all mining related activities as well as general foot traffic (construction workers, and the general public) should be avoided in this area.

8.15.3.2 Loss of Other Bird and Mammal Habitat

- Avoid the clearing of vegetation and / or the establishment of mine infrastructure in the watercourses and their associated 200 m buffers.
- Clearly demarcate the footprint area (to exclude all highly sensitive habitats) and restrict all Project related disturbances to in this area.
- Keep the placement of infrastructure close to the access road where the habitat is considerably more degraded.
- Where possible, existing access routes and walking paths must be made use of, and the creation of new routes limited;
- All equipment laydown, storage areas etc. should be restricted to in the downslope Project area;
- Areas outside of the footprint that are denuded during construction need to be re-vegetated with locally indigenous vegetation.
- Rehabilitate (till, install wood brush at regular intervals and re-vegetate) all drill prospecting roads that will no longer be used.
- Commission a wetland delineation and baseline assessment followed by a detailed wetland rehabilitation and offset strategy.
- Implement the rehabilitation and offset strategy.

8.15.3.3 Increased Mortality Risk to Birds and Mammals

- An experienced, qualified environmental control officer must be on site when construction begins to identify potential fauna and potential nests that will be directly disturbed and to relocate fauna/flora that are found during construction.
- Where possible, work should be restricted to one area at a time. This will give the smaller birds, mammals and reptiles a chance to weather the disturbance in an undisturbed zone close to their natural territories.
- Seek the advice of an appropriate qualified specialist as required.
- No trapping, killing or poisoning of any wildlife should be allowed and the intentional killing of any animals including snakes, insects, lizards, birds or other animals by staff should not be allowed.

- Staff should be educated about the sensitivity of faunal species by means of an induction video and the erection of biodiversity awareness signs and posters.
- Selected staff must be trained to be able to safely capture and relocate potentially dangerous or injured mammal and bird species.
- Speed control signs must be installed and implemented- maximum speed on the property must be limited to 40km/h.
- Fill trenches and temporary excavations as soon as possible to avoid trapping mammal and birds and causing habitat fragmentation by restricting dispersal;
- Leave one side of the trench with a 45° to allow for trapped animals to crawl out.
- Regularly inspect pits and trenches to remove trapped animals. This should be done by appropriately trained staff.

8.15.3.4 Sensory Disturbance to Birds and Mammals

- To minimize potential sensory disturbance to the roosting bat colony and other sensitive / endemic species It is recommended that any mining on the hill be left to last and that areas furthest from the hill are mined first. It appears that, based on communications with the on-site staff that the flatter areas would be mined first in any case due to practical reasons and the ease of ore extraction from the deeper weathered material.
- Monitor noise on site, if possible, attempt to attain readings from the top of the hill as close to the bat roost cave as possible.
- Prohibit general access to the bat roost cave.
- During construction and operation efforts should be made to reduce general sensory disturbances to local fauna. Noise must be kept to a minimum. Dust must be minimized by means of water or the use environmentally friendly dust suppressants. Light pollution and its effects on biodiversity can be reduced by keeping outdoor lighting to a minimum, using yellow lights and by fitting lights with hoods that direct the light downwards.
- Construction activities should take place during winter when the risk of disturbing sensitive life history stages (e.g. nesting) is lowest.
- Regularly apply environmentally sustainable dust control agents to suppress dust in working areas and along roads.

8.5 Loss of Red-listed Raptor Species Nests

- It is not anticipated that any large raptor nests will be encountered on site.
- However, if any large nests (comprised of sticks only) are encountered during clearing, activities in 100m of the nest should be ceased, a picture taken and sent to an appropriately qualified avifaunal specialist for assessment of the situation and advise on the best way forward.

8.6 Exposure of Birds and Mammals to Contaminated Water Downstream of the Mine

See mitigation and management actions as outlined in section 8.9 and 8.10 of the herpetofauna assessment.

8.7 Effects of Potential Dewatering of Wetlands on Birds and Mammals

- Develop a comprehensive mine water balance assessment and use in conjunction with geohydrological studies to determine maximum abstraction rates. Adjust extraction rates accordingly during operation to prevent flows in the watercourses from being reduced to below the ecological reserve limit necessary for continued functionality.

8.8 Increase in the Prevalence of Alien and Pest Species

- Prevent the establishment and spread of alien and invasive plant species. To do this most efficiently it is recommended that an alien and invasive species management plan be compiled and implemented.
- No alien plants should be brought into the Project area only locally indigenous species should be planted in the mine gardens.
- Areas that are denuded during construction need to be re-vegetated with indigenous vegetation.

- Appropriately manage waste and limit the accumulation of rubbish on site to avoid the influx of Pied Crow and non-native rats and mice.

8.9 Collision and Electrocution of Birds with Novel Powerline Infrastructure

- Any new powerline infrastructure should be as far as possible parallel to existing infrastructure.
    - o All new powerlines should be fitted bird flappers and anti-perch spikes to reduce the risk of collision and electrocution respectively

8.15.4 Herpetofauna - additional mitigation measures

8.15.4.1 Loss of existing habitat

- Divert the watercourse around the southern TSF;
- Rehabilitate and offset the loss / damage to this reach of the watercourse;
- Restrict as much of the infrastructure and mining activities to lower-lying areas of Low ecological sensitivity;
- Utilise the existing sand road to access the southern TSF; and
- As far as practical, implement safe and financially feasible consideration of a rolling rehabilitation approach of mined-out pit areas as the pit progresses. This will disperse rehabilitation costs over the life of mine while greatly expediting the rehabilitation process.

8.15.4.2 Direct mortality of herpetofauna due to excavation

- Attempt to adopt a rolling TSF construction method in which tailings deposition starts on one end, depositing tailings material as high as safely possible with new areas only being cleared as the TSF expands. This would allow herpetofauna more time to move out of the area (i.e. not clearing the entire planned extent of the TSF waste dump or topsoil stockpile areas all at once but rather in phases / zones).

8.15.4.3 Watercourse contamination from mine waste and tailings storage facilities

- Divert the watercourse that currently flows through the proposed location for the southern TSF around it;
- Commission a wetland delineation and baseline assessment;
- Commission and implement a detailed wetland rehabilitation and offset strategy;
- Utilise both in-situ and ex-situ wetland compensation. In-situ efforts should include the construction of the diversion such that it functions as an artificial unchannelled valley bottom wetland. Ex-situ rehabilitation should involve the restoration and protection of an existing but degraded wetland elsewhere in the project area;
- Monitor water quality upstream, in and downstream of the watercourse diversion;
- It is recommended that herpetofauna monitoring centred on amphibians is conducted at sites situated above, in and below the watercourse diversion as well as a control site to gauge the success of the diversion and rehabilitation efforts.

8.15.5 Hydrogeology - additional mitigation measures

Groundwater monitoring boreholes should be drilled both up and down-gradient of all major mining activities that could cause groundwater contamination. This includes the Pit, waste rock dumps, tailings dams, accommodation facilities, ore processing plants and fuel storage yards. The aim of these monitoring holes would be to:

- Provide groundwater quality information around the Plant and related infrastructure;
- Monitor groundwater trends around all mining activities, including the pit and ore stockpiles;
- Identify water quality trends around waste rock dumps, tailings dams (TSF) and related infrastructure;

- Alert the Mine as to the existence or migration of any contamination within the local groundwater systems;
- Provide long-term trends as to the degradation or improvement in groundwater quality in the mining lease area; and
- To be preserved and become permanent groundwater monitoring fixtures.

Once all the Mine-related infrastructure's planning and spatial location have been finalised, the location, design, and drilling of the monitoring boreholes will be proposed relative to each potential pollution source.

The new 13 monitoring boreholes drilled around the 2 new proposed TSF locations provided very good information about these areas' shallow granitic aquifer systems. These systems are shallow, contain very good quality water, and are used extensively by the local communities for the irrigation of to irrigate their crops especially during the dry season. As a result, the regular monitoring of the boreholes is proposed together with a network of springs located below the TSF. Should any contamination from the TSF be detected, consideration should be given to intercepting this with a shallow trench system.

8.15.6 Hydrology

It is not possible to evaluate the possibility of water quality deterioration relating to tailings and waste material, as a waste classification report was not available. Also, the process chemicals used for operations were not available at the report writing stage. However, preliminary indications show that water quality deterioration will not be a major risk should mitigation measures be put in place and maintained. In addition, the effect on the main tributaries passing the mining site will be significantly less due to the dilution effect (total catchment areas investigated only 2.78% and 0.38% of the larger catchments).However, it will ultimately depend on actual pollutant concentrations and volumes flowing the tributaries.

If the usable flow in tributaries and groundwater decreases, local communities using the water from these sources shall be supplied with volumes of water equal to predevelopment requirements from alternative approved sources or compensated.

If the environmental maintenance flow (i.e. minimum water flow required to sustain biological processes in the water resource) in tributaries reduces to less than the minimum established requirements, the water flow must be augmented for approved other sources.

The TSF (southern TSF – TSF 9/10) proposed in catchment number 5 is placed on a small watercourse. Clean water must be diverted around the proposed tailings storage facility, especially during the early construction stage of the TSF. This may cause secondary negative impacts on the environment, which must be assessed and mitigated. The diversion structure will increase the disturbed footprint and cause erosion if not carefully designed.

8.15.7 Noise and vibration

No additional mitigation measures that those stipulated in section 8.15.

8.15.8 Radiation management

Naturally occurring radio-nuclides such as uranium (U), thorium (Th) and radium (Ra) are often associated with rare earth deposits, such as those to be mined at the Longonjo mine. Pensana engaged “Radiation Advice & Solutions Pty Ltd” of Australia, with principal Mr Mark Sonter, a recognised expert in the area, to make sure that regulatory compliance is achieved and that appropriate health, safety and transport procedures are implemented. Mr Sonter is an independent specialist; therefore has reviewed the project on such a basis. Mr Sonter was instrumental in drafting the Radiation Management Plan (RMP) and HCV Africa included the RMP in the ESIA as Appendix P. Note that the tailings will be substantially depleted of radioactivity through the removal of the ore and formation of the MRES concentrate; thus radiation levels will be less in the TSF than the in-situ orebody (as explained in the RMP).

8.15.9 Traffic - additional mitigation measures

Negative impacts of Project induced traffic (air quality, noise, health and safety etc.) may be mitigated as follows:

- Develop and implement a traffic management plan.
- Spraying gravel roads with water to suppress dust, or use a commercial product to seal surfaces (which is likely to be more costly than using water);
- Maintaining all vehicles to minimise emissions and noise;
- Induction and training for drivers / operators so they:
  - Take full responsibility for their actions as road-users
  - Are trained in first-aid
  - Check they have spill kits in their vehicles before staring shifts
  - Do routine checks before driving (check lights, indicators, washers, and safety belts)
  - Have a procedure in case of accidents/incidents
- Put up warning signs at road junctions and in strategic places on-site; and
- Enforce speed limits on the Project site (40km/h), public roads and when travelling through villages (30km/h).

8.15.10 Waste management - additional mitigation measures

All contractors must adhere to the company's Waste Management Plan (WMP) as required by Angolan legislation. The WMP must be implemented prior to the commencement of the construction phase, and the following general principles will apply:

- Minimization of waste generation by efficient use of resources and following the waste management hierarchy (prevent/minimise, re-use, recycle, other recoveries of waste and lastly only, disposal);
- Waste separation at source (metals, plastics, glass, wood, organic wastes, oil and lubricants, oil rags, filters, medical waste, tyres and other), compact/crush recyclable wastes and store in dedicated waste storage bays;
- Hazardous wastes to be correctly handled, contained in, e.g., leak-proof drums and stored in paved, covered and bunded areas for disposal (to be confirmed);
- Reduce the volume of waste through product selection, re-use and recycling;
- Properly contain waste in a proper manner as per best practices, all wastes to avoid any environmental pollution;
- Minimization of environmental impacts of waste hydrocarbons and chemicals through appropriate storage, handling, and disposal;
- All contractors / sub-contractors to adhere to the WMP and waste related requirements of the ESMP;
- General unseparated waste will be disposed in a project dedicated landfill designed, constructed and operated according to national and international requirements (to be subject to a separate EIA process); and
- WMP shall be referenced in the ESMS / SOPs / work instructions etc.

8.15.10.1 Disposal

Waste disposal shall be conducted in line with the provisions and requirements of the law. GIIP comprises implementing the waste hierarchy that ranks waste management to minimise volumes and impacts on the environment (Figure 8-1).

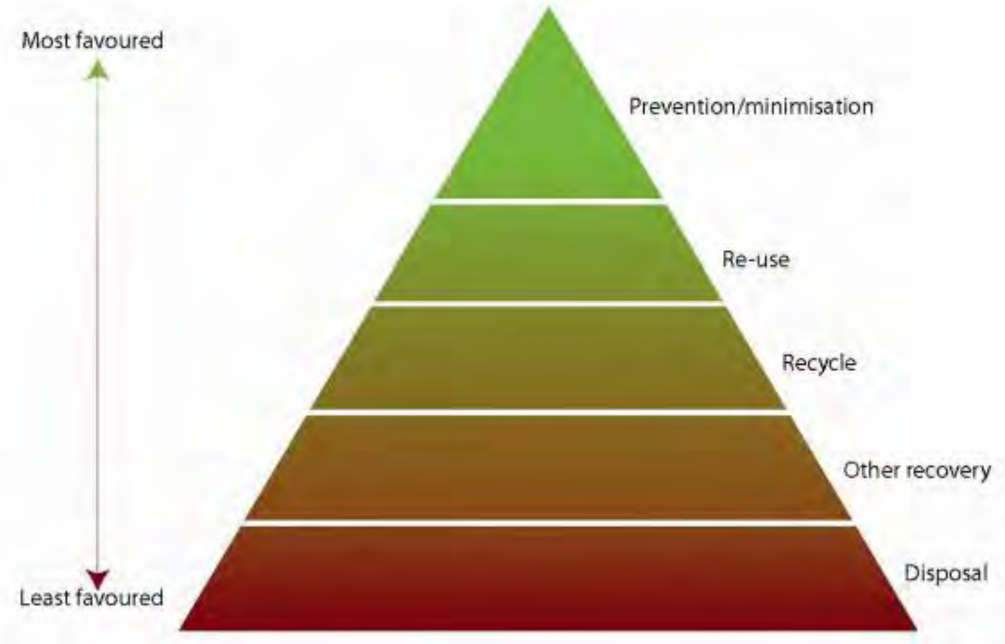

Figure 8-1: Waste hierarchy

Prevention

Waste can be minimised during construction (e.g. using pre-fabricated materials for on-site assembly and using standard dimensions of construction materials to avoid site cutting). A system should be put in place to enable the accurate estimates of material requirements at the start of the Project. Suppliers should discuss opportunities to reduce packaging or implement take-back schemes for packaging and unused materials. Where possible, hazardous materials will be substituted for less hazardous alternatives.

Re-Use

Opportunities to re-use materials shall be investigated when appointing suppliers (e.g., return containers).

Recycling

Waste generated during construction and operation shall be segregated into waste types to facilitate recycling (e.g., metals, paper, wood, and plastic). Containers should be placed at strategic points around the site to encourage good practice, and staff will be given training on waste segregation. Containers will be clearly labelled / colour-coded. PENSANA will consider using recycled materials where possible, subject to cost and availability (for example, recycled secondary aggregates as road base).

Disposal

All waste that cannot be reused, recycled or recovered will be collected and disposed of at a licensed or on-site landfill. An engineered facility has been proposed and will be finalised during detailed design.

Storage of Waste

Waste will be stored in dedicated areas fit-for-purpose skips / containers. Each skip /container will be marked and colour coded to indicate the intended contents and will be suitable for storing the specified contents. All skips will be covered to prevent waste from being blown away during windy conditions. If liquid waste is being stored, an appropriate bund and drip trays will be in place. Storage areas will be located away from potential contaminant pathways and bunded. Any hazardous waste will be stored safely in a designated area away from non-hazardous and inert wastes and labelled accordingly.

Control measures to be included are, but are not exhaustive of:

Waste prevention and reuse

- Use of refillable containers for collection of waste fluids, such as waste oil, hydraulic oil, used grease, etc;
- Seeking "buy-back" arrangements with chemical suppliers for return of surplus chemicals;
- When mixing or diluting chemicals, confirm that the correct amounts are used; and
- Avoid purchase or use of disposable materials such as plastic cups, straws.

Waste segregation

- Waste will be segregated at the source;
- A dedicated waste segregation area will be provided on-site;
- A dedicated team for waste segregation will be appointed; and
- Training sessions on waste management will be provided via toolbox talks.

Waste recycling

- Waste containers will be clearly labelled, and all staff (construction staff and contractors as well as operational staff) will be given adequate training on waste management on-site; and
- Recyclable waste will be taken to an appropriate waste recycling facility if such a facility becomes available.

Storage of waste

- A dedicated waste storage area will be provided on-site;
- Separate waste skips will be provided for timber, paper, plastic, wood, hazardous waste, steel, food and general wastes. All skips will be clearly labelled in multiple relevant languages;
- Food waste skips will be provided with lids to prevent animals from gaining access to the waste;
- Hazardous waste storage container(s) will have a label that is waterproof and marked with waste content (type, volume), hazards associated with waste, date of storage, and where it was generated;
- Hazardous waste will be stored in a designated location that is signposted;
- Incompatible hazardous wastes will be segregated; and
- As a general principle, all waste will be stored for the minimum amount of time before being removed from the site.

Waste disposal

- Contractors/members of staff shall not dump or bury waste on or surrounding the Project area (i.e., outside of designated areas);
- PENSANA will arrange for the transfer and transportation of waste with a licensed waste management contractor;
- Removal of hazardous waste from site will be done only via an approved serviced provider, to an approved disposal site for appropriate disposal;
- All waste that cannot be reused, recycled or recovered will be disposed of at a suitably engineered landfill onsite or collected by a licensed waste management sub-contractor and disposed at a permitted site suitable for the type of waste (if available);
- Vehicles removing waste from the Project should be covered;
- PENSANA will maintain waste transfer notes (WTN) from the waste contractor; and
- PENSANA provided a design philosophy for an onsite landfill site. Note that PENSANA shall still finalise the design and siting of such a landfill site.

8.16 Decommissioning phase ESMP

Discussions with stakeholders shall be had well before the decommissioning phase to plan decommissioning objectives and post-Project landuse. The ESMP shall then be updated accordingly to address the potential impacts of the decommissioning phase.

9 ENVIRONMENTAL MONITORING PLAN

9.1 Air Quality

9.1.1 Receptor Based Performance Indicators

Dustfall Network

Based on the impacts from the proposed project, it is recommended that a dust fallout network be established prior to operation commencement of the project. The dust fallout network is a relatively inexpensive management tool to monitor mitigation effectiveness. The dustfall immediately downwind of the emission sources should be < 1200 $mg/m^2/day$ and dustfall at sensitive receptors to be < 600 $mg/m^2/day$.

The dust fallout network is recommended as follows:

- Dust bucket 1: co-located with sensitive receptor (R6) in the vicinity of the access road;
- Dust bucket 2: co-located with sensitive receptor (R3) to the east of project operations;
- Dust bucket 3: co-located with sensitive receptor (R4) to the east of project operations;
- Dust bucket 4: co-located with sensitive receptor (R1) to the west of the TSF;
- Dust bucket 5: located in the vicinity of the crushing operations;
- Dust bucket 6: located to the west of the open pit operations; and
- Dust bucket 7: co-located with sensitive receptor (R12) to the south of the preferred TSF location.

The performance assessment and reporting programme recommended for the dust fallout sampling is provided in Table 9-1.

Table 9-1: Ambient air monitoring, performance assessment and reporting programme

Monitoring Strategy Criteria	Dustfall Monitoring
Monitoring objectives	• Facilitate the measurement of progress against environmental targets within the main impact zone of the operation. • Temporal trend analysis to determine the potential for nuisance impacts within the main impact zone of the operation. • Tracking progress due to pollution control measure implementation within the main impact zone of the operation. • Informing the public of the extent of localised dust nuisance impacts occurring in the vicinity of the mine operations.
Monitoring location(s)	Figure 9-1
Sampling techniques	*Single Bucket Dust Fallout Monitors* Dust fallout sampling measures the fallout of windblown settleable dust. Single bucket fallout monitors will be deployed following the American Society for Testing and Materials standard method for collection and analysis of dustfall (ASTM D1739). This method employs a simple device consisting of a cylindrical container exposed for one calendar month (30 days, ±2 days).
Accuracy of sampling technique	The margin of accuracy is given as ±200 mg/m²/day.
Sampling frequency and duration	On-going, continuous monitoring to be implemented facilitating data collection over a 1-month averaging period.
Commitment to Quality Assessment/ Quality Control (QA/QC) protocol	Comprehensive QA/QC protocol implemented.
Interim environmental targets (i.e. receptor-based performance indicator)	The maximum total daily dustfall (calculated from total monthly dustfall) is not greater than 600 mg/m²/day for residential areas. The maximum total daily dustfall to be less than 1 200 mg/m²/day on-site (non-residential areas).
Frequency of reviewing environmental targets	Annually
Action to be taken if targets are not met	(i) Source contribution quantification. (ii) Review of current control measures for significant sources (implementation of contingency measures where applicable).
Procedure to be followed in reviewing environmental targets and other elements of the monitoring strategy (e.g. sampling technique, duration, procedure)	Procedure to be drafted in liaison with I&APs through the proposed community liaison forum. Points to be considered will include, for example (i) trends in local and international ambient particulate guidelines and standards and/or compliance monitoring requirements, (ii) best practice with regard to monitoring methods, (iii) current trends in local air quality, i.e. is there an improvement or deterioration, (iv) future development plans within the airshed (etc.)
Progress reporting	At least annually to the community forum.

PM_{10} Sampling

It is recommended that PM_{10} sampling (12 months in duration) be undertaken during project operations to make sure that evaluation criteria are met at the closest sensitive receptors. The monitoring and management of PM_{10} will ensure the management of $PM_{2.5}$ as well. The location of the PM_{10} sampler will depend on the site's security, and it is recommended that it be co-located with a close sensitive receptor to the project.

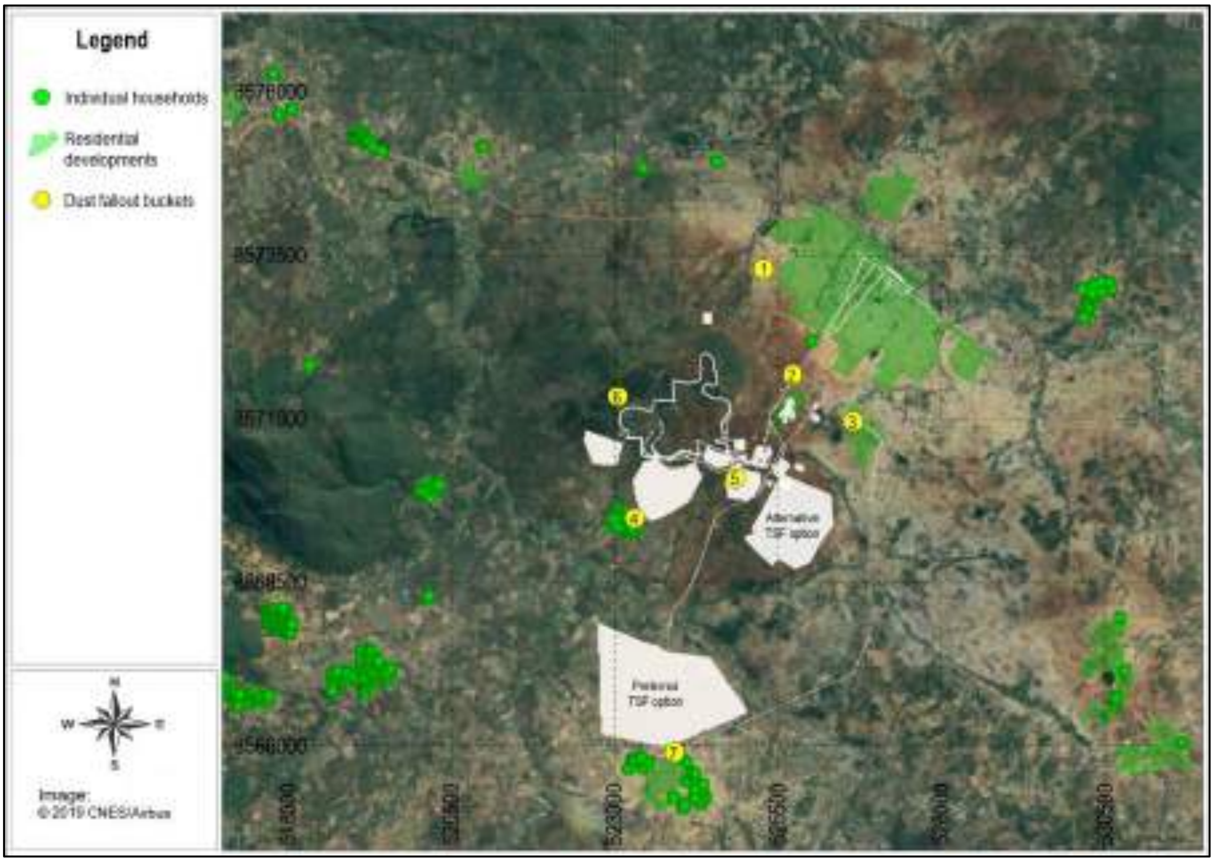

Figure 9-1: Recommendation of dust fallout network

9.2 Avifauna and Mammals

9.2.1 Sensory Disturbance: Resident Bat Colony on the Carbonatite Outcrop

The bat colony shall be monitored using detailed counts, trapping and acoustic sampling by an appropriately qualified specialist in association with a dedicated ECO from PENSANA for training purposes. Before construction, the bat surveys should be conducted on an annual basis and thereafter on a bi-annual basis during construction and operation for the life of mine. The specialist must be a reputable zoologist, preferably with experience in avifauna (as the Angolan Cave Chats will also need monitoring) and conducted in synchrony with the aquatic biomonitoring regime to minimize logistical and cost implications of multiple specialist visits. Specialist involvement is recommended for the first official pre-construction bat monitoring survey and at least the first year to two years of post-construction / operational monitoring and thereafter should be involved in at least a review / data interpretation capacity. It is imperative that the first monitoring be conducted just before the first blasting and earthmoving activities begin. Noise, dust and preferably vibration (seismic) levels must be monitored near the cave to allow for comparisons with bat attendance data (it would be better if specialists in these areas of expertise were responsible for dust, noise and seismic readings). Bat monitoring must include a survey of the maternal roost and a survey of the bat community occupying the hill.

9.2.1.1 Maternal Roost Monitoring

- Count all of the bats in the cave as non-invasively as possible;
- However, surveys will require at least some live captures to collect morphometric data, assess general conditions, identify species and link species to acoustic data. This will be most effectively achieved with a hand net in the cave. However, once the initial survey is completed, the subsequent visits should

involve non-invasive visual counts, and only bats thought to be undocumented species should be captured.

- From next to the guano pile in the centre of the cave, take a picture of the main huddle on the cave's roof with a wide-angle lens, one facing forward, one to the left, one to the right and one behind. Finally, take a picture of all other huddles or different species encountered outside the fixed point photographs field of view.
- Take release calls of each captured and identified bat, remembering to note time and bat species and sample number; this data is important.
- Only a maximum of two people must be allowed to enter the maternal roost at any one time.
- An ultrasonic time-expansion bat detector must be in hand for the count duration in all corners of the cave.
- The count shall be a fixed time limit to standardize the survey effort and acoustic recording time (e.g. 30 min).
- It is recommended that the team take measures for their safety and that of the bats. Appropriate PPE in this regard should involve a standard overall, a hard hat with a chinstrap, headlamp, surgical gloves worn at all times, thicker gloves for handling and a respirator. In addition, some bats may harbour viruses that are transmittable to humans and *vice versa*.

9.2.1.2 Hill Monitoring

- Establish a fixed, timed meander that is walked across the hill at night with a handheld bat detector.
- The route should focus on the crest of the hill and include as much crevice and tree roosting habitat as possible.
- Walk the same route during the day to inspect diurnal roosts for bats and record calls in these roosts with a bat detector.
- Establish a mist-netting site in an area of high bat traffic on the hill that is also easily accessible and far from frequently used roads / paths. There must always be at least one person monitoring the mist net. Set the mist net up at sunset and monitor it for at least 2 hours. However, if too many bats are being captured for how fast you can process them, remove the net. The net must be moved around each night to sample multiple locations.
- The first monitoring survey may require a few extra days to find mist-netting hotspots (or bat flyways), which can be narrowed down and prioritized on subsequent surveys.

9.2.2 Sensory Disturbance: Resident Pair of Angolan Cave Chats on the Carbonatite Outcrop

During the 2021 wet season survey, the pair of cave chats was observed again (following the 2019 surveys), confirming that they are a resident breeding pair. Cave chats are rare habitat specialists endemic to Angola (extending only marginally into Namibia). The species occupies caves and associated rocky outcrops. The following is recommended as part of the monitoring protocol:

- Conduct a pre-construction survey for the species during the breeding season in September - November.
- Thereafter conduct bi-annual surveys during construction and operation for the life of mine during the breeding and non-breeding seasons.
- This species is easily confused with other more common black and white birds and its shy cryptic nature make it difficult for the untrained eye / ear to locate. Therefore, specialist in-field involvement is required for at least the first pre-construction survey and at least one year of bi-annual monitoring. Thereafter the PENSANA ECO should re-assess budget availability for specialist fieldwork but, at a minimum, continue to monitor in collaboration with the specialist who should be involved in at least a data interpretation and review capacity.
- The surveys should focus on the hill where the pair is known to occur and seek to locate another pair on another hill in the vicinity as a control.
- Both the project pair and control pairs should be monitored to establish favoured feeding and nesting locations.
- Chick development in nests and thereafter fledging success should be monitored.

- It may prove valuable to investigate acquiring a motion camera to monitor chick development during the breeding season as non-invasively as possible. This data can be used to gauge nest attendance, breeding success and diet.
- The duration of each survey needn't be long as it will focus on presence / absence, and as such should be conducted preferably by the same specialist working on the bat monitoring.

9.2.3 Carbonatite Outcrop and Associated Habitats: Consequences for Endemic, and / or Habitat Specific Avifauna and Roosting Bat Colonies.

Monitor habitat loss in the Project area using appropriate methods such as satellite imagery or drone footage and GPS. Use GIS software to map the disturbance footprint concerning the identified highly sensitive habitats.

9.2.4 Increased Mortality Risk to Birds and Mammals

Fences and major paths or known active burrows should be regularly patrolled to remove snares (weekly to monthly basis). All faunal encounters / relocations should be logged. GPS any faunal mortality incidents as and when they happen, record GPS location, date, time, photo, and species.

9.2.5 Exposure of Birds and Mammals to Contaminated Water Downstream of the Mine

Monitor water quality (for sites, parameters and frequency of sampling see aquatic report) and compare against national target water quality guidelines and standards. While collecting water quality samples, look for and document any dead birds or mammals. If found, record date, time, GPS location, species, and collect the specimen and store in the freezer for later ecotoxicology investigations.

9.3 Aquatic ecology

The monitoring of river water provides a brief overview into the conditions occurring within a catchment. However, pollution events typically take the form of spills or via immediate rainfall runoff. Depending on the timing of the sample, this pollution event may be missed and thereby un-accounted for. However, the contamination event still exerts a negative effect to ecological health and the ecosystems services watercourses provide. Routine monthly standard water quality sampling, although important, has been found to be ineffective as the sole means for environmental monitoring. Aquatic fauna are permanently exposed to the water-column, have complex life cycles and wide ranges in physical tolerance. Given these attributes, aquatic fauna can serve as an effective endpoint for water resource monitoring.

Aquatic fauna biomonitoring methods, as applied in this study, have been developed to support standard monthly water sampling. The endpoints of the aquatic biomonitoring can account for temporal pollution events, dilute and diffuse contaminants, as well as the physical impacts such as reduced water volume or erosion and sedimentation. Thus in order to facilitate the effective management of water resources in the proposed study area aquatic biomonitoring has been proposed in conjunction with routine monthly water sampling.

The following monitoring programmes were derived from the completion of this study:

- Riverine aquatic biomonitoring for the duration of the construction and operation phase on bi-annual basis;
- Riverine aquatic biomonitoring for 12 months following closure.
- Monthly water quality monitoring for the duration of the construction and operation phase;

Table 9-2: Recommended riverine biomonitoring methods

Method	Duration	Key Performance Indicator
Aquatic Biomonitoring as per this study.	Bi-annually of the duration of the construction and operation phase	No significant ($p<0.05$) changes in ASPT, EPT% and macroinvertebrate sensitivity between sites up and downstream of the project area.
Odonata	Bi-annually of the duration of the construction and operation phase	Monitor for the presence of *Chlorocypha bamptoni*.

Macroinvertebrates	Bi-annually of the duration of the construction and operation phase	Monitor for the presence/absence of Heptageniidae in the Luluvila River.
Macroinvertebrates	Bi-annually of the duration of the construction and operation phase	Monitor for the presence/absence of Perlidae in the Cuiva River.
Fish	Bi-annually of the duration of the construction and operation phase	Monitor for the presence of fish species in the watercourses, extend this study to surrounding catchment to assess the degree of endemism.
Water quality sampling	Monthly for the duration of the construction and operation phase	No significant variation ($p<0.05$) in the water quality parameters from baseline levels.
Sediment quality monitoring: substrate sampling to assess metal content	Bi-annual sampling of the duration of the construction and operation phase	No significant variation ($p<0.05$) in the sediment quality parameters from baseline levels.

9.4 Botany

See ESMP section 8.15 for specific mitigation measures under the 'Botany' heading. Most of the mitigation measures for botany relates to monitoring requirements and shall be implemented as part of the requirements of the Environmental Monitoring Plan.

9.5 Herpetology

9.5.1 Loss of existing habitat

The habitats that are excluded from the development footprint in the Project Area must be monitored annually for any disturbance. This monitoring must be incorporated into the adaptive management plan to prevent further disturbance and restore affected habitats. In addition, vegetation change detection (e.g. NDVI differences) using freely available satellite imagery (e.g. Sentinel 2) shall be performed annually for an area of at least 1 km surrounding the Project Area. This will provide insights into the degree to which additional habitat change has taken place since the inception of the proposed mine and allow for detection and mitigation of cumulative impacts.

9.5.2 Direct mortality of herpetofauna due to excavation and ore processing

An annual report indicating appropriate metrics to demonstrate the degree of investment in staff education regarding sustainable utilisation and conservation. Key examples with photographic evidence to be provided, if possible, of, e.g., incidents where herpetofauna was allowed to escape from Project activities safely or were captured and relocated by a trained person..

9.5.3 Direct mortality of herpetofauna due to increased traffic

- Monitor amphibian populations annually to evaluate and adjust mitigation measures related to roadkills;
- Road mortalities should be monitored by both vehicle operators (for personal incidents only) and the ECO[61] (all roadkill on a periodic monitoring basis as well as specific incidents). Trends shall be monitored and subject to review as part of the monthly reporting; and
- Monitoring should occur via a logbook system where the staff takes note of the date, time and location of the sighting/incident. This will determine the locations where the greatest likelihood exists for road mortalities and allow mitigation against it (e.g. fauna underpasses, and speed reductions mentioned above). Mitigation should be adaptable to the on-site situation, which may vary over time.

[61] Environmental Control Officer

9.5.4 Mortality of herpetofauna due to an influx of people

- ECO to record any poaching or attempted bushmeat trade incidents for annual review;
- All staff and contractors shall receive appropriate induction (including periodic training sessions) regarding the on-site biodiversity, sustainable utilisation of natural resources, and the necessity for conservation. This shall also be communicated to the local community where possible; and
- ECO shall record any snakebite incidents or near-misses for annual review.

9.5.5 Disruption/alteration of ecological life cycles due to the restriction of species movement (migration/dispersal)

ECO and other trained staff shall regularly patrol trenches or areas of excavation as a routine to report any trapped herpetofauna to trained staff for removal and to verify that any open excavations, trenches or drainage canals have slopes with an angle of less than 45°, or have soils slopes (< 45°) at <10 m intervals to allow for animals to crawl out.

9.5.6 Disruption/alteration of ecological life cycles (breeding, migration, feeding) due to noise, dust and lighting

- A dust monitoring system shall be implemented;
- Noise levels shall be monitored by a qualified specialist at least yearly basis or as prescribed by the noise impact assessment study;
- Lighting shall be monitored and, where necessary, adjusted in areas that attract fauna species; and
- At least one dust monitoring site shall be located in the sensitive aquatic habitats to determine the relative contribution of dust towards nutrient levels and silt in the aquatic systems.

9.5.7 Introduction of alien flora affecting native herpetofauna assemblages

- ECO shall continuously monitor the growth and spread of alien flora coupled with an adaptive management approach to identify suitable control mechanisms; and
- Alien and invasive species monitoring and eradication action plan shall be implemented for the life of the Project (including post-mining rehabilitation) in order to make sure that the spread and establishment of alien and invasive species are controlled and monitored and that disturbances post-mining are minimised and mitigated where necessary. Where possible, the site needs to be restored to its previous condition / land-use.

9.5.8 Erosion from construction, infrastructure and excavations

Monitor amphibian populations (particularly breeding efforts) annually to evaluate and adjust mitigation measures related to sedimentation/siltation.

9.5.9 Watercourse contamination from mine waste storage facilities

- Regular inspection by ECO of waste storage facilities to identify any potential problems;
- Regular inspection by ECO of solid barrier perimeter to ensure exclusion of herpetofauna from contaminated water of the facility; and
- Water quality monitoring and soil-testing around potentially contaminated areas shall be conducted regularly by a qualified aquatic specialist. Annual amphibian monitoring should target these same locations to assess any impacts on local amphibian assemblages.

9.5.10 Watercourse contamination due to chemical spillage

- Amphibian populations shall be monitored annually by a herpetologist to evaluate and adjust mitigation measures relating to chemical spills (in the event of a chemical spill, specific sites downstream of the spill should be targeted to assess impact and monitor recovery of the amphibian assemblage);
- Water quality shall be monitored regularly around potential spill; and

- An aquatic specialist should do water quality monitoring for the presence of hydrocarbons and other chemicals in the watercourse. Annual amphibian monitoring should target these same locations to assess any impacts on local amphibian assemblages.

9.5.11 Potential impacts due to Water abstraction

Monitor water chemistry and flow rates - limit abstraction volumes to ensure ecological reserve and, when necessary, achieve sufficient dilution of any chemical spills to reduce toxicity, as per recommendations from the aquatic ecologist should be sufficient.

9.6 Hydrology

9.6.1 Monitoring localities

Monitoring localities are located as per Table 9-3 and illustrated in Figure 9-2.

Table 9-3: Location of new points in UTM -33 WGS 84 format

LABEL	X	Y
N1	526899	8573911
N2	526570	8573629
N3	525397	8574101
N4	521093	8574492
S1	526668	8569444
S2	524083	8567876
S3	523618	8567601
S4	523861	8568858
S5	522417	8568764
S6	522361	8568738
S7	522769	8569358
S8	521533	8569551

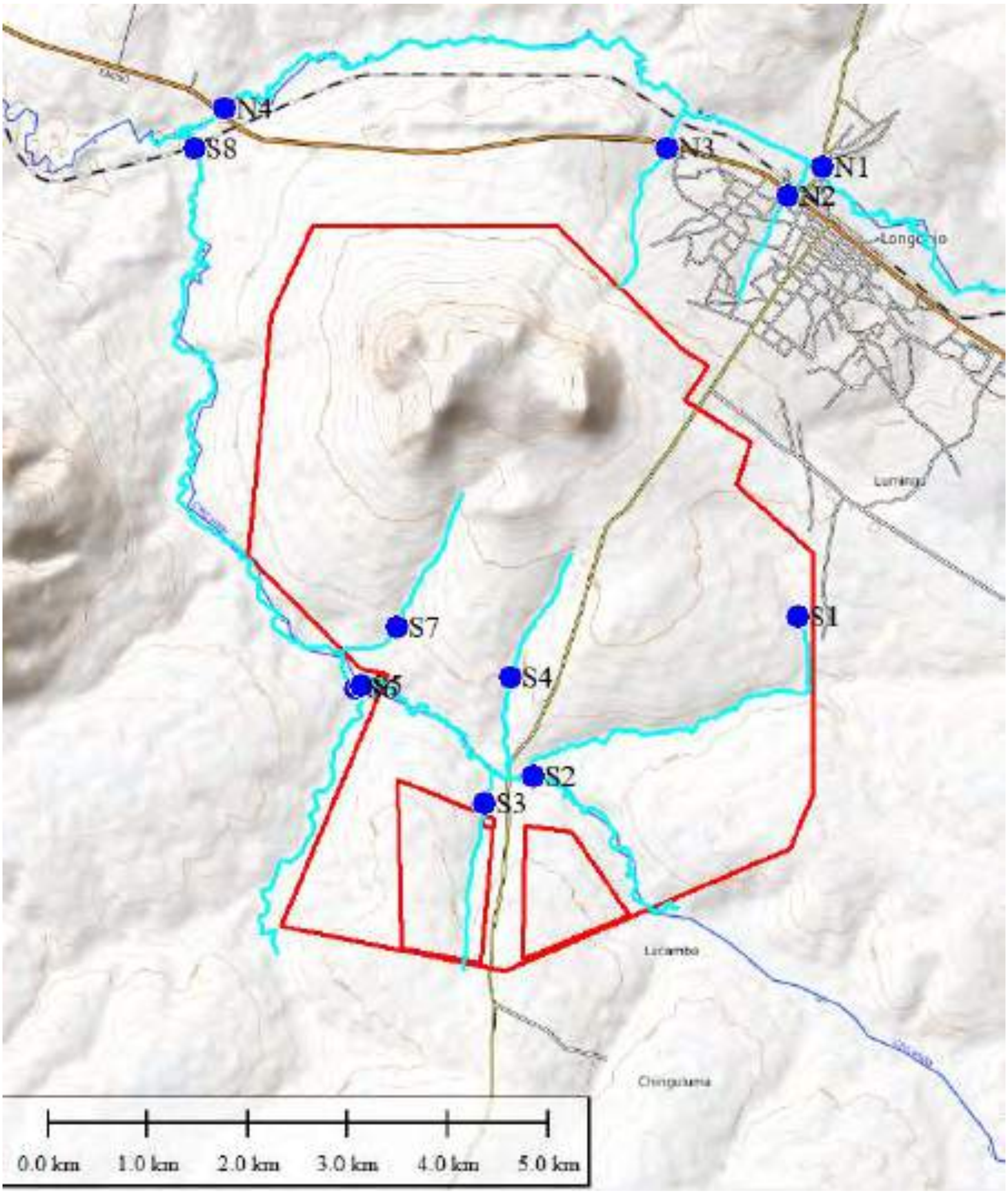

Figure 9-2: Location of all new points (points 5 and 6 close to each other)

Notes on the selected sampling localities are presented in Table 9-4.

Table 9-4: Notes on the proposed sampling points

NO.	COMMENTS	FURTHER COMMENTS
S1	Can be at same point as new V notch providing it is close enough to confluence with larger stream	Can be same point as previous ET1
S2	To be just upstream of the confluence with the stream from the north east for best detection of potential pollution from TSF 10 's eastern embankment.	Not presently sampled
S3	To best detect potential pollution from TSF 9's northern embankment	Not presently sampled
S4	Can be at same point as existing V notch	Can be same point as previous ST1
S5	Combined monitoring point of Luluvile river. Also essential for the proposed make-up water supply testing.	Not presently sampled. Not really represented by LU1B or LU1
S6	For best detection of potential pollution from TSF 9 in river west of TSF 9's western embankment.	Not presently sampled
S7	Existing V notch is too far upstream to use same point as V notch	Can be same point as previous SET1
S8	Combined monitoring point of all streams on southern side of opencast/plant area. Also essential for the proposed make-up water supply testing	Can be LU2B (sampled as LU2 by Ambi Africa ?)
N1	For best detection of potential pollution from the siding which is to be used by the mine	Can be same point as previous CH1
N2	Can be at same point as new V notch providing water will flow the whole season at the point, else further downstream as proposed but upstream of railway line.	Not presently sampled
N3	Can be at an existing measuring point, providing it is upstream of confluence with larger stream north of railway line	Can be same point as previous NT2
N4	Combined monitoring point of all streams on northern side of mine	Can be same point as previous CH2

9.6.2 Sample analyses and schedule

The proposed testing schedule is presented in Table 9-5. The full list of constituents recommended to be analysed for are presented in Table 9-6.

Table 9-5: Proposed testing schedule

Frequency/Point	Monthly On Site	Bacteria Quarterly Local	Other Quarterly Local	Other Quarterly SA	TOC Quarterly Local
S1	F	B	OA	OSA	
S2	F		OA	OSA	
S3	F		OA	OSA	
S4	F		OA	OSA	
S5	F		OA	OSA	C
S6	F		OA	OSA	
S7	F		OA	OSA	
S8	F		OA	OSA	C
N1	F		OA	OSA	
N2	F		OA	OSA	
N3	F		OA	OSA	
N4	F		OA	OSA	C
B1*	F	B	OA	OSA	
B2*	F		OA	OSA	
B3*	F		OA	OSA	
Total annual (NO.)	180	8	60	60	12

Abbreviations:

F - Infield (In-situ) tests that needs to be done immediately on-site.
B - Biological tests that needs to be done within 24 hours in Angola
OA - Other constituents to be tested in Angola within 24 hours.
OSA - Other constituents to be tested in SA (metals and metalloids) within 28 days (preserved)
C - Total Organic Carbon to be tested in Angola within 24 hours
B1* - Estimate for boreholes to be monitored (as for river water)

Table 9-6: Recommended full list of constituents to analysed for, for baseline (quality standards are also included where relevant)

DETERMINANT	UNITS	DETECTION LIMIT REQUIRED	IRRIGATION WATER STANDARDS	AQUACULTURE WATER STANDARDS DWS SA	AQUATIC LIFE WATER STANDARDS DWS SA	AQUATIC LIFE EPA	DOMESTIC		ANGOLA PRESIDENTIAL DECRETO
							SANS 241	WHO	
pH	pH units	0-14 (0.001)	6.5-8 5	6.5-9	***		5-9.7		6.5-8 5
Dissolved Oxygen (DO)/BOD	mg/ℓ	0-20 (0.1)		6-9 (Cold water species) 5-8 (Warm water species)	80% -120% of saturation				50%
Electrical Conductivity	mS/m	0.01-20000 (	40				170		100
Water temperature	Deg. C	0-50 (0.1)							
Turbidity	NTU	0-1000		25			1	1	
Dissolved Aluminium	µg Al/ℓ	2	5000	0-30 (pH >6.5)	5 (pH<6 5) ; 10 (pH >6.5)	1.3	300		
Dissolved Antimony	µg Sb/ℓ	1					20	20	
Dissolved Arsenic	µg As/ℓ	6	100	0-50	10		10	10	10
Dissolved Beryllium	µg Be/ℓ	1					700		100
Dissolved Barium	µg Ba/ℓ	1	100						
Dissolved Boron	µg B/ℓ	1	500			1200	2400	2400	1000
Dissolved Cadmium	µg Cd/ℓ	0.1	10	0.2	0.07	0.25	3	3	10
Dissolved Calcium	mg Ca/ℓ	0.12					150		
Dissolved Cobalt	µg Co/ℓ	3	50		5		500		
Dissolved Copper	µg Cu/ℓ	0.3		5	0.3		50	50	50
Dissolved Chromium	µg Cr/ℓ	3	200			100	2000	2000	20
Dissolved Iron	µg Fe/ℓ	4	200 drippers	10	>10% of background Fe		2000	2000	100
Dissolved Lead	µg Pb/ℓ	0.3	200	10	0.2	0.75	10	10	50
Dissolved Lithium	µg Li/ℓ	1	2500						
Dissolved Manganese	µg Mn/ℓ	1	20 crops	100	180		400	400	10
Dissolved Magnesium	mg Mg/ℓ	0.07							
Dissolved Mercury	µg Hg/ℓ	0.15		1	0.04	1.3	6	6	0.5
Dissolved Nickel	µg Ni/ℓ	2	200			30	70	70	
Dissolved Potassium	mg K/l	0.08					50		
Dissolved Selenium	µg Se (vi)/ℓ	2	20	300	2		10	10	10
Dissolved Sodium	mg Na/ℓ	0.19					200	50	
Disolved Uranium	µg U/ℓ	1					30		
Dissolved Vanadium	µg V/ℓ	1	100				200		
Dissolved Zinc	µg Zn/ℓ	1	1000	30	2		5000	3000	500
E coli	no. per 100m	0	0	<10 E.coli/g			0		
Faecal Coliforms	no. per 100m	0	10000				10		20
Total Organic Carbon	mg C/ℓ	10					10		
Ammonia as N	mg N/ℓ	0.11				0.9	1.5	1.5	1
Ammonia	mg NH3/ℓ	0.02		0.025 (Cold water fish) 0.30 (Warn water fish)	0.007	0.2			
Ammonium	mg NH4/ℓ	0.05							0.05
Chloride	mg Cl/ℓ	10	100			250	300	250	200
Cyanides Free and Total	µg Cn/ℓ	0.1		0.02	1	2	200	70	50
Fluoride	mg F/ℓ	0.26	2		0.75		1.5	1.5	0.7
Nitrogen as N	mg N/ℓ	0.5	0.5 algae growth		5	0.3			1
Nitrate	mg NO3/ℓ	5.00		300			50	50	25
Nitrite	mg NO2/ℓ	0.01		0.05			3		
Phosphorus as P	mg P/ℓ	0.05				0.03			
Phosphate (ortho phosphate)	mg PO4/ℓ	0.1		0.1					
Phosphorus trioxide	mg P2O3/ℓ	0.1							0.4
Sulphate	mg SO4/ℓ	5.0	200				500		150
Total Alkalinity	mg CaCO3/ℓ	5	60-120	20-100		200			
Suspended solids at 105°C	mg/ℓ	5.0	50	20 000 (Turbid water species) <25 NTU (Clear water species)	<10% increase of background Total Suspended Solids				25
Total Dissolved Solids	mg/ℓ 180°C	10.0		2000	<15% variation of normal TDS cycle		1200		

***pH values should not be allowed to vary from the range of the background pH values for a specific site and time of day, by > 0.5 of a pH unit, or by > 5 %, and should be assessed by whichever estimate is the more conservative.

9.6.3 Sampling procedures

The general requirements for water sampling include:

- Shall only be conducted under normal flow conditions (no flooding).
- Shal not to be conducted under very windy conditions.
- Sampling should be undertaken at the same time of the day, same place, same depth per sampling point throughout the year. Thus, record time, place in the stream, depth etc.
- It is preferable not to sample in shaded areas or areas with plant growth.
- Avoid contamination/inclusion with sediment and suspended solids.
- Sampling shall be done at a representative location in the stream, which will represent the average volume of water flowing, thus far enough in the stream where water flow is average for the stream and approximately at a third of the stream depth from the surface at a place where the stream is of average depth (or 30 cm deep for deeper water). If the water is not flowing, the measuring tip/bottle must be moved around in the water.
- Label the sample with the sample name, point and sampling date and time.
- Fill the sample bottle to exclude air and replace the cap immediately. Only for *Escherichia coli* (*E. coli*) and faecal coliforms do NOT completely fill bottle.
- Do not touch the inside of the bottle or cap.
- If Dissolved Oxygen cannot be measured on-site, seal bottle immediately and seal the cap with tape/wax to ensure oxygen does not escape or enter the sample after sampling.
- Samples must generally be transported to the laboratory (on ice or with ice packs, temperature to be kept at ± 1 to 4°C, not frozen) for delivery within 24 hours. For longer delivery times, some samples would need to be preserved by Nitric Acid (for cations, sodium, and metals) and Sulfuric Acid (for nitrogen, ammonia, ammonium, nitrate, and nitrite), etc., all in accordance with the lab's instructions. The lab to provide tests kits which will include all this with the correct bottles, sizes, acids, instructions etc.

9.6.4 Field testing

Field tests are required for specific parameters, as taking samples to a lab may significantly reduce the tests' validity. These tests are generally to be performed monthly as well as when bottled samples are taken. Refer to the proposed schedule in Table 9-5.

Good quality handheld instruments will be required capable of testing the following:

- pH
- Dissolved Oxygen (DO) and possibly also BOD with the same instrument.
- Conductivity (EC) (can derive TDS from EC).
- Water temperature
- Turbidity.

A combination meter is suggested for the first four tests with turbidity a separate instrument

9.7 Hydrogeology

A groundwater monitoring programme shall be implemented and incorporated in the Environmental Management Plan for the proposed Mine. The following basic preliminary groundwater monitoring programme is proposed:

- Groundwater levels to be recorded every month (for a minimum of one year, after which frequency will be revised according to seasonal variations); and
- Groundwater sampling and analysis biannually (dry and wet season). Chemical parameters to be analysed should include: pH, Total Dissolved Solids, Alkalinity, Macro inorganic elements (incl. Ca, Mg, Na, SO_4, NO_3, NO_2, Cl, F, NH_4, PO_4,) and a selection of metals (incl. Fe, Mn, Zn, Cu, Ni).

A detailed groundwater monitoring programme can be prepared and submitted to the authorities for approval, should this be required. However, the groundwater monitoring programme will have to be reviewed and revised if required once the Mine is operational to ensure it remains relevant.

9.8 Noise and vibration

The noise monitoring plan for the mining operations is given in Table 9-7.

Table 9-7: Noise monitoring plan

Impact	Monitoring requirements							
	Objective	Detailed Mitigation measures	Procedures	Monitoring Mechanism	Target / Performance indicator	Responsibility	Start	End
Land use change - change of traditional land use to mining.	Minimise noise impacts and promote and establish sustainable environmental noise levels.	• Final Project infra structure, lay down and access areas will be clearly indicated in final construction plans provided to contractors/employees. The plans will consider environmental noise constraints. • Access roads (etc.) will be planned to avoid sensitive areas. Environmental noise monitoring to be done. Procedures on noise monitoring to be adhered to. • The noise mitigatory measures for the Construction, Operational and Decommissioning phases (Table 9-1).	Prevention of excessive noise levels	As per monitoring mechanism in Table 9-2.	The prevailing ambient noise levels may not be exceeded by more than 3.0dBA at the boundary of the mining area – see Table 3-2.	Environmental Department	Construction	Decommissioning phases
Land use change - change of traditional land use to mining.	Minimise ground vibration and/or air-pressure levels, impacts, promote, and	• Final Blast design to be done for blasting operations at the pit. The blast design will consider environmental ground vibration and air-pressure levels constraints.	Prevention of excessive ground vibration and air-pressure levels	As per monitoring mechanism in Figure 10-1.	The prevailing ground vibration and air-pressure threshold levels of 12.5mm/s	Environmental Department	Construction	Decommissioning phases

Impact	Monitoring requirements							
	Objective	Detailed Mitigation measures	Procedures	Monitoring Mechanism	Target / Performance indicator	Responsibility	Start	End
	establish sustainable ground vibration and air-pressure levels.	• Environmental ground vibration and air-pressure level monitoring to be done. Procedures on ground vibration and air-pressure monitoring to be adhered to. • The ground vibration and air-pressure mitigatory measures for the Construction, Operational and Decommissioning phases (Table 9-1).			(clay huts)and 25mm/s (modern type buildings)may not be exceeded.			

9.9 Social

Recommended monitoring mechanisms is outlined in Table 8–2.

9.10 Soils

The following monitoring activities shall be undertaken during the Project phases to monitor the effectiveness of the mitigation measures proposed:

- Soil samples should be taken at regular intervals, *i.e.* twice annually on selected areas with a high contamination risk and submitted for analyses at an accredited SANAS laboratory with adequate internal and external Quality Assurance / Quality Control measures;
- Sampling should be conducted in line with best practices and sample contamination should avoided;
- Methodology for the analyses should be accredited methods, as was used during the initial baseline assessment;
- Parameters recommended include: pH, EC, Ca, Mg, K, Na, P, CEC, heavy metals, SO_4, Cl, B, NO_3 and F;
- Increasing, static and/or decreasing anomalies shall be measured and reported on; and
- From the above data and interpretation thereof, proactive measures shall be formulated and implemented to prevent pollution migration.

9.11 Visual

Recommended monitoring mechanisms is outlined in Table 8–2 and consists of regular audits during both the construction and operational phases of the mine. These audits should be undertaken by the mine and its contractors, as well as independent auditors or specialists. Design principles and specialist recommendations should be followed.

9.12 Waste

Waste monitoring shall be done through the requirements as stipulated in the Waste Management Plan as approved by the MCTA. This will involve *inter alia*:

- Monthly volumes recorded for waste types;
- Monthly recording of waste per operational area;
- Monitoring of hazardous wastes;
- For all waste leaving the mining site (e.g. removed by a contractor), waste manifests / receipts shall be issued by the contractor and retained as part of the record keeping system of the mine;
- Monitoring as per any additional legal / permitting requirements from MCTA;
- Monitoring as per the WMP / ESMS procedures / SOPs; and
- Collation of data to produce monthly trend graphs per operational area to identify problem areas where waste management can be improved.

10 ACTION PLAN

10.1 Landfill site

The landfill site will be finalised during the detailed design phase. Once it has been designed and sited, regulatory ESIA would likely be required specifically for the landfill site. The Bankable ESIA shall then be supplemented through an addendum presenting the specific baseline relating to the location of the landfill site (i.e. groundwater, Geotech, soil and water), assessment of anticipated impacts, and conclusions about management operation thereof.

10.2 Incineration

Although not designed yet, waste incineration was listed as a potential waste management solution. Once the design of the incineration plant becomes available, the Air Quality Dispersion Model and impact assessment must be updated to account for emissions from the incineration plant.

10.3 MRES plant

At the time of finalisation of the ESIA and specifically the Air Quality Dispersion Model and impact assessment, the processing plant (e.g. MRES plant) emission details (e.g. stack heights, vents, emission flow rates, emission compositions etc.) was not available. During the subsequent design stages of the Project, this information would become available, and the Air Quality Dispersion Model and associated impact assessment shall be updated to account for this additional emission source.

10.4 Offset strategy and planning

The location of TSF 9/10 in the south will destroy a watercourse classified as critical habitat due to the presence of SCC species. Therefore, an offset strategy and action plan are required to make sure that the requirements of specifically PS6 are adhered to.

10.5 Detailed design information

Generally, the updating of all the modelling related specialist studies shall be done, as more information becomes available during detailed design.

11 CONCLUSION AND RECOMMENDATION

Based on the findings of the ESIA, the following conclusions are made:

- There are no red flags that should prevent the Project from going ahead;
- The negative impacts that have been identified can be managed through SMART mitigation;
- The positive impacts on the economy through a large mining project means that the proposed mine can make a meaningful and significant contribution to Angola; and
- The Project aligns with the President's commitment to diversify the economy and encourage sustainable development in Angola.

Based on the findings of the ESIA, the following recommendations are made:

- ESMP – Implementation of the requirements of the ESMP is critical;
- ESMS – The ESMS shall be managed as a live system to manage environmental and social aspects and impacts; and
- Monitoring – Monitoring of all relevant physical, biological and social parameters is critical to maintaining the efficacy of adaptive management.

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APPENDIX A

PENSANA Health, Safety and Environmental Policy

APPENDIX B

Scoping Report

APPENDIX C

Air Quality Specialist Study

APPENDIX D

Hydrogeology Specialist Study

APPENDIX E

Hydrology Specialist Study

APPENDIX F

Noise and Vibration Specialist Study

APPENDIX G

Soils and Land Capability Specialist Study

APPENDIX H

Visual Impact Specialist Study

APPENDIX I

Aquatic Ecology Specialist Study

APPENDIX J

Avifauna and Mammals Specialist Study

APPENDIX K

Botany Specialist Study

APPENDIX L

Herpetofauna Specialist Study – 2021 update

APPENDIX M

Herpetofauna Specialist Study 2019

APPENDIX N

Socio-economic Specialist Study

APPENDIX O

Comments and Response Report

APPENDIX P

Radiation (NORM) Specialist Study

APPENDIX Q

Closure and Rehabilitation