Proposed Pilot Carbon Dioxide Storage Project near Leandra in the Govan Mbeki Local Municipality, Mpumalanga Province

Basic Assessment Report

DFFE Reference No.: *To be assigned*

Draft

May 2023

Applicant: Council for Geoscience

nemus

NEMAI CONSULTING
Environmental, Social and OHS Consultants
P.O. Box 1673
Sunninghill
2157
147 Bram Fisher Drive
Ferndale
2194
Tel: 011 781 1730
Fax: 011 781 1731
Email: info@nemai.co.za

A. TITLE & APPROVAL PAGE

Project Name:	Proposed Pilot Carbon Dioxide Storage Project near Leandra in the Govan Mbeki Local Municipality, Mpumalanga Province
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Prepared By:	Nemai Consulting in collaboration with NEMUS			
NEMAI CONSULTING	☎	+27 11 781 1730		147 Bram Fischer Drive, FERNDALE, 2194
		+27 11 781 1731		
		donavanh@nemai.co.za		PO Box 1673, SUNNINGHILL, 2157
		www.nemai.co.za		
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	Name	Date
Authors:	D. Henning	26/05/2023
Reviewed By:	N. Naidoo	26/05/2023

B. Amendments Page

Date	Nature of Amendment	Amendment No.
May 2023	Draft for Review by Authorities and the Public	0

C. EXECUTIVE SUMMARY

A. INTRODUCTION

The Council for Geoscience (CGS) (the "Applicant") has proposed a Pilot Carbon Dioxide (CO_2) Storage Project near Leandra in the Govan Mbeki Local Municipality, Mpumalanga Province (the "Project").

Overall, the Project aims are as follows:

- Construction and operation of the Pilot CO_2 Storage Project, through the implementation of Carbon Capture and Storage (CCS) technology;
- Investigation and characterization of a suitable CO_2 storage site and subsequent injection, storage, and monitoring into deep geological formations;
- Injection and storage between 10,000 to 50,000 tons of CO_2; and
- Understanding the viability of the Mpumalanga Province for CO_2 storage.

A Basic Assessment is being undertaken according to the process prescribed in the Environmental Impact Assessment (EIA) Regulations of 2014, as amended, to seek Environmental Authorisation for the Project in terms of the National Environmental Management Act (Act No. 107 of 1998) (NEMA).

This document serves as the draft Basic Assessment Report (BAR) for the proposed Project.

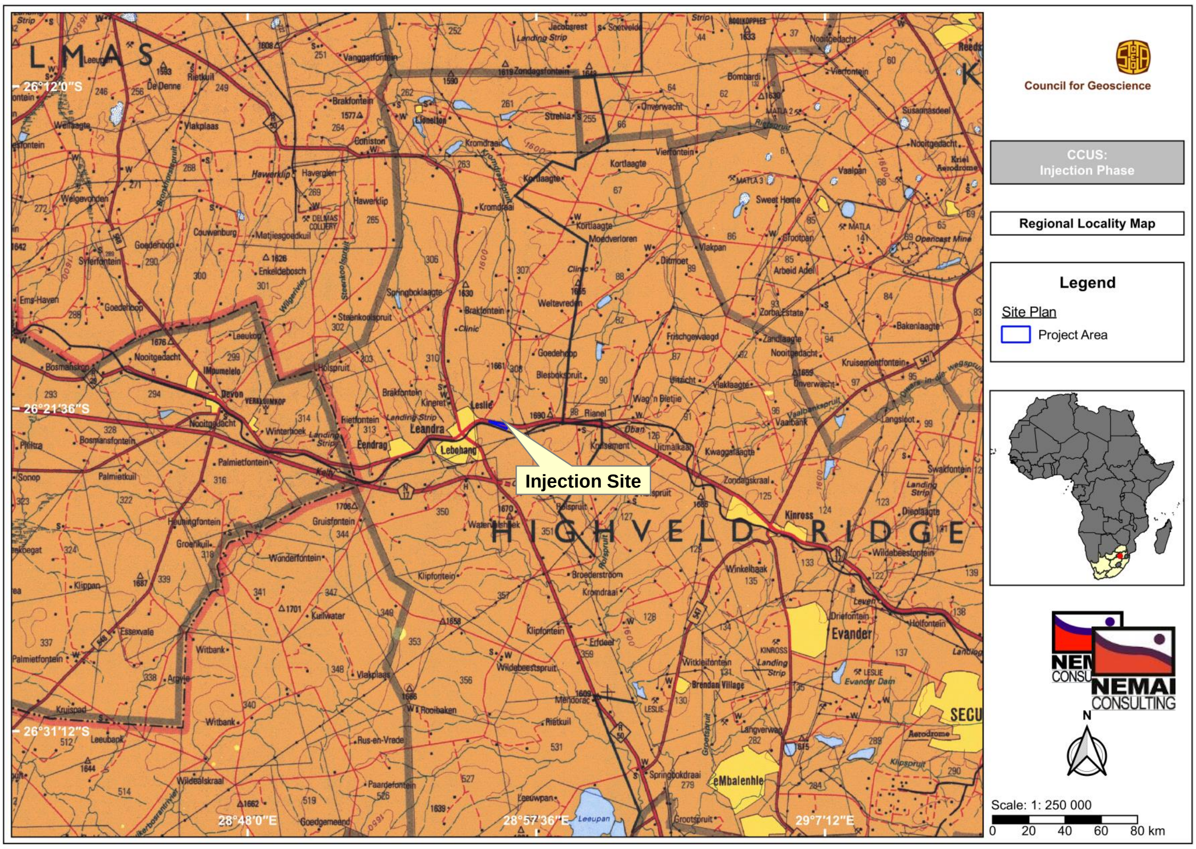
B. PROJECT DESCRIPTION & ALTERNATIVES

The project site is situated near the town of Leandra in the Mpumalanga Province of South Africa (SA). The project site falls within the Gert Sibande District Municipality (GSDM) and is located within Ward 6 of the Govan Mbeki Local Municipality (GMLM). The site is bordered by the road reserve of the R29 to the north and the railway servitude to the south (see map below).

The areas considered for the Basic Assessment are listed in the table to follow.

Project areas for the assessment

Area Type	Extent	Details
Project Property Area	14 ha	Chosen property area for the development of the Project.
Project Implementation Area	10 ha	Area, within the Project property, considered as useful area for the Project implementation (also considering road and railway safety distances).
Direct Area of Influence	Buffer of 1 km	Area within which it is considered that impacts may be felt directly.
Indirect Area of Influence	Buffer of 5 km	Area within which it is considered that impacts may be felt indirectly.



Locality map of the project area

Overall, the technology proposed is based on the utilization or storage of CO_2 in suitable deep geological formations, leading to a reduction in the anthropogenic release of CO_2 into the atmosphere. The process entails the following three key stages:

1. Capturing CO_2 from anthropogenic sources;
2. Transporting the CO_2 to the injection site; and
3. Permanent geological storage or utilization of the CO_2.

The Project is a test of this application, considering specifically the storage component.

With the purpose of assessing the Project's environmental and social risks and impacts and the feasibility of and to build expert capacity for CCS, the Project activities include the site establishment, drilling and construction of an injection well of approximately 1,800 m deep, road transportation, and operation/injection of CO_2 at the designated site.

The alternatives listed in the table to follow were considered during the Basic Assessment Process.

Assessed Project alternatives

Alternative	Description
No-go Alternative	The no-go alternative implies that the proposed Project does not go ahead, resulting in no environmental impacts (positive and negative) on the preferred site or the surrounding local area. The no-go alternative is not preferred.
Land-use Alternatives	Currently, the land is vacant (fallow land). As it is an area presently without any human use, the proposed Project is considered to offer broad social benefits. As such, the development on the preferred site is favorable.
Location Alternatives - Development footprint within the preferred site	An environmental footprint area was defined, which consists of the project area, implementation area, area of direct influence and area of indirect influence.
Technology alternatives	Both injection technologies are assessed in the BAR, namely injection of supercritical CO_2 and injection of water-CO_2 solution.

C. LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

The BAR presents the pertinent legislation that has possible bearing on the proposed Project from an environmental perspective, as well as the mandated authorities.

The relationship between the Project and the following key pieces of environmental legislation is also explained:

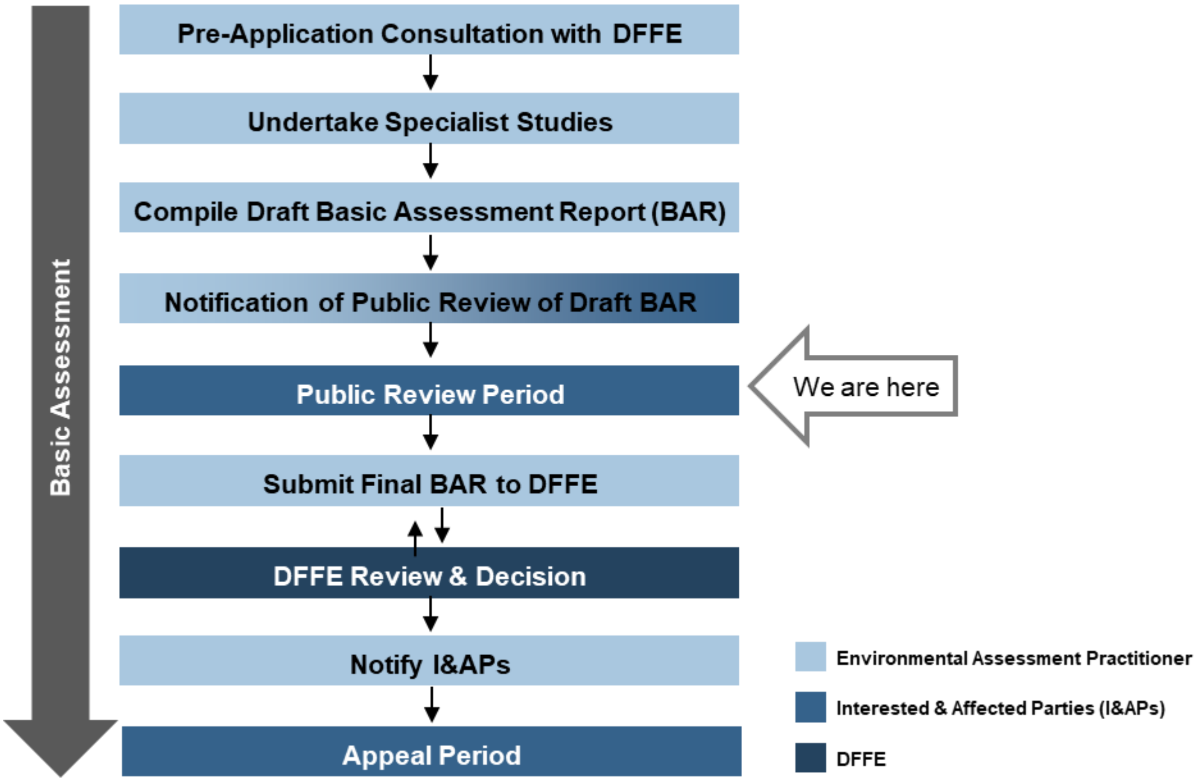
- National Environmental Management Act (No. 107 of 1998);
- National Environmental Management: Waste Act (Act No. 59 of 2008);
- National Water Act (Act No. 36 of 1998);
- National Environmental Management Air Quality Act (Act No. 39 of 2004);
- National Environmental Management: Biodiversity Act (Act No. 10 of 2004);
- National Heritage Resources Act (Act No. 25 of 1999);
- Mineral and Petroleum Resources Development Act (Act No. 28 of 2002);
- Hazardous Substances Act (Act No 15 of 1973); and
- Mpumalanga Nature Conservation Act (Act No. 10 of 1998).

D. BASIC ASSESSMENT PROCESS

An Application for Environmental Authorisation in terms of the NEMA and the EIA Regulations of 2014, as amended, has been made for the proposed Project. In terms of the aforementioned Act, the lead decision-making authority for the environmental assessment is the Department of Forestry, Fisheries and the Environment (DFFE).

The process for seeking authorisation is undertaken in accordance with Government Notice No. R. 982 of 4 December 2014 (as amended). The Project triggers activities listed in Listing Notice 1 of the aforementioned Regulations and a Basic Assessment Process is thus being undertaken.

An outline of the Basic Assessment Process is provided below.



Overview of Basic Assessment Process

Considering the Project's scope and objectives, the BAR identifies the environmental and social impacts, including direct and indirect, short, and long term, as well as cumulative impacts. The focus is on both positive and negative impacts on the biophysical, social, economic, and cultural features of the receiving environment associated with the construction, operational and decommissioning phases of the Project.

The following specialist studies were undertaken as part of the Basic Assessment:

- Freshwater Assessment;
- Terrestrial Biodiversity Compliance Statement;
- Heritage Impact Assessment;
- Desktop Palaeontological Impact Assessment;
- Air Quality Modelling; and
- Hydrogeological Study.

E. PROFILE OF THE RECEIVING ENVIRONMENT

The BAR described the status quo of the receiving environment in the project area. This serves to provide the context within which the assessment was conducted and allows for an appreciation of sensitive environmental features and possible receptors of the effects of the proposed Project.

The receiving environment is explained in terms of the following features:

- Climate and meteorology;
- Geology and topography;
- Soils;
- Groundwater;
- Surface hydrology;
- Waste management;
- Environmental quality;
- Fauna and flora;
- Land use and spatial planning;
- Socio-economic environment & public health;
- Cultural heritage & palaeontology; and
- Land capability.

The main sources of information for establishing the baseline and characterizing the project area included the following:

- Site visits and inputs from the specialists that form part of the project team;
- National Web-Based Environmental Screening Tool, where applicable;
- Policies and legal framework;
- Information provided by the CGS;
- Statistics, studies, and publications available on the topics under analysis; and
- Existing and available spatial information (among others).

F. IMPACT ASSESSMENT

The BAR identifies and assesses the relevant environmental impacts that may be caused by the Project's activities during the construction, operational, and decommissioning phases. An environmental impact is understood to be any change that occurs in the project area and its surroundings, at the level of the environmental features under analysis, and that results directly or indirectly from the implementation of the Project.

The methodology that was employed to assess the significance of the potential environmental and social impacts consisted of the following:

- Defining the nature of the potential impact;
- Rating of the potential impact; and
- Determining the overall significance of the impact.

The impact assessment considered the same features of the receiving environment for which the baselines were determined.

The table to follow provides a summary of the assessed impacts. The significance ratings in the table are based on the application of suitable mitigation measures.

Overall Impact Assessment

Impact	Phase	Signal	Directionality	Extent	Duration	Intensity	Probability	►	Significance	Risk level
CLIMATE AND METEOROLOGY										
Reduction of the CO_2 in the atmosphere	Operational	Positive	Indirect	Regional	Permanent	Low	Definite	►	Low	N/A
SOILS										
Pollution/contamination of the soil	Construction	Negative	Direct	On site	Permanent	Medium	Unlikely	►	Low	Low
Soil replacement	Decommission	Positive	Direct	On site	Permanent	Low	Definite	►	Low	N/A
GROUNDWATER HYDROLOGY										
Potential risk of groundwater quality degradation	Operational	Negative	Indirect	On Site	Temporary	Low	Unlikely	►	Low	Low
Changes in groundwater flow	Operational	Negative	Indirect	On Site	Permanent	Low	Unlikely	►	Low	Low
Potential risk of groundwater quality degradation	Decommission	Negative	Indirect	On Site	Temporary	Low	Unlikely	►	Low	Low
SURFACE HYDROLOGY										
Impacts from exposure to contamination	Operational	Negative	Indirect	Local	Short-term	Low	Unlikely	►	Low	Low
Impacts from increased service demand	Operational	Negative	Direct	Regional	Short-term	Low	Definite	►	Low	Moderate
Legacy impacts on surface hydrology through potential indirect leaks	Decommission	Negative	Indirect	Local	Long-term	Low	Unlikely	►	Low	Low
WASTE MANAGEMENT										
Impacts of non-hazardous waste sent to landfill	All Phases	Negative	Direct	Regional	Permanent	Low	Definite	►	Low	Moderate
Impact of hazardous waste sent to landfill	All Phases	Negative	Direct	Regional	Permanent	Medium	Unlikely	►	Low	Low
LANDSCAPE AND LIGHT POLLUTION										
Light Pollution (night-time) – Biophysical Environment	Construction	Negative	Direct	Local	Short-term	Low	Definite	►	Low	Moderate

Impact	Phase	Signal	Directionality	Extent	Duration	Intensity	Probability	►	Significance	Risk level
NOISE AND VIBRATIONS										
Noise impact in socio-economic environment at night-time and biophysical environment.	Construction	Negative	Direct	Local	Short-term	Low	Definite	►	Low	Moderate
AIR QUALITY										
Air quality deterioration due to concentrated release of CO_2	Operational	Negative	Direct	Local	Temporary	Low to Moderate	Unlikely		Low to moderate	Low
Air quality deterioration due to gradual leakage of CO_2	Operational	Negative	Direct	Local	Long-term	Low	Likely		Low	Low
FAUNA AND FLORA										
Disturbance and deterioration of fauna populations, release of CO_2	Operational	Negative	Direct	Regional	Long-term	Low to high	Unlikely	►	Low to moderate	Low
Restoration of the habitats	Decommission	Positive	Indirect	On site	Long-term	Low to high	Likely	►	Low to high	N/A
LAND USE AND SPATIAL PLANNING										
Fulfilment of the development models	Construction	Positive	Direct	Regional	Short-term	Low	Definite	►	Low	N/A
Land occupation	Construction	Negative	Direct	On site	Short-term	Low	Definite	►	Low	Moderate
Civil aviation sensitivity	Construction	Negative	Direct	On site	Short-term	Medium	Unlikely	►	Low	Low
Fulfilment of the development models	Operational	Positive	Direct	Regional / National	Short-term / Permanent	Low/High	Definite	►	Low to High	N/A
Land occupation	Operational	Negative	Direct	On site	Short-term	Low	Definite	►	Low	Moderate
Change of the projected local development	Decommission	Negative	Indirect	Local	Permanent	Negligible / Medium	Unlikely	►	Negligible to Low	Acceptable / Low
SOCIOECONOMICS AND PUBLIC HEALTH										
Generation of employment and income	Construction	Positive	Direct	Regional	Short-term	Low	Definite	►	Low	N/A
Security threats	Construction	Negative	Direct	Local	Short-term	Medium	Likely	►	Moderate	Moderate
Impact on the health and quality of life of local communities	Construction	Negative	Direct	Local	Short-term	Medium	Definite		Low	Moderate

Impact	Phase	Signal	Directionality	Extent	Duration	Intensity	Probability	►	Significance	Risk level
Generation of employment, income and skills	Operational	Positive	Direct	Regional	Long-term	Low	Definite	►	Low to moderate	N/A
Investment in the local economy	Operational	Positive	Direct & Indirect	Regional	Long-term	Medium	Definite	►	Low to moderate	N/A
Security threats	Operational	Negative	Direct	Local	Long-term	Medium	Likely	►	Moderate	Moderate
Increase in road traffic	Operational	Negative	Direct	Regional	Long-term	Low	Definite	►	Low	Moderate
Impact on the health of local communities	Operational	Negative	Direct	Local	Long-term	High	Unlikely	►	Low	Low
Public opposition to the project	Operational	Negative	Direct	Local	Long-term	Medium	Unlikely	►	Low to moderate	Low
Impacts on workers' health and safety	Operational	Negative	Direct	Regional	Long-term	Medium	Likely	►	Low	Low
Pilot project and associated potential impacts	Not applicable	Positive	Indirect	National	Permanent	High	Likely	►	High	N/A

G. IMPACT MITIGATION

Following the impact assessment, the BAR identifies the measures that should be adopted to mitigate the Project's negative environmental impacts and enhance the positive impacts.

The primary goal of the mitigation measures is to implement the Project in the most environmentally optimal manner to safeguard the interests of the community and the biophysical environment. The purpose is that no high significance impacts occur after mitigation measures have been implemented and that all residual impacts are of low significance or negligible.

General measures are provided to mitigate potential impacts during the construction phase. These measures are based on best practices and take into consideration the various environmentally sensitive features identified during the Basic Assessment. The measures are integrated into the EMPr and Closure Plan to ensure the effective implementation of the Project.

In addition, mitigation measures are also provided for specific environmental features for the Project's construction, operational and decommissioning phases.

The table below addresses the sensitive themes identified in the National Web-Based Environmental Screening Tool, based on the site sensitivity verification.

Verification of sensitivity based on results from Screening Tool

Theme & Sensitivity based on Screening Tool	Verification
Palaeontology - medium sensitivity	It was concluded in the desktop Palaeontological Impact Assessment that the proposed development will not lead to detrimental impacts on the palaeontological resources of the area.
Animal Species - medium sensitivity	Based on the findings of the Terrestrial Biodiversity Compliance Statement, the project area has experienced long-term and continuous disturbances, mostly due to the agricultural grazing practices and associated impacts. Hence, the project area is modified and as such is assigned a low sensitivity rating.
Plant Species - medium sensitivity	
Terrestrial Biodiversity - very high sensitivity	
Agriculture - high sensitivity	The Screening Tool shows that field crops occur on the site. This is consistent with the land cover map in the BAR, which shows the site consists of commercial croplands. This is disputed, as it is noted that from historical aerial imagery the site has not been cultivated in at least the last 20 years. The land is currently fallow and exposed to informal grazing. The Project is temporary in nature and the site will be reinstated during the decommissioning phase to a pre-project state.
Civil Aviation - high sensitivity	According to the Screening Tool, the project area has a high sensitivity in terms of civil aviation, as it is located within 8 km of other civil aviation aerodrome. in SA, all structures taller than 15 m above ground level must be assessed and registered as potential obstacles to aviation in the Electronic Terrain and Obstacle Database. As such, the impact of the Project on civil aviation will be limited because the proposed CO_2 storage will be below-ground, with the exception of the construction and support infrastructure and equipment. The largest structure is expected to be the drilling equipment which may vary depending on the equipment and techniques used; however, it is not expected to exceed 15 m.

Theme & Sensitivity based on Screening Tool	Verification
	The South African Civil Aviation Authority will be afforded an opportunity to review the draft BAR.
Defence Theme - low sensitivity	According to the Screening Tool, the project area has a low sensitivity in terms of defence. Upon interrogation of the surrounding environment, through the site visit and desktop review, no evidence was found of any military or defence operations or installations. The site verification thus supports/confirms the findings of the Screening Tool of low sensitivity.

H. ANALYSIS OF ALTERNATIVES

Alternatives are the different ways in which the Project can be executed to ultimately achieve its objectives.

The no-go alternative is not preferred, as the objectives of the Project will not be met, and the associated benefits will not materialise. Although not proceeding with the Project would avoid the adverse environmental impacts, these impacts are considered to be manageable through the measures contained in the BAR and EMPr.

Both technical alternatives (i.e., injection of supercritical CO_2 or water-CO_2 solution) are based on successful pilot projects that are discussed in the BAR. At this stage, both alternatives are considered to be preferable.

I. PUBLIC PARTICIPATION

The BAR provides the details of the following tasks that form part of the public participation process:

- Developing a database of Interested and Affected Parties (I&APs);
- Obtaining landowner consent;
- Reviewing of the draft BAR –
    - Period to review the draft BAR;
    - Notification of review of the draft BAR;
    - Means of accessing the draft BAR;
    - Commenting on the draft BAR;
    - Addressing comments received on the draft BAR; and
    - Details of the public meeting to present the draft BAR.
- Notification of DFFE's decision.

J. CONCLUSIONS

The following key tasks were undertaken during the Basic Assessment Process for the proposed Project:

- The Project's areas of influence were defined and assessed;
- Specialist studies were undertaken and the findings were incorporated into the BAR in terms of understanding the environmental status quo and sensitive features, assessing the potential impacts and establishing concomitant mitigation measures;
- Potentially significant impacts pertaining to the construction, operational and decommissioning phases of the Project were identified and assessed, and mitigation measures were provided;
- Alternatives for achieving the objectives of the proposed activity were considered;
- An EMPr and Closure Plan was compiled, which represents a detailed plan of action to ensure that recommendations for enhancing positive impacts and/or limiting or preventing negative environmental impacts are implemented during the life-cycle of the Project; and
- Authorities and I&APs were identified and notified of the review of the draft BAR.

Attention is drawn in the BAR to specific sensitive environmental features for which mitigation measures are included in the BAR and EMPr and Closure Plan. A consolidated sensitivity map for the project area is also provided.

With the adoption of the mitigation measures included in the BAR and the dedicated implementation of the EMPr and Closure Plan, it is believed that the significant environmental aspects and impacts associated with this Project can be suitably mitigated. With the aforementioned in mind, it can be concluded that there are no fatal flaws associated with the Project and that Environmental Authorisation can be granted, based on the findings of the specialists and the impact assessment, through the compliance with the identified environmental management provisions.

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E. List of Acronyms

ADU	Animal Demography Unit
AEL	Atmospheric Emission License
ALARP	As Low as Reasonably Practicable
AQMP	Air Quality Management Plan
AWARD	Association for Water and Rural Development
BAR	Basic Assessment Report
BPEO	Best Practicable Environmental Option
BSCP	Big Sky Carbon Sequestration Partnership
CAT	Climate Action Tracker
CBA	Critical Biodiversity Area
CBD	Central Business District
CCPP	CO_2 Capture Pilot Project
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilisation and Storage
CGS	Council for Geoscience
CO_2	Carbon Dioxide
CRR	Comments and Responses Report
CVB	Channelled Valley Bottom
DAI	Direct Area of Influence
DARDLEA	Department of Agriculture, Rural Development, Land and Environmental Affairs
DEA	Department of Environmental Affairs
DEA&DP	Department of Environmental Affairs and Development Planning
DEFF	Department of Environment, Forestry and Fisheries
DEL	Department of Employment and Labour
Dep	Depression
DFFE	Department of Forestry, Fisheries and the Environment
DMRE	Department of Mineral Resources and Energy
DPWRT	Department of Public Works, Roads and Transport
DWS	Department of Water and Sanitation
EAPASA	Environmental Assessment Practitioners Association of South Africa
EC	Electrical Conductivity
ECA	Environmental Conservation Act (Act No. 73 of 1989)
EIS	Ecological Importance and Sensitivity
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
EMPr	Environmental Management Programme
EN	Endangered

ESA	Ecological Support Area
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESS	Environmental and Social Standards
eTOD	Electronic Terrain and Obstacle Database
FEED	Front-End Engineering Design
Fl	Flat
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMLM	Govan Mbeki Local Municipality
GN	Government Notice
GSDM	Gert Sibande District Municipality
H_2O	Water
HGM	Hydrogeomorphic
HIV/AIDS	Human Immunodeficiency Virus, Acquired Immunodeficiency Syndrome
HPA	Highveld Priority Area
HSA	Hazardous Substances Act (Act No 15 of 1973)
IAI	Indirect Area of Influence
I&APs	Interested and Affected Parties
IDP	Integrated Development Plan
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
IWQMP	Integrated Water Quality Management Plan
KZN	KwaZulu-Natal
LUS	Land Use Scheme
mamsl	meters above mean average sea level
MBSP	Mpumalanga Biodiversity Sector Plan
MPHRA	Mpumalanga Provincial Heritage Resource Authority
MPRDA	Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)
MNCA	Mpumalanga Nature Conservation Act (Act No. 10 of 1998)
MSDS	Material Safety Data Sheet
MTPA	Mpumalanga Tourism and Parks Agency
MTSF	Medium-Term Strategic Framework
NAMA	Nationally Appropriate Mitigation Actions
NBA	National Biodiversity Assessment
NDP	National Development Plan
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NEM:AQA	National Environmental Management: Air Quality Act (Act No. 39 of 2004)
NEM:BA	National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
NEM:WA	National Environmental Management: Waste Act (Act No. 59 of 2008]
NFEPA	National Freshwater Ecosystem Priority Area
NFSD	National Framework for Sustainable Development
NGA	National Groundwater Archive

NGO	Non-Governmental Organisation
NGP	New Growth Path
NHRA	National Heritage Resources Act (Act No. 25 of 1999)
NO_2	Nitrogen Dioxide
NPAES	National Protected Area Expansion Strategy
NSDF	National Spatial Development Framework
NSSD	National Strategy for Sustainable Development and Action Plan
NWA	National Water Act (Act No. 36 of 1998)
NWM	National Wetland Map
NWRS	National Water Resource Strategy
O_3	Ozone
OHS	Occupational Health & Safety
OHSA	Occupational Health & Safety Act (Act No. 85 of 1993)
OP/BP	Operational Policy/Bank Procedures
ORC	Olifants River Catchment
PCSP	Pilot CO_2 Storage Project
PES	Present Ecological State
PPE	Personal Protective Equipment
S	Seep
SA	South Africa
SABAP2	South African Bird Atlas Project Version 2
SACAA	South African Civil Aviation Authority
SAHRA	South African Heritage Resources Agency
SAHRIS	South African Heritage Resources Information System
SAIIAE	South African Inventory of Inland Aquatic Ecosystems
SANBI	South African National Biodiversity Institute
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standard
SAWS	South African Weather Service
SCC	Species of Conservation Concern
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
SEI	Site Ecological importance
S&EIR	Scoping and Environmental Impact Reporting
SIP	Strategic Integrated Project
SO_2	Sulphur Dioxide
SPLUMA	Spatial Planning and Land Use Management Act (Act No. 16 of 2013)
Stats SA	Statistics South Africa
SWSA	Strategic Water Source Area
UCVB	Unchanneled Valley Bottom
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USEPA	United States Environmental Protection Agency

WB	World Bank
WHO	World Health Organisation
WMA	Water Management Area
WML	Waste Management Licence
WSS	Water Supply Scheme
WUL	Water Use Licence

1 PURPOSE OF THIS DOCUMENT

Nemai Consulting (Pty) Ltd was appointed by NEMUS, on behalf of the Council for Geoscience (CGS) (the "Applicant"), as the independent Environmental Assessment Practitioner (EAP) to apply for Environmental Authorisation for the proposed Pilot Carbon Dioxide Storage Project near Leandra in the Govan Mbeki Local Municipality, Mpumalanga Province (the "Project").

The Basic Assessment Process is being undertaken according to the process prescribed in the Environmental Impact Assessment (EIA) Regulations of 2014, published under Government Notice (GN) No. 982 in Gazette No. 38282 of 4 December 2014 and amended by GN 326 of 7 April 2017 published in Gazette No. 40772 (the "EIA Regulations"). The EIA Regulations were promulgated in terms of the National Environmental Management Act (Act No. 107 of 1998) (NEMA). The Department of Forestry, Fisheries and the Environment (DFFE) is the Competent Authority in respect to this proposed Project in terms of NEMA.

According to the EIA Regulations, the objectives of the Basic Assessment Process are to undertake the following, through a consultative process:

(a) Determine the policy and legislative context within which the proposed activity is located and how the activity complies with and responds to the policy and legislative context;
(b) Identify the alternatives considered, including the activity, location, and technology alternatives;
(c) Describe the need and desirability of the proposed alternatives;
(d) Through the undertaking of an impact and risk assessment process, inclusive of cumulative impacts which focused on determining the geographical, physical, biological, social, economic, heritage, and cultural sensitivity of the sites and locations within sites and the risk of impact of the proposed activity and technology alternatives on these aspects to determine -
    (i) The nature, significance, consequence, extent, duration, and probability of the impacts occurring to; and
    (ii) The degree to which these impacts -
        (aa) can be reversed;
        (bb) may cause irreplaceable loss of resources;
        (cc) can be avoided, managed or mitigated;
(e) Through a ranking of the site sensitivities and possible impacts the activity and technology alternatives will impose on the sites and location identified through the life of the activity to -
    (i) Identify and motivate a preferred site, activity and technology alternative;
    (ii) Identify suitable measures to avoid, manage or mitigate identified impacts; and
    (iii) Identify residual risks that need to be managed and monitored.

This document serves as the draft Basic Assessment Report (BAR) for the proposed Project. The draft BAR will be made available to Interested and Affected Parties (I&APs) for a 30-day review period from **29 May until 28 June 2023**. All comments received will be addressed in the final BAR and will also be included in the Comments and Responses Report. The final BAR will then be submitted to the DFFE for review and decision-making.

2 DOCUMENT ROADMAP

As a minimum, the BAR aims to satisfy the requirements stipulated in Appendix 1 of the EIA Regulations. Table 1 below presents the document's composition in terms of the aforementioned regulatory requirements.

Table 1: BAR Roadmap

<table>
<tr><th>Chapter</th><th>Title</th><th>Correlation with EIA Regulations</th><th>Prescribed Content</th></tr>
<tr><td>1.</td><td>Purpose of this Document</td><td>–</td><td>–</td></tr>
<tr><td>2.</td><td>Document Roadmap</td><td>–</td><td>–</td></tr>
<tr><td>3.</td><td>Introduction</td><td rowspan="2">3(1)(b), (c) & (d)</td><td rowspan="2">(b) the location of the activity, including:
(i) the 21-digit Surveyor General code of each cadastral land parcel;
(ii) where available, the physical address and farm name;
(iii) where the required information in items (i) and (ii) is not available, the coordinates of the boundary of the property or properties.
(c) a plan which locates the proposed activity or activities applied for as well as associated structures and infrastructure at an appropriate scale; or, if it is -
(i) a linear activity, a description and coordinates of the corridor in which the proposed activity or activities is to be undertaken; or on land where the property has not been defined, the coordinates within which the activity is to be undertaken.
(d) a description of the scope of the proposed activity, including -
(ii) a description of the activities to be undertaken including associated structures and infrastructure.</td></tr>
<tr><td>4.</td><td>Project Description</td></tr>
<tr><td>5.</td><td>Alternatives</td><td>3(1)(h)</td><td>(h) a full description of the process followed to reach the proposed preferred alternative within the site</td></tr>
<tr><td>6.</td><td>Legislative and Institutional Framework</td><td>3(1)(e)</td><td>(d) a description of the scope of the proposed activity, including
(i) all listed and specified activities triggered and being applied for.
(e) a description of the policy and legislative context within which the development is proposed including -
(i) an identification of all legislation, policies, plans, guidelines, spatial tools, municipal development planning frameworks, and instruments that are applicable to this activity and have been considered in the preparation of the report; and
(ii) how the proposed activity complies with and responds to the legislation and policy context,</td></tr>
</table>

Chapter	Title	Correlation with EIA Regulations	Prescribed Content
			plans, guidelines, tools frameworks, and instruments;
7.	**Basic Assessment Process**	3(1)(a)	(a) Details of – (i) the Environmental Assessment Practitioner (EAP) who prepared the Environmental Management Programme (EMPr); and (ii) the expertise of that EAP to prepare an EMPr, including curriculum vitae.
8.	**Need and Desirability**	3(1)(f)	(f) a motivation for the need and desirability for the proposed development including the need and desirability of the activity in the context of the preferred location.
9.	**Financial Provisions**	3(1)(s)	(s) where applicable, details of any financial provisions for the rehabilitation, closure, and ongoing post decommissioning management of negative environmental impacts.
10.	**Description of the Environment**	3(1)(h)	(h) a full description of the process followed to reach the proposed preferred alternative within the site, including: (iv) the environmental attributes associated with the alternatives focusing on the geographical, physical, biological, social, economic, heritage and cultural aspects.
11.	**Impact Identification and Assessment**	3(1)(h), (i), (j), (k) and (m)	(h) a full description of the process followed to reach the proposed preferred alternative within the site, including: (v) the impacts and risks identified for each alternative, including the nature, significance, consequence, extent, duration and probability of the impacts, including the degree to which these impacts- (aa) can be reversed; (bb) may cause irreplaceable loss of resources; and (cc) can be avoided, managed or mitigated; (vi) the methodology used in determining and ranking the nature, significance, consequences, extent, duration and probability of potential environmental impacts and risks associated with the alternatives; (vii) positive and negative impacts that the proposed activity and alternatives will have on the environment and on the community that may be affected focusing on the geographical, physical, biological, social, economic, heritage and cultural aspects; (viii) the possible mitigation measures that could be applied and level of residual risk; (ix) the outcome of the site selection matrix; (xi) a concluding statement indicating the preferred alternatives, including preferred location of the activity. (i) a full description of the process undertaken to identify, assess and rank the impacts the activity will impose on the preferred location through the life of the activity, including- (i) a description of all environmental issues and risks that were identified during the environmental impact assessment process; (ii) an assessment of the significance of each issue and risk and an indication of the extent to which the issue and risk could be avoided or

Chapter	Title	Correlation with EIA Regulations	Prescribed Content
12.	**Impact Mitigation**		addressed by the adoption of mitigation measures. (j) an assessment of each identified potentially significant impact and risk, including- (i) cumulative impacts; (ii) the nature, significance and consequences of the impact and risk; (iii) the extent and duration of the impact and risk; (iv) the probability of the impact and risk occurring; (v) the degree to which the impact and risk can be reversed; (vi) the degree to which the impact and risk may cause irreplaceable loss of resources; (vii) the degree to which the impact and risk can be avoided, managed or mitigated. (k) where applicable, a summary of the findings and impact management measures identified in any specialist report complying with Appendix 6 to these Regulations and an indication as to how these findings and recommendations have been included in the final report. (m) based on the assessment, and where applicable, impact management measures from specialist reports, the recording of the proposed impact management objectives, and the impact management outcomes for the development for inclusion in the EMPr.
13.	**Overall Assessment**		
14.	**Analysis of Alternatives**	3(1)(h) & (g)	(h) full description of the process followed to reach the proposed preferred alternative within the site, including - (i) details of all the alternatives considered. (g) a motivation for the preferred site, activity and technology alternative.
15.	**Assessment Limitations**	3(1)(o)	(o) a description of any assumptions, uncertainties, and gaps in knowledge which relate to the assessment and mitigation measures proposed.
16.	**Public Participation Process**	3(1)(h)	(h) a full description of the process followed to reach the proposed preferred alternative within the site, including: (ii) details of the public participation process undertaken in terms of regulation 41 of the Regulations, including copies of the supporting documents and inputs; (iii) a summary of the issues raised by interested and affected parties, and an indication of the manner in which the issues were incorporated, or the reasons for not including them.

Chapter	Title	Correlation with EIA Regulations	Prescribed Content
17.	**Conclusions**	3(1)(l), (m), (n) & (p)	(l) an environmental impact statement which contains- (i) a summary of the key findings of the environmental impact assessment; (ii) a map at an appropriate scale which superimposes the proposed activity and its associated structures and infrastructure on the environmental sensitivities of the preferred site indicating any areas that should be avoided, including buffers; and (iii) a summary of the positive and negative impacts and risks of the proposed activity and identified alternatives. (m) based on the assessment, and where applicable, impact management measures from specialist reports, the recording of the proposed impact management objectives, and the impact management outcomes for the development for inclusion in the EMPr. (n) any aspects which were conditional to the findings of the assessment either by the EAP or specialist which are to be included as conditions of authorisation. (p) a reasoned opinion as to whether the proposed activity should or should not be authorised, and if the opinion is that it should be authorised, any conditions that should be made in respect of that authorisation.
Appendix G	**Oath of Environmental Assessment Practitioner**	3(1)(r)	(r) an undertaking under oath or affirmation by the EAP in relation to: (i) the correctness of the information provided in the reports; (ii) the inclusion of comments and inputs from stakeholders and I&APs; (iii) the inclusion of inputs and recommendations from the specialist reports where relevant; and (iv) any information provided by the EAP to interested and affected parties and any responses by the EAP to comments or inputs made by interested and affected parties;
N/A		3(1)(t)	Where applicable, any specific information required by the Competent Authority.
N/A		3(1)(u)	Any other matters required in terms of sections 24(4)(a) and (b) of the Act.

3 INTRODUCTION

3.1 Project Background and Motivation

Carbon Capture Utilisation and Storage (CCUS) has been acknowledged by South Africa (SA) as one of the technologies to mitigate the emissions of carbon dioxide (CO_2) into the atmosphere and forms one of the Nationally Appropriate Mitigation Actions (NAMA). It is also one of the national flagship projects. CCUS forms part of a just transition to a future low-carbon energy economy.

CCUS reduces the release of anthropogenic CO_2 emissions into the atmosphere by capturing CO_2 at the source (e.g., point-source emitters such as coal-fired plants) and transporting and storing the captured CO_2 in suitable deep geological formations. Some of the captured CO_2 may then be used in additional downstream industries.

According to Dhansay *et al*. (2022), SA is the highest CO_2 emitter on the African continent and has one of the largest rates of CO_2 emissions in the world. In general, SA's coal reserves, current coal utilisation and subsequently most CO_2 emissions occur in the north-eastern part of the country.

Basaltic rocks, which is rocks rich in iron, calcium, magnesium, and aluminium silicate minerals, are regarded as very promising CO_2 storage reservoirs. This is largely because basaltic rocks are globally voluminous, have unique trapping mechanisms linked to their multi-phase geodynamic emplacement; and have a chemical composition that is highly susceptible for mineral carbonation on a large scale and which is several orders of magnitude faster than in classical siliciclastic reservoirs (Dhansay *et al*., 2022). SA has extensive basaltic occurrences across the country. Figure 1 below provides an overview of the surface expression of significant basaltic sequences across SA, together with coalfields and coal-fired energy generation plants.

An assessment of available geological data undertaken by the CGS identified the availability of deep coal seams and potential CO_2 storage reservoirs that can support CCUS development in the Mpumalanga Province (see Figure 2 below). Hence, the CGS is undertaking a geoscientific research project for the piloting of CCUS in Leandra in Mpumalanga, where it is proposed to inject CO_2 into deep suitable geological formations, approximately 1km below the surface.

The Mpumalanga Province, where the piloting of CCUS is proposed, is home to mining and petrochemical industries and, as a result, the area is where the country's CO_2 emissions are most prevalent.

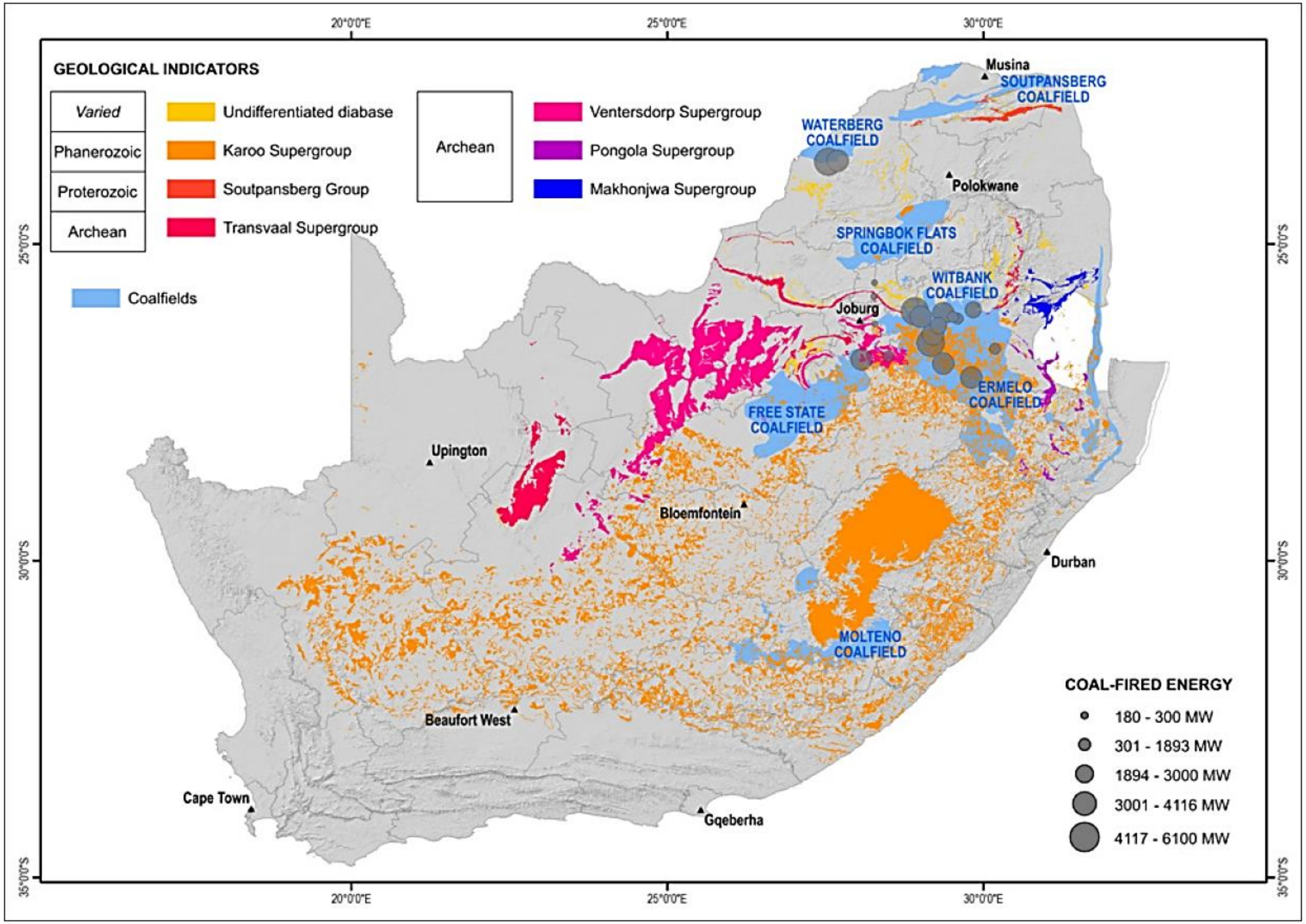

Figure 1: Significant basaltic sequences across SA together with coalfields and coal-fired energy generation plants (Dhansay *et al*., 2022)

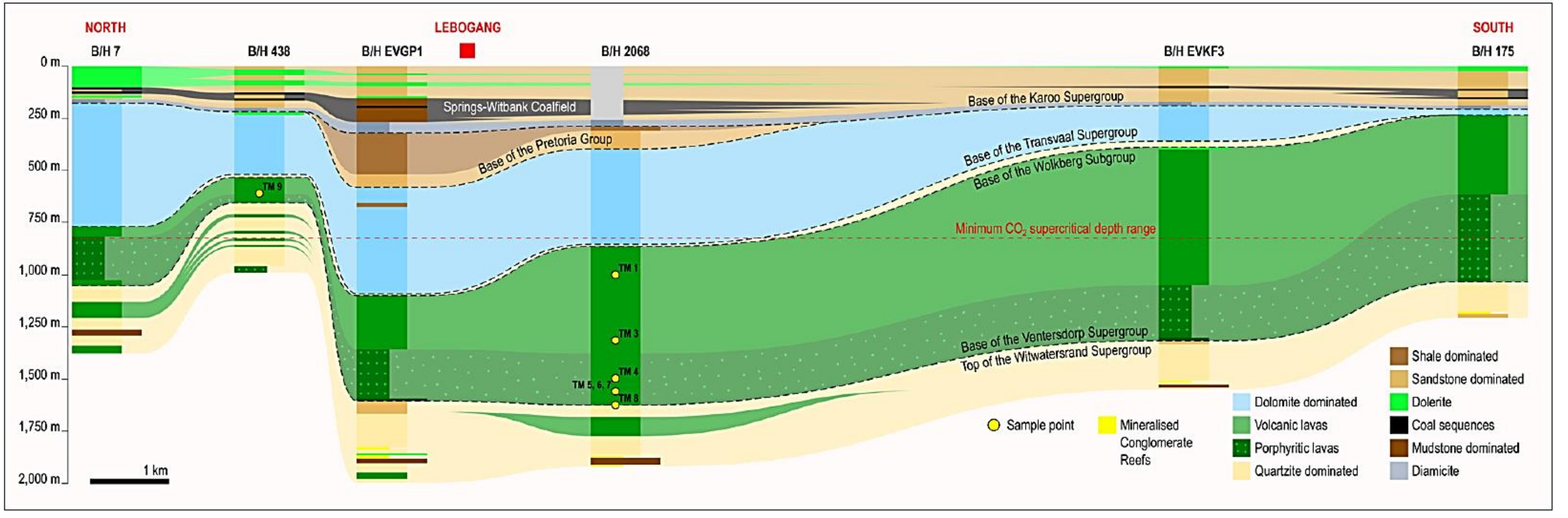

Figure 2: Schematic geological profile developed proximal to SA's significant point-source CO_2 emitters (Dhansay *et al*., 2022)

The purpose of the Pilot Project is to demonstrate the application of CCUS technology to SA conditions. The overall Project comprises the following two components:

- **Component 1**: Pilot CO_2 Storage Project for the investigation and characterization of a suitable CO_2 storage site and the subsequent injection, storage and monitoring of between 10,000 and 50,000 tons of CO_2 at the identified site and a depth of at least 1,800 m from the surface in suitable geological formations; and
- **Component 2**: A CO_2 Capture Pilot Project (CCPP) Front-End Engineering Design (FEED) for the preparation of a FEED study for a capture pilot plant at the Eskom Kusile Power Station.

This application is related to Component 1 of the Pilot Project and the scope entails specifically the injection and storage parts.

The Government of SA received funding from the World Bank's (WB) International Bank for Reconstruction and Development to finance the CCUS Project, and therefore it is to be executed to meet all related requirements. As defined in the Operations Manual 4.01 - Environmental Assessment (OP/BP), the proposed Pilot CO_2 Storage Project under review falls under category A, which requires a full Environmental and Social Impact Assessment (ESIA). A separate ESIA Report was compiled by NEMUS for the Project.

It is noted that a separate ESIA, in terms of the World Bank's requirements, is also being undertaken for the stratigraphic drilling and 3D seismic survey. These activities do not trigger any listed activities in terms of the Listing Notices under the EIA Regulations.

3.2 Project Aims

Overall, the Project aims are as follows:

- Construction and operation of the Pilot CO_2 Storage Project, through the implementation of Carbon Capture and Storage (CCS) technology;
- Investigation and characterization of a suitable CO_2 storage site and subsequent injection, storage, and monitoring into deep geological formations;
- Injection and storage between 10,000 to 50,000 tons of CO_2; and
- Understanding the viability of the Mpumalanga Province area as a suitable storage site.

3.3 Implementing Agency

The CGS is a schedule 3A public entity organisation as defined by the Public Finance Management Act (Act No. 1 of 1999) of SA. The CGS derives its mandate from the Geoscience Act (Act No. 100 of 1993). The objectives of the CGS under the Act, is to produce world-class geoscience knowledge products and to render geoscience-related services to SA public and industry.

4 PROJECT DESCRIPTION

4.1 Project Location

4.1.1 Geographical Context

The project site is situated near the town of Leandra in the Mpumalanga Province of SA. The project site falls within the Gert Sibande District Municipality (GSDM) and is located within Ward 6 of the Govan Mbeki Local Municipality (GMLM). The GPS coordinates of the approximate centre of the proposed drill site are 26°22'04.84"S, 28°56'19.47"E. The site is bordered by the R29 to the north and the railway servitude to the south. Locality maps are provided in Figure 3 and Figure 4 below. Further maps are contained in Appendix A.

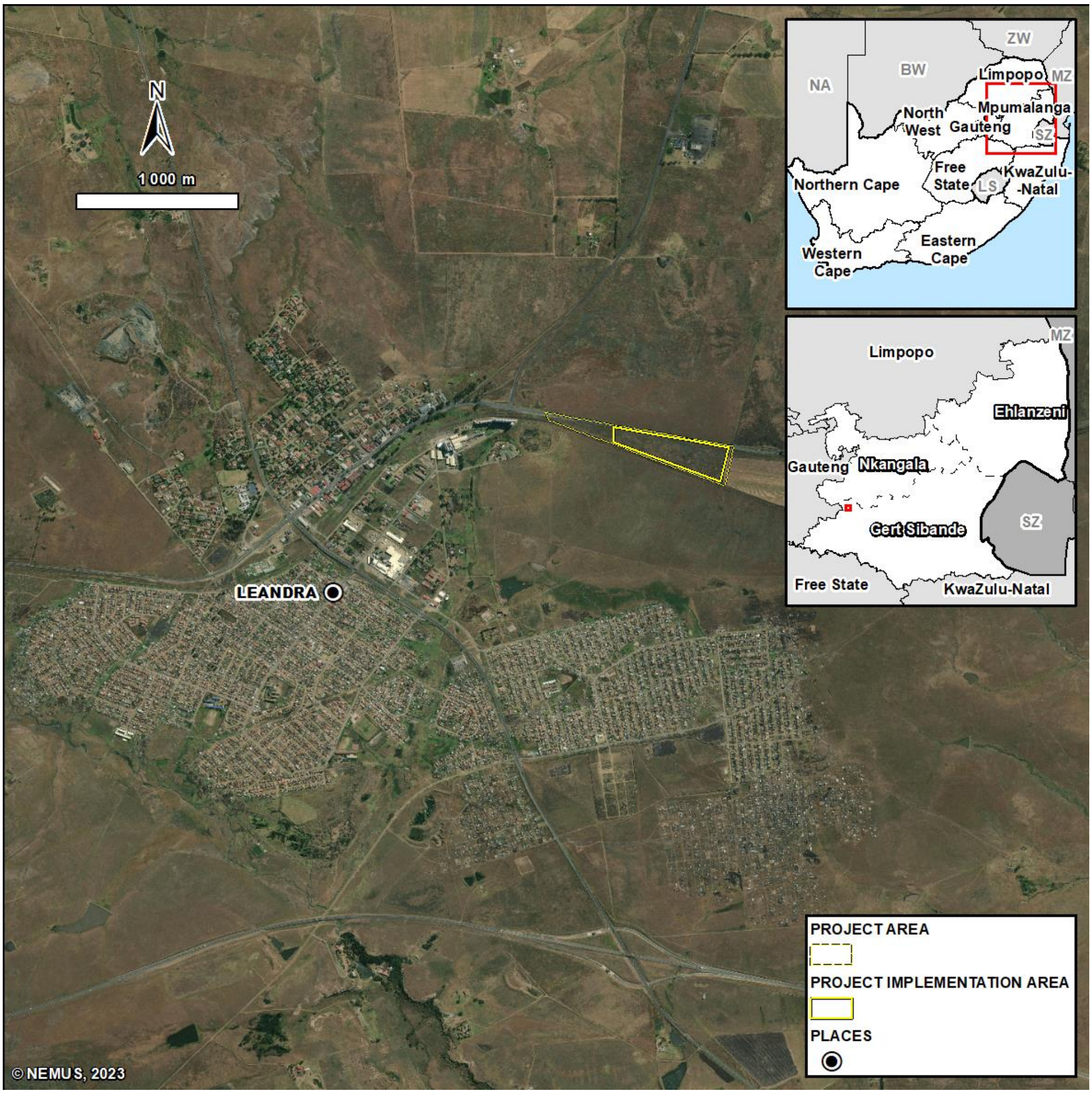

Figure 3: National, provincial and local geographical context

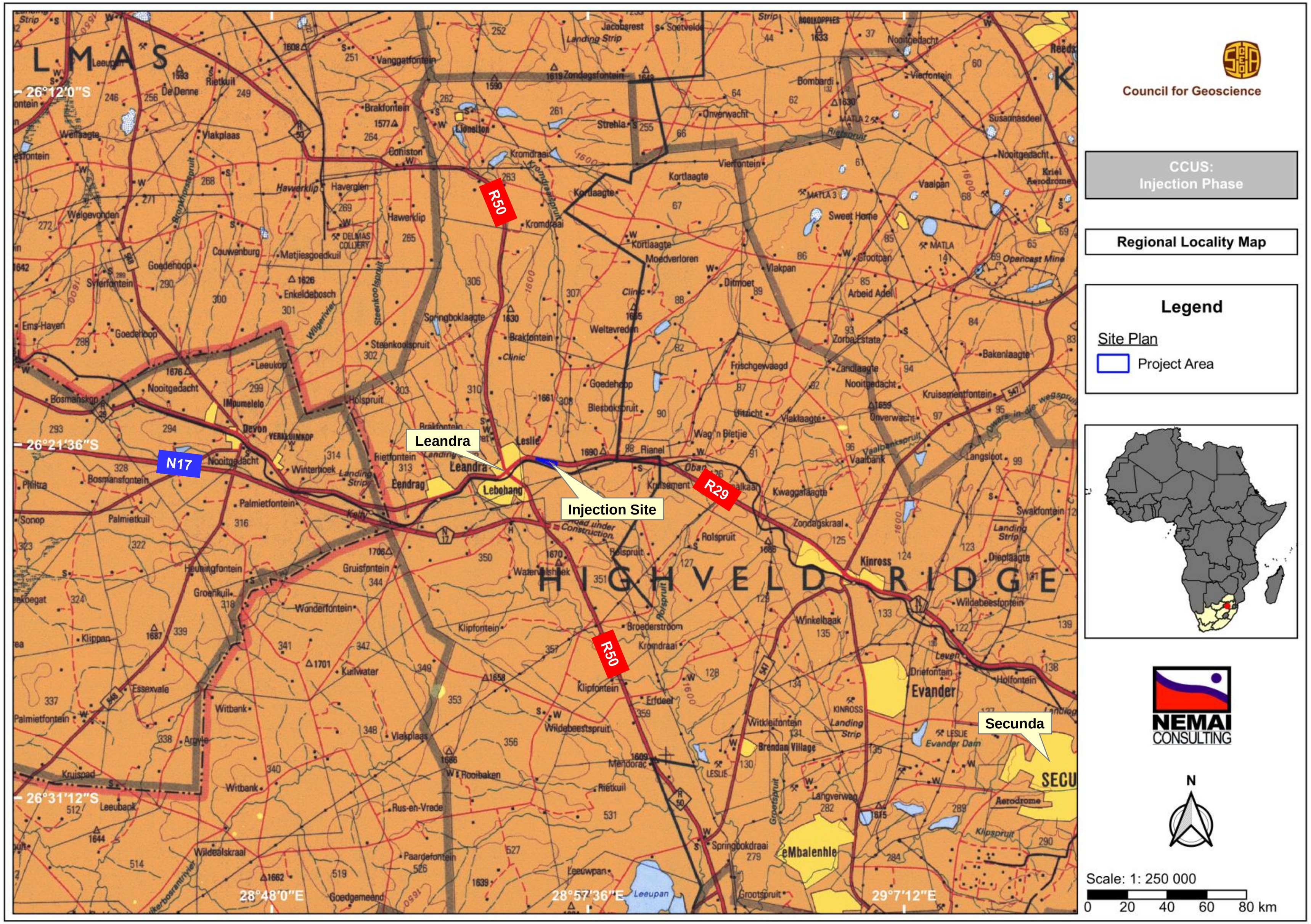

Figure 4: Regional locality map

The Mpumalanga Province is a prime mining area with intensive mining and petrochemical activities and thus is the area with the most prevalent CO_2 emissions in the country. As stated, this factor, along with the identification of suitable geological formations, makes the earmarked site near the town of Leandra the identified location for the Project.

4.1.2 Property Details & Ownership

The property earmarked for the CO_2 injection belongs to the GMLM, who has entered into a lease agreement with the CGS in 2021 as a research site for the investigation into the viability of CCUS. According to this agreement, the site is located on Portion 2 of the Farm Goedehoop 308 (21-digit Surveyor General No.: T0IR00000000030800002) (see Figure 5 below).

The coordinates of the property as well as the Project Implementation Area are presented in Table 2 below.

Table 2: Coordinates of the Property and Project Implementation Area

ID	Latitude	Longitude	ID	Latitude	Longitude
Property			**Project Implementation Area**		
1	-26.366304	28.933773	1	-26.366959	28.937543
2	-26.368118	28.943966	2	-26.368118	28.943966
3	-26.370033	28.943483	3	-26.370033	28.943483
4	-26.366608	28.933906	4	-26.367824	28.937545

4.1.3 Project Areas

4.1.3.1 Overview

Based on the Project location, Table 3 below outlines the areas considered for the environmental and social assessment. The Project Property Area and Project Implementation Area are shown in Figure 8 below.

Table 3: Project areas for the assessment

Area typology	Units	Details
Project Property Area	14 ha	Chosen property area for the development of the Project.
Project Implementation Area	10 ha	Area, within the Project property, considered as useful area for the Project implementation (also considering road and railway safety distances).
Direct Area of Influence	Buffer of 1 km	Area within which it is considered that impacts may be felt directly.
Indirect Area of Influence	Buffer of 5 km	Area within which it is considered that impacts may be felt indirectly.

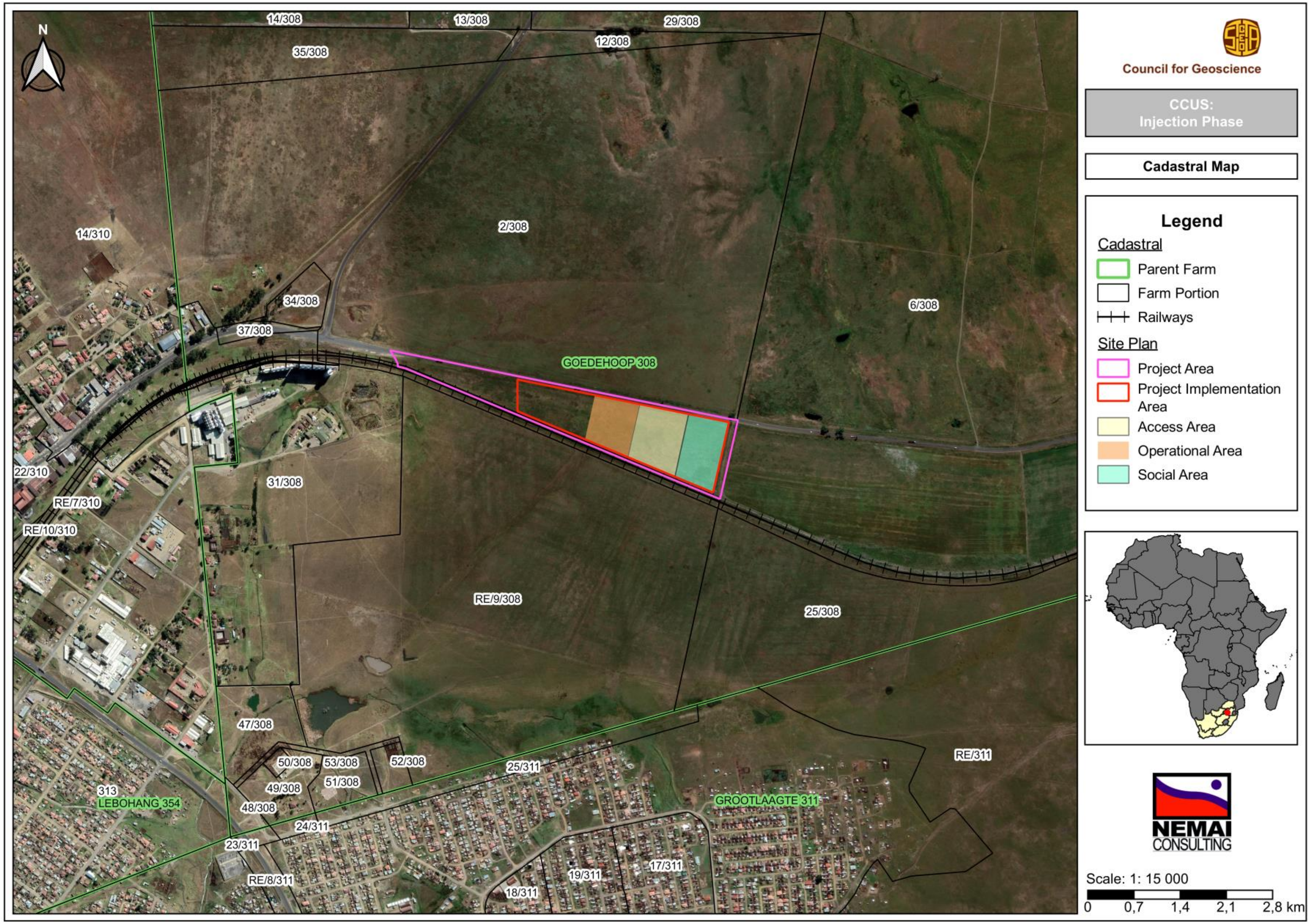

Figure 5: Map showing cadastral boundaries

It is noted that, although the environmental and social assessment considers these areas as the baseline, the direct and indirect areas of influence (described hereafter) can be adjusted according to the subject under assessment.

4.1.3.2 Direct Area of Influence

The Direct Area of Influence (DAI) is the area of direct impacts of the Project on the natural environment (flora, pollution, physiographic changes, among others) and the socioeconomic environment (land occupation, local and regional development, among others). Typically, DAI corresponds to the areas of physical deployment of infrastructure and construction work and a marginal area where the effects of the presence and operation of these actions may be felt directly. Although there may be minor changes to the definition of the area of direct influence for the description of the environment (including the social component), it will be considered a baseline buffer around the Project footprint of 1,000 metres (see Figure 6 below).

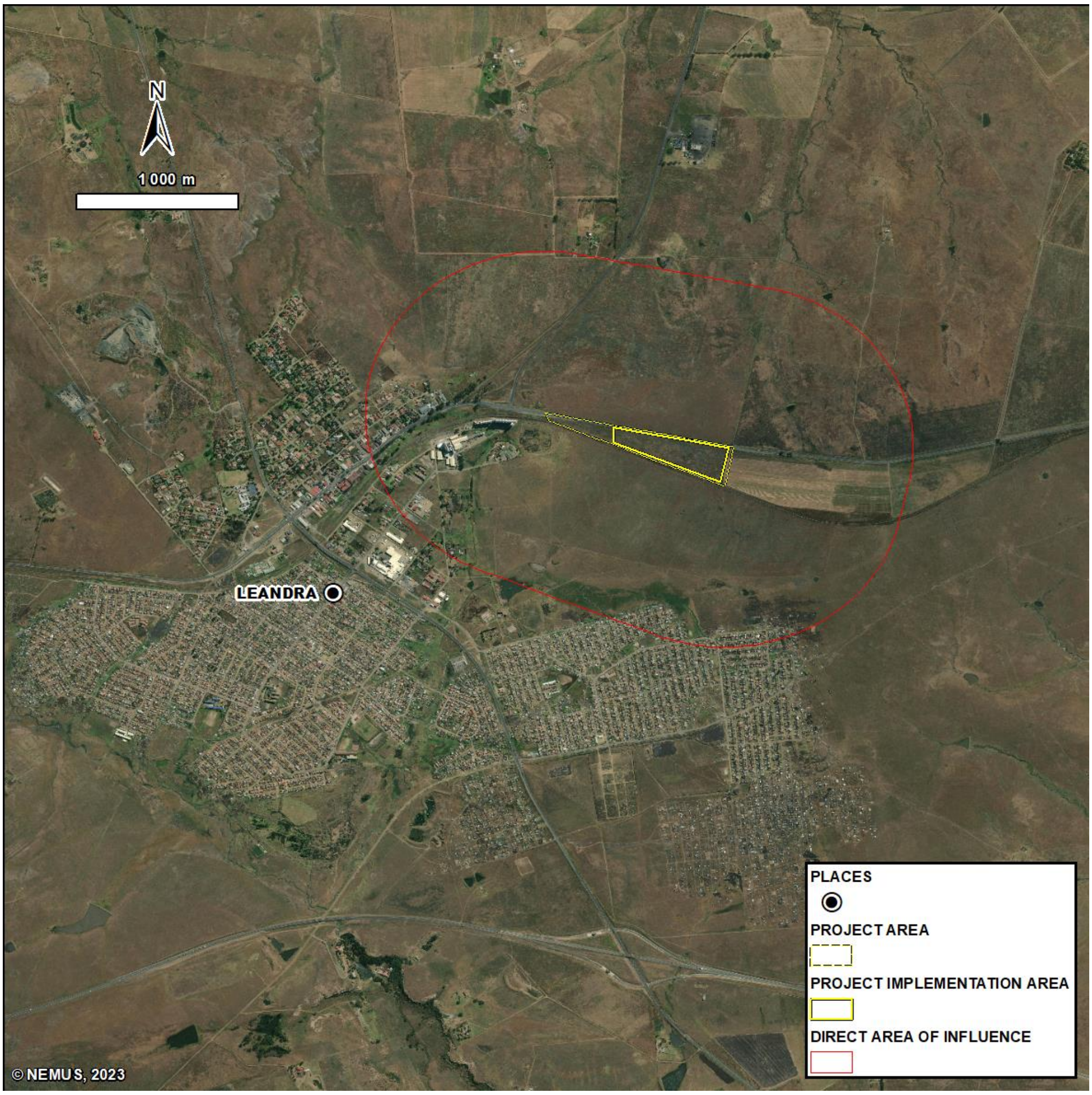

Figure 6: Direct Area of Influence

4.1.3.3 Indirect Area of Influence

The Indirect Area of Influence (IAI) is generally a more extensive area to analyse the effect of the indirect influences of the proposed activities, through the possible side effects that may result from the Project. Thus, the IAI defined for the Basic Assessment includes a broader area, considering a buffer around the Project footprint of 5,000 metres (see Figure 7 below).

Figure 7: Indirect Area of Influence

4.2 General Characteristics

4.2.1 Introduction

CCS is a technically feasible method, studied over the years, for reducing carbon dioxide emissions from sources such as combustion of fossil fuels, as in power generation, and the preparation of fossil fuels, as in natural-gas processing (IPCC, 2005).

Overall, the technology is based on the utilization or storage of CO_2 in suitable deep geological formations, leading to a reduction in the anthropogenic release of CO_2 into the atmosphere. The process entails the following three key stages:

1. Capturing CO_2 from anthropogenic sources;
2. Transporting the CO_2 to the injection site; and
3. Permanent geological storage or utilization of the CO_2.

The Project is a test of this application, considering specifically the storage component.

With the purpose of assessing the Project’s environmental and social risks and impacts and the feasibility of and to build expert capacity for CCS, the Project activities include the site establishment, drilling and construction of an injection well of approximately 1,800 metres deep, road transportation, and operation/injection of CO_2 at the designated site.

The characteristics of the Project to be assessed are outlined below.

4.2.2 Location

The location choice is based on the following main factors:

- Coal-fired power stations, as well as mining and petrochemical industrial activities, that are responsible for high levels of CO_2 emissions, occur within the Mpumalanga Province. The project area is also located near to major CO_2 sources (including Eskom Power Plants and the Sasol Secunda Plant);
- The project area is characterized by a basaltic geological nature with storage potential;
- The project area is under the ownership of the GMLM and is currently not used; and
- The site location fulfils the main factors that led to the selection of the preferred site.

Further information regarding the selection of the proposed site is provided in in Section 5.4.

4.2.3 CO_2 Capture Site

One of the key points of the Project is the definition of the site for capturing CO_2 from an anthropogenic source. As a result, a pilot of a capture plant has been defined near the Sasol Secunda Plant to test capture technology and be a Centre of excellence to train operators for the future commercialization phase (Kamrajh, *et al.*, 2022).

4.2.4 Activities

Once the site location is settled and, considering the aims presented in Section 3.2 above, being characterized as a research Project for the development of a Pilot CO_2 Storage Project, the Project is divided into the following activities:

- Site establishment;
- Drilling;
- Construction of injection well to a depth of approximately 1,800 m; and
- Operation - injection of CO_2 at the designated site.

Along with the phases defined above, further activities to be considered include Stakeholder Engagement, securing of the Area (fencing to be installed along the implementation area), Environmental Monitoring, and site decommissioning.

4.2.5 Timeframe

The Project is expected to be developed over 2.5 years, considering 6 months for the construction phase and 24 months for the operational phase.

During the construction phase, drilling (the primary activity to take place), will be carried out 24 hours a day. During the operational phase, the CCS technology will be tested and operations will take place 16 hours a day. The injection activity will, over the two years, operate 250 to 365 days per year This frequency will aid reaching the final injection target.

4.2.6 Project Phases

Table 4 below identifies, by phase, the main activities underway and to be assessed. It should be noted that the current Basic Assessment evaluates two alternatives of CO_2 injection methodologies.

Table 4: Project phases and respective main activities

Construction Phase	Operational Phase	Decommissioning Phase
Site Establishment	CO_2 Transportation	Dismantling of site infrastructure
Drilling	CO_2 Injection	Secure borehole sealing
Construction of the Operational area		

4.2.7 Labour Required

For a project of this nature, and being a pilot project and thus of reduced size, the following is expected in terms of storage and manpower needs:

- Estimated labour required for construction phase: 4-6 people (including guard, drilling team). Since this phase will run 24 hours a day, three shifts are considered necessary and, therefore, a total of 12-18 people; and
- Estimated labour required for operation: 10-20 people (including guard, operators, technicians).

It is highlighted that these labour requirements may change over the course of the Project.

4.3 Project Activities

4.3.1 Site Plan

Based on the Project aims (see Section 3.2 above) and the Project Implementation Area (identified in Table 3 above) required, Figure 8 below shows the Project site plan (including social, access and operational area). The site plan was developed to ensure the execution of the activities in a structured and safe manner. A 50 m buffer around the injection site was defined, and the entire area will be fenced off.

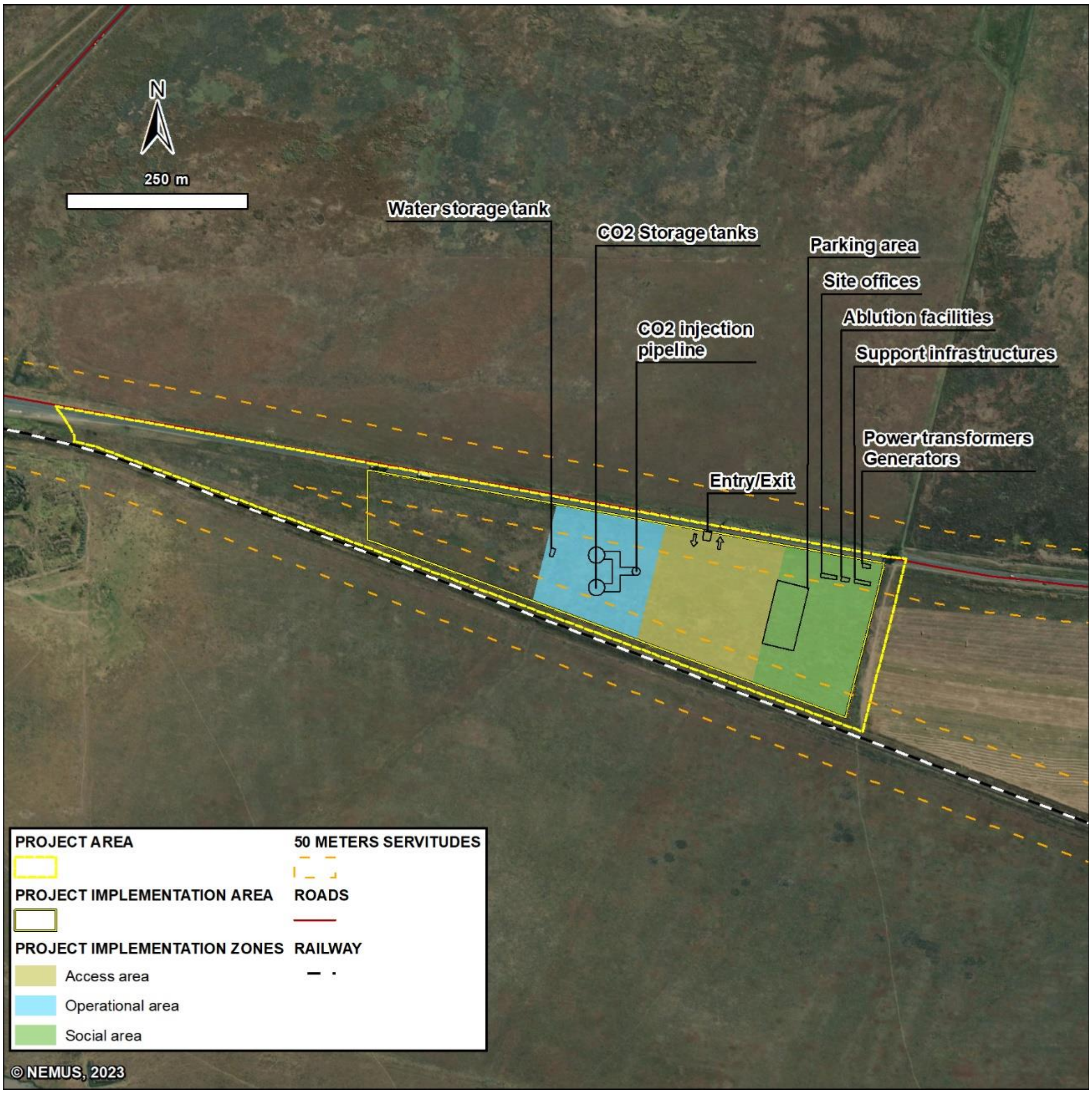

Figure 8: Site Plan

As shown in the Figure 8 above, the site plan is divided into the following three reference zones:

- Access area, which makes provision for the entry, exit and circulation of trucks, equipment, machinery, and other vehicles (approximately 24,200 m^2 in extent);

- Operational Area, where drilling, injection and storage operations will be carried out (approximately 18,500 m^2 in extent); and
- Social Area, where main site establishment infrastructure will be installed (approximately 22,700 m^2 in extent).

The Project activities, which include the site establishment, drilling, and construction of one injection well of approximately 1,800 m deep, road transportation, and operation/injection of CO_2 at the designated site, are set out below.

4.3.2 Site Establishment

Considering the site plan, the site establishment comprises the following activities:

- Levelling of ground for access;
- Fencing of site perimeters (throughout the implementation area);
- Access roads for drilling rigs and CO_2 tankers and parking area;
- Installation of power - transformers/generators etc., which will operate on a regular basis during the Project;
- Construction of temporary potable water and feed water storage facilities (water storage tank) (for the estimated duration of the Project of 2.5 years);
- Construction of shelter for security personnel (at the entry/exit identified in Figure 8);
- Installation of site offices, ablution facilities and support infrastructure for equipment, CGS personnel and contractors.

Table 5 below shows the dimensions considered for the development of the site plan.

Table 5: Dimensions considered for the development of the site plan

Infrastructure	Considered dimensions for implementation
Ablution Facilities	10 m x 5 m (Area: 50 m^2), Height[1]: 2.5 m
CO_2 Cryogenic Storage Tanks	Height: 8 m, Diameter: 6 m (Volume: 226 m^2)
CO_2 Injection Pipeline	Extension: around 50 m, Diameter: 125 mm
Parking Area	40 m x 80 m (Area: 3,200 m^2)
Power Transformers/Generators	10 m x 5 m (Area: 50 m^2)
Shelter for security personnel	6 m x 6 m (Area: 36 m^2), Height[1]: 2.5 m
Site Offices	20 m x 5 m (Area: 100 m^2), Height[1]: 2.5 m
Support Infrastructure	20 m x 5 m (Area: 100 m^2), Height[1]: 2.5 m
Water Storage	10 m x 5 m (Area: 50 m^2)

It should be noted that the areas indicated above are estimations and may vary with the implementation of the Project.

[1] Estimated height for the implementation of a prefabricated modular infrastructure.

4.3.3 Drilling

The drilling is the main activity during the Project's construction phase, and involves the following:

- Drilling of slim holes for geological characterization;
- Hole - The estimated total depth for the wells is approximately 1,800 m;
  - Surface Hole – Approximately 125 mm diameter;
  - Intermediate Hole – Approximately 125 mm diameter; and
  - Production Hole – Approximately 96 mm diameter.
- Core acquisition, handling and transport; and
- Well completion - cap the well with a swage and valve or other apparatus approved by CGS.

Plant, equipment and goods associated with drilling shall include (amongst others):

- Drill rigs including masts or derricks;
- Drilling fluid mixing, pumping and recycling equipment;
- Grouting pumps, mixers and all other equipment necessary for grout casing of the borehole, when necessary;
- Lighting plants and other equipment necessary to allow safe and efficient 24-hour operation;
- Adequate power supply unit for the drilling operation and the staff camp;
- Water supply for drilling and potable water for workers;
- Site office accommodation, stores, workshops and kitchen facilities at the site;
- Office for CGS representatives;
- Adequate vehicles to allow completion of the work, including suitable transport to safely transport contractor personnel to and from the drill site;
- Adequate, approved temporary ablution and latrine facilities;
- A reliable communication system; and
- All spare parts and back-up plant and equipment to ensure safe and efficient completion of the work.

For decommissioning, the borehole will be securely capped with a concrete sanitation block and a lockable metal cap with a clear sign to avoid potential hazards to people and animals.

4.3.4 Construction of Operation/Injection Area

It is necessary to construct the following to allow for the Project's operational phase:

- Pad preparation earthworks for a large diameter well drilling rig for injection and monitoring wells;
- Sump for drill rig and system to treat and dispose of drilling fluids and cuttings;
- Concrete pads for two (2) CO_2 Cryogenic Storage Tanks (with a capacity of 100 tons each), compressor/s, heaters;
- Injection wells, monitoring wells, well head and equipment, pipelines from storage tanks to injection equipment and monitoring equipment, CO_2 pump skid; and

- Storage area for diesel, oils, spare parts, drilling rods, etc.

4.3.5 Operation - Injection of CO_2 at the Designated Site

The operational activity, carried out according to the site plan (shown in Figure 8 above), is the result of the construction of the operation / injection area. This activity involves the process of CO_2 Capture at source (with an independent assessment process in progress), transport via the road defined in Section 4.3.6 below and injection into the designated site.

Once the CO_2 reaches the injection site, it is carefully stored in Cryogenic Storage Tanks, with a maximum capacity of 100 tons each, and conveyed via pipeline to the injection well. As injection target, the following injection scenarios can be distinguished:

- **40 to 100 tons per day** - considering 250 days a year of injection, for two years, to reach the proposed total injection (10,000 to 50,000); and
- **15 to 70 tons per day** - considering 365 days a year, for two years, to reach the proposed total injection (10,000 to 50,000).

The following two technology alternatives are being assessed for CO_2 injection (refer to Section 5.7 below):

- **Injection of supercritical CO_2**: The supercritical CO_2 injection method implies the transport of liquefied CO_2 by road-tanker trucks to the injection site. Given the small volume of CO_2 to be injected and the project timeline, CO_2 transportation via pipeline is not deemed feasible for the pilot CCS Project. However, this alternative should be considered if there is an existing infrastructure that can connect to the potential injection site and the source(s) of CO_2. Before injection, the liquefied CO_2 will be stored in intermediate cryogen tanks. The proposed injection process will involve the use of high-pressure pumps to increase the pressure and temperature of the CO_2 so that it becomes a supercritical fluid. Supercritical CO2 is characterized by liquid-like density and gas-like viscosity, which are physical properties favourable to the injection process. Therefore, the supercritical CO_2 can then be safely injected into the target geological formations through the injection well under controlled conditions.
- **Injection of water-CO_2 solution**: The second alternative considers the injection of a CO_2 solution into water in reactive basaltic rocks. This process involves dissolving a pure or flue gas stream of CO_2 in water and then injecting the solution into a basaltic rock through the injection borehole. It is highlighted that the use of a CO_2 flue gas stream may result in the absorption of other water-soluble gases, which may lead to a reduction in the amount of CO_2 that can be absorbed. The water-CO_2 approach is still being researched, but a typical aqueous solution will contain around 0.5% CO_2 by mass, according to preliminary results from other similar projects.

4.3.6 Road Traffic

The Project site is bounded by the Provincial Route R29 to the north. Therefore, considering the distance of approximately 30 km between the proposed injection site as the Sasol Secunda

Plant, the CO_2 will mainly be transported via the R29, which is the direct access route to the project area.

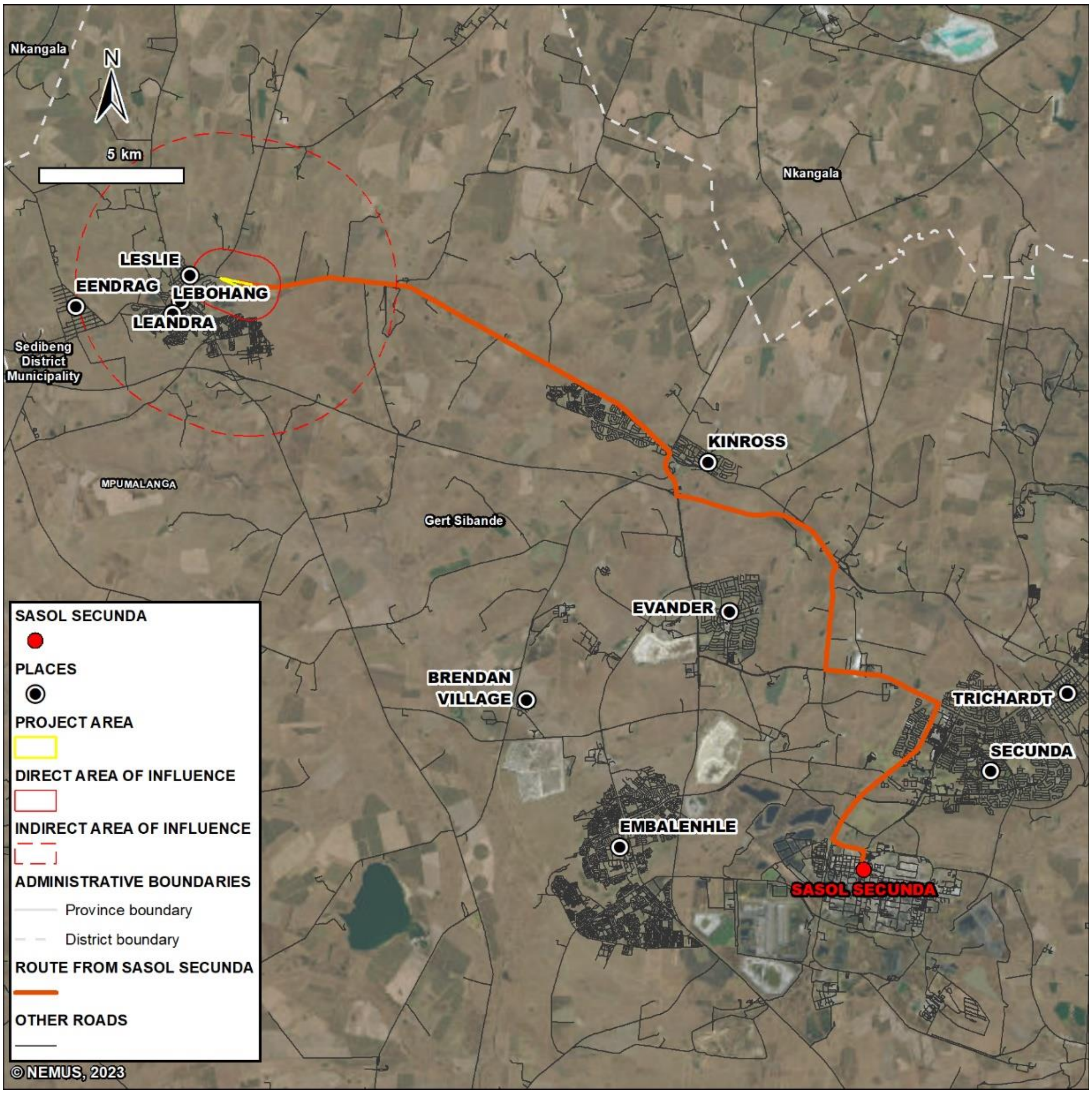

Figure 9: Route from Sasol Secunda Plant to injection site

Regarding the expected road traffic (to be analysed within the project's area of influence) the cryogenic CO_2 will be transported in 20-ton tankers, which means the following (based on the injection scenarios identified above):

- **40 to 100 tons per day** - 2 to 5 trucks are expected to circulate daily; and
- **15 to 70 tons per day** - 1 to 4 trucks are expected to circulate daily.

5 Alternatives

5.1 Introduction

Alternatives are the different ways in which the Project can be executed to ultimately achieve its objectives. Examples could include carrying out a different type of action, choosing an alternative location or adopting a different technology or design for the Project.

5.2 No-Go Alternative

To establish the baseline, the no-go alternative assumes that the proposed Project will not go ahead, considering, as a result, no environmental impacts on the site or surrounding local area. If the Project does not proceed, the following consequences stand out:

- No benefits will be derived from the implementation of an additional land-use;
- No opportunity for additional employment in an area, where job creation is a priority;
- No opportunity for a further understanding of the site potential for the CO_2 Storage;
- No contribution to and assist the government to achieve its commitment to implement climate change mitigation measures through CCUS;
- No opportunity to contribute to achieving the government target for reducing carbon dioxide emissions;
- No opportunity to implement a pilot technology and contribute to the research currently being carried out at national level;
- No opportunity to implement a mitigation measure recognized by NAMA; and
- No opportunity to have positive impacts on local people and surrounding ecosystems by being able to capture CO_2 that would otherwise go into the atmosphere.

On the other hand, the benefits of not proceeding with the Project should also be indicated, namely:

- No surface or underground water will be disturbed;
- No negative impacts on the natural rock mass matrix;
- No vegetation will be disturbed;
- No noise impacts will occur, mainly during the construction phase (when the drilling operation is occurring);
- No additional traffic will be generated; and
- No additional water use and energy will be required.

Despite not having negative environmental impacts in the area, the no-go alternative means that no additional contribution will be made to the CCUS technology investigations and no additional studies regarding the carbon dioxide storage capacity of geological formations in basaltic sequences of the Ventersdorp Supergroup. Furthermore, it will not have any positive community development or socio-economic benefits, and it will not assist the government addressing the climate change through CCUS. Besides, it is an area without any current human use and is under the ownership of the GMLM, which means that it is not planned to be currently used for any other activity. Once the Project is complete, the site will be reinstated to a pre-project state.

Therefore, the no-go alternative is not the preferred alternative. However, the impacts on the baseline and thus on the no-go alternative were assessed at the level of their significance in this BAR.

5.3 Land-use Alternatives

The project area is located in a Grassland Biome, the second largest in SA, covering 28.4% of the land area. Moreover, most of the area is covered by dolerite, comprising black clay soil underlain by shale and fine sandstone.

The municipal area is semi-urban, consisting of farms and urban settlements, with the proposed project area under the ownership of the GMLM and not currently being utilised (vacant).

According to Portfolio Committee on Agriculture - Integrated Spatial Analysis on land capability and land use for Agriculture and Forestry (2015), Mpumalanga is the province with the most area (in ha) of mining rights and prospecting rights. Within this area, the predominant land capability is 4 to 6. According to the Screening Tool (attached to the Application Form) the project area has high agricultural sensitivity. Despite that, the land is located between a main road and a railway, without any current agricultural use. Additionally, once the Project is completed, the aim is to return the space to conditions close to its pre-occurrence state.

5.4 Site Alternatives

The Project is identified as an investigation project to assess the CCS technology. The preferred site was strategically selected by the CGS based on the following considerations:

- The Mpumalanga Province area, where the piloting of CCUS is proposed, is home to mining and petrochemical industries and, as a result, the area is where the country's CO_2 emissions are most prevalent;
- The project area is characterized by a basaltic geological nature with storage potential; and
- The project area is under the ownership of the GMLM and the land is currently vacant.

Nevertheless, the implementation of the Project at the preferred site may result in possible occurrence of CO_2 leakage, which is assessed in the BAR.

5.5 Site Specific Considerations

As mentioned above, the proposed site for the Project implementation is vacant, with no current human use, which is an important selection factor. The following factors also contributed to the selection of the earmarked site:

- **Land Availability**: The property where the injection site is proposed is approximately 14 ha in extent, which is suitable for the proposed activities. The area will allow for the inclusion of all the necessary facilities;
- **Biodiversity Sensitivity**: The proposed project site does not contain any high sensitivity in the area (refer to Section 10.10);
- **Site Accessibility**: The proposed project site is bounded by the Provincial Route R29 to the north, which will be used as direct access. No extra access will be required;
- **Geology**: The geological profile of the project area consists of the formation that has been studied as potential for CO_2 storage - the Ventersdorp Ultramafic lavas (further information is presented in Section 10.3);
- **Current Land Use**: No current use (vacant land); and
- **Landowner Willingness**: The GMLM, as landowner, has granted access and use of this land for the purposes of the Project.

Furthermore, the proposed site is located approximately more than 800 m from the nearest residential house, which is also considered a positive factor.

Given the site selection requirements associated with the Project, and the suitability of the land available on the preferred site, adding the fact that no initial fatal flaws are present on the site, no other alternatives were considered. The proposed Project site is deemed feasible and selected as the preferred site.

5.6 Location Alternatives - Development Footprint within the Preferred Site

Once the preferred site for the Project implementation has been defined, the next step involves determining the development footprint within the site. Firstly, for this purpose, it is necessary to identify potential areas of sensitivity within the study area. Therefore, a preliminary analysis was carried out using the National Web-Based Environmental Screening Tool ("Screening Tool") for a baseline description of the prevalent environmental sensitivities. The Site Sensitivity Verification Report is contained in Appendix D7.

Besides information on the areas of environmental sensitivity, the characteristics of the preferred site and the infrastructure required to implement the Project must also be considered.

Project components (infrastructure required): As identified before, overall, the main project components include perimeter fencing, access road inside the area and parking area, power transformers/generators, portable temporary storage facilities, shelter for security personnel, mobile offices, concrete pads for two CO_2 Cryogenic Storage Tanks (100 tons each), geological survey, injection well, and storage area for diesel, oils, spare parts, and drilling rods.

Preferred site characteristics: With an area of approximately 14 ha (extent of overall site), as mentioned before, between a Provincial Route (which will be used as access), and a railway line, forming a triangular area. Given the project area and the main infrastructure required, an implementation area was defined based on the following:

- The creation of a suitable area to allocate all the necessary infrastructure and considering a safety zone, taking into consideration, 20 m in relation to the left edge of the area, and 10 m in relation to the road and railway line.

This then guided the selection of the best suitable developable footprint to be assessed, in this phase, by the specialists from an environmental sensitivity and practical/ technical perspective.

In addition to the definition of the implementation area, a preliminary area of potential Direct and Indirect influence of the Project was also defined for the environmental footprint analysis (refer to Section 4.1.3 above). These areas have been defined to ensure an overview of the possible influence of the Project.

Given the information above, no other alternative development footprints within the preferred project site will be considered.

Having identified the development footprints within the preferred project site, a proposal for the project layout will be outlined later in this report. The layout is influenced by the parameters identified above, which include environmental sensitive areas, project components, and preferred site characteristics.

5.7 Technology Alternatives

For the understanding of the proposed injection technologies, it is first necessary to analyse the storage process in basaltic formations.

5.7.1 CCS in Basalt

About 60% of the earth's surface comprises basaltic rocks. This means that there are potentially options for geological storage, including large volumes (Kamrajh *et al.*, 2022).

The implementation of CCS technology in basaltic formations, being currently subject of studies, through two pilot projects successfully completed - CarbFix at the Hellisheidi geothermal power plant in Iceland and Wallula in the Columbia River plateau, in the United States - has been proven to be feasible (Kamrajh *et al.*, 2022).

Through this type of storage, it is expected that the CO_2 once precipitated the trapping is permanent. Moreover, mineral carbonation in basaltic formations has been seen to occur over the timescale of weeks to months, which represents an advantage over, for example, trapping in sedimentary environments. This highlights the potential of long-term geological storage, and permanent fixation of carbon by mineralization (Kamrajh *et al.*, 2022).

Further justification of the storage potential of basaltic and ultramafic units is provided in Section 10.3.2.

Once the advantages and potential of implementing CCS in basalts are understood, an approach regarding injection techniques follows.

5.7.2 Basaltic CO_2 Injection

The injection technology possibilities analysed in the Project are directly related to the two pilot projects successfully developed. The Carbfix project in Iceland has injected dissolved CO_2 in water into young basaltic units. The Big Sky Carbon Sequestration Partnership (BSCP) in Wallula, Washington, USA injected supercritical CO_2 into a porous basaltic layer within the Columbia River flood basalt province (U.S. Department of Energy, 2013).

Figure 10 below shows a schematic representation of both technologies. An explanation of these technologies is provided in the sub-sections to follow.

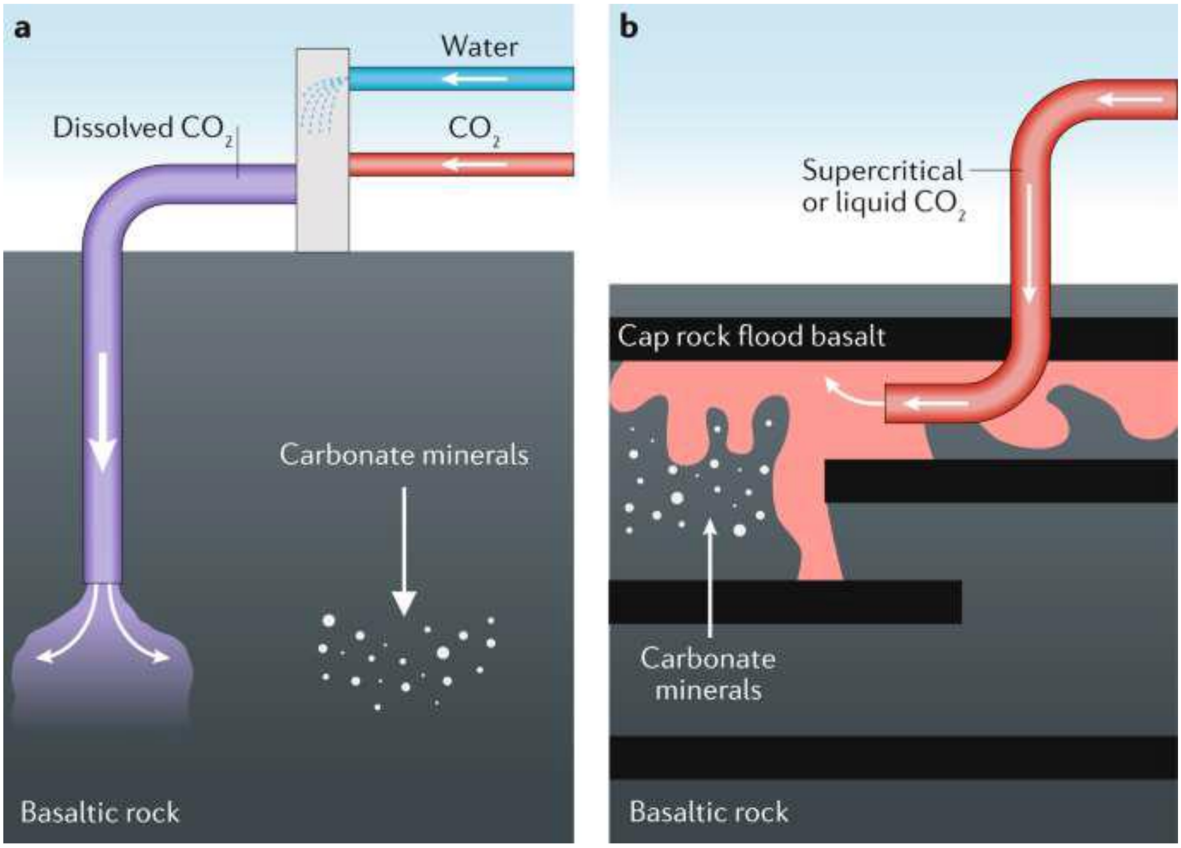

Figure 10: CO_2 injection technologies: a) Injection of dissolved CO_2 into a basaltic reservoir, b) Injection of pressurized liquid CO_2 injected into a basaltic reservoir

5.7.2.1 Injection of Water-CO_2 Solution

Through this technology, carbonization occurs when soluble CO_2 in water reacts with mafic or ultramafic formations. Overall, the acid solution generated by the combination of carbon dioxide and water reacts with the rock, namely with divalent cations leading to the precipitation of carbonate minerals and to the occurrence of the mineralization process described in Section 10.3.2 (Yadav *et al.*, 2023). According to the Carbfix project, CO_2 concentrations should be kept below its solubility at reservoir conditions to reduce the risk of degassing and to allow immediate reaction with the reservoir rocks.

Although the water requirement for the implementation of the Project is dependent on the average pressure, temperature, and salinity of the injection fluid, in general, this method requires a large amount of water, ~25 tons are required for each ton of gas injected to fully dissolve the CO_2. Consequently, it is necessary to identify a source of water with sufficient volume and quality, preferably saline, and the requisite environmental and water permits obtained for its use in the water charged CO_2 injection system. However, in accordance with the “Carbon Capture, Utilization and Storage (CCUS): Project Progress Report for Geological CO2 Storage in the Ventersdorp Supergroup, Mpumalanga, South Africa”, the water to be used could be sourced from the target injection reservoir. Therefore, it is possible to provide access for monitoring the chemistry of the injected gas- charged fluid and preventing pressure build-up in the reservoir owing to injection.

Compared to the injection of supercritical CO_2 technology, a dissolved stream is denser and therefore buoyancy problems and the need for specific sealing structures are neglected. Dissolved CO_2 flow can be injected into fractured and even open aquifers if the flow path is long enough to generate alkalinity and eventually mineralize the CO_2 (Kamrajh *et al.*, 2022).

The implementation of this method leads to rapid mineralization, Carbfix project reported >95% of the injected gas mineralized within 2 years. Briefly, this method of dissolving CO_2 before and during injection into an acidic medium result in a significantly reduced time scale for mineral storage process, with solubility trapping occurring immediately, and thus CO_2 is immobile and deemed stored on geological time scales (Kamrajh *et al.*, 2022).

5.7.2.2 Injection of Supercritical CO_2

Supercritical CO_2 means the carbon dioxide is in a fluid state while at or above both its critical temperature and pressure (U.S. Department of Energy, 2013). According to U.S Department, the temperature should exceed 31.1°C (88ºF) and pressure 72.9 atm (about 1,057 psi). Once these conditions are fulfilled, CO_2 reaches a critical point of properties where it has the density of a liquid with the viscosity of a gas. The main advantage of this condition is that the required storage volume is substantially less than if the CO_2 were at “standard” conditions (U.S Department of Energy and National Energy Technology Laboratory, 2023).

Temperature naturally increases in depth, and therefore an increase in fluid pressure also occurs. At depths greater than 800 m it is expected to reach the CO_2 critical point of pressure and temperature (U.S Department of Energy and National Energy Technology Laboratory, 2023). As the injection borehole to be developed under this Project is at a depth of approximately 1,800 m, this means that it is expected that the CO_2, once injected, will remain in the same supercritical condition.

Considering its characteristics, the Supercritical CO_2 should be provided in tanks, and the gas stream heated and pressurized before injection.

Most underground carbon dioxide storage projects are developed by implementing this methodology, but into large sedimentary basins. Although there are projects implementing this method and with larger amounts of injected CO_2 (as is the case with the Sleipner project, west of Norway - where about one million tons of CO_2 has been injected annually since 1996), the major difference is in the timescale of the mineralization process (Section 10.3.2) (Gislason, *et al*., 2014). According to the Wallula Basalt Pilot, monitoring results revealed that much of the CO_2 was mineralized by the end of 24 months after injection.

Therefore, as the dissolved CO_2 injection methodology, this method also demonstrated potential for rapid *in-situ* carbonation occurring from a free phase supercritical CO2 injection into a flood basalt reservoir (McGrail *et al.*, 2017).

5.7.2.3 Alternatives Overview

Table 6 below lists the data needed for both the CO_2 injection technology options.

Table 6: Data needed for CO_2 injection technology options (Kamrajh et al., 2022)

Characteristics/Requirement	Water-CO_2 solution	Supercritical CO_2
Non-Potable Saline Water	216-ton H_2O / CO_2 ton	>1ton H_2O / CO_2 ton
Permeability	X	X
Porosity	X	X
Chemistry/ mineralogy	X	X
Reactive minerals	X	X
Water quality (non-potable)	X	X
Water source close to site	X	
Age of the Basaltic Lava	X	n/a
Extent of secondary mineralization	X	X
Characterization of the Caprock	X	X
Seismic to map deep faulting	X	X
Detailed hydrological characterization		
Progressive drill-and-test characterization strategy (down-the-hole packer testing)	X	
Hydraulic properties of the isolated zone	X	
Cyclic constant-rate pumping test	X	
Slug & Drill Stem Tests (DST)	X	X

Considering the information presented so far, Table 7 briefly summarizes the advantages and disadvantages of the injection alternatives presented.

Table 7: Brief comparison of the alternatives

Injection Solution	Main advantages	Disadvantages
Water-CO_2 solution	• >95% of the injected gas mineralized within 2 years; • Once in contact with basaltic and ultramafic units generates stable, non-toxic, void-filling carbonate minerals; • Due to its density, buoyancy problems and need for specific sealing structures are negligible. Can be injected into fractured and even open aquifers if the flow path is long enough.	• Requires substantial amount of water. A typical aqueous solution will contain around 0.5% CO_2 by mass.
Supercritical CO_2	• Saves water; • Saves pore space, since it occupies a less volume; • Much of the CO_2 were mineralized by the end of 2 years.	• Implies the need to increase the pressure and temperature of liquefied CO_2 to a supercritical state prior to injection.

As both technologies are still under research and in need of data evaluation (based on Table 6 above) there is currently no preferable alternative and both alternatives are analysed in the context of this Basic Assessment. A final comparison between the two alternatives is presented in Section 14.3 below.

5.8 Concluding Statement of Preferred Alternative

In compliance with Appendix 1, section 3(g) and 3(h)(xi) of the EIA Regulations, the alternatives listed in Table 8 below will be taken forward for further assessment.

Table 8: Alternatives to be assessed

No-go alternative	The no-go alternative implies that the proposed Project does not go ahead, resulting in no environmental impacts (positive and negative) on the preferred site or the surrounding local area. The no-go alternative is not preferred.
Land-use Alternatives	Currently, the land is vacant (fallow land). As it is an area presently without any human use, the proposed Project is considered to offer broad social benefits. As such, the development on the preferred site is favorable.
Location alternatives - Development footprint within the preferred site	A proposal for the Project layout is outlined later in this report. Note that, as an environmental footprint area has been defined, which consists of the project area, implementation area, area of direct influence and area of indirect influence.
Technology alternatives	Both injection technologies are assessed in the BAR, namely injection of supercritical CO_2 and injection of water-CO_2 solution

6 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

6.1 Introduction

This chapter presents the environmental and social governance framework for the Project. The WB requirements are discussed, followed by an explanation of the national environmental regulatory framework that the Project needs to adhere to.

6.2 WB Policies & Environmental, Health and Safety Guidelines

In order to ensure that people and the environment are protected for projects financed by the WB, the institution requires the borrowing governments to comply with defined policies that identify, avoid and minimize the negative impacts of project design, implementation and operation, including the promotion of a framework for consultation with communities and public disclosure. The environmental and social policies of the WB are known as the "Safeguard Policies", currently assigned as Environmental and Social Standards (ESS) (World Bank, 2022a). Of the ten existing ESS, it is important to highlight ESS1 (Assessment and Management of Environmental and Social Risks and Impacts) and ESS10 (Stakeholder Engagement and Information Disclosure).

These policies are part of the WB's Environmental and Social Framework (ESF), which also includes a Vision for Sustainable Development. In addition, it is also necessary to ensure compliance with the WB's Environmental and Social Policy for Investment Project Financing and the Directive on Addressing Risks and Impacts on Disadvantaged or Vulnerable Individuals or Groups (World Bank, 2022b).

As defined in the Operations Manual 4.01 - Environmental Assessment (OP/BP), the project under review falls under category A, which requires a full ESIA. As mentioned, a separate ESIA Report was compiled by NEMUS for the Project to satisfy the requirements of the WB.

For a Category A project, the potential negative and positive environmental impacts of the project are examined, compared with those of feasible alternatives (including the 'no project' situation), and any measures needed to avoid, minimise, mitigate, or compensate for adverse impacts and improve environmental performance are recommended.

The WB Group Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice that are generally considered to be achievable in new facilities at reasonable costs by existing technology. These guidelines are referred in the WB's ESF and in International Finance Corporation (IFC) Performance Standards (IFC, 2022a).

The IFC Performance Standards provide guidance on how to identify risks and impacts, as well as how to avoid, mitigate and manage them. The IFC Performance Standards require that clients engage affected communities through disclosure of information, consultation, and informed participation, in a manner commensurate with the risks to and impacts of the project on the affected communities. Of the available standards, it is relevant to highlight the Performance Standard 1 (Assessment and Management of Environmental and Social Risks and Impacts) (IFC, 2022b).

6.3 SA's Environmental Regulatory Framework

6.3.1 Environmental Legislation

The legislation that has possible bearing on the Project from an environmental perspective is captured in Table 9 below. Note that this list does not attempt to provide an exhaustive explanation, but rather represents an identification of some of the most appropriate sections from pertinent pieces of legislation.

Table 9: SA's Environmental Regulatory Framework

Legislation	Description and Relevance
The Constitution of the Republic of South Africa (Act 108 of 1996)	▪ Chapter 2 – Bill of Rights. ▪ Section 24 – Environmental Rights.
National Environmental Management Act (Act No. 107 of 1998)	▪ Key sections (amongst others): ○ Section 24 – Environmental Authorisation (control of activities which may have a detrimental effect on the environment). ○ Section 28 – Duty of care and remediation of environmental damage. ▪ Environmental management principles. ▪ Authorisation type – Environmental Authorisation. ▪ Authorities – Department of Forestry, Fisheries and the Environment (DFFE) (national) (competent authority for the Project) and the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) (provincial).
EIA Regulations of 2014 (as amended)	▪ Purpose – regulate the procedure and criteria as contemplated in Chapter 5 of NEMA relating to the preparation, evaluation, submission, processing and consideration of, and decision on, applications for environmental authorisations for the commencement of activities, subjected to EIA, in order to avoid or mitigate detrimental impacts on the environment, and to optimise positive environmental impacts, and for matters pertaining thereto.
National Water Act (Act No. 36 of 1998)	▪ Sustainable and equitable management of water resources. ▪ Key sections (amongst others): ○ Chapter 3 – Protection of water resources. ○ Section 19 – Prevention and remedying effects of pollution. ○ Section 20 – Control of emergency incidents. ○ Chapter 4 – Water use. ▪ Authorisation type – General Authorisation (GA) or Water Use Licence (WUL). It is not anticipated that the Project will require authorisation under this Act. ▪ Authority – Department of Water and Sanitation (DWS).
National Environmental Management: Waste Act (Act No. 59 of 2008)	▪ Management of waste. ▪ Key sections (amongst others): ○ Section 16 – General duty in respect of waste management. ○ Chapter 5 – licensing of waste management activities listed in Government Notice (GN) No. R. 921 of 29 November 2013 (as amended). ▪ Authorisation type – Waste Management Licence (WML). A WML is not required for the Project. ▪ Authority – DFFE (national) and DARDLEA (provincial).

Legislation	Description and Relevance
National Environmental Management Air Quality Act (Act No. 39 of 2004)	▪ Air quality management. ▪ Key sections (amongst others): o Section 32 – Dust control. o Section 34 – Noise control. ▪ Authorisation type – Atmospheric Emission License (AEL). An AEL is not required for the Project. ▪ Authority – DFFE (national), DARDLEA (provincial) and GSDM (local).
National Environmental Management: Biodiversity Act (Act No. 10 of 2004)	▪ Management and conservation of the country's biodiversity. ▪ Protection of species and ecosystems. ▪ Authorisation type – Permit. It is not anticipated that a permit under this Act will be required for the Project. ▪ Authority – DFFE (national) and Mpumalanga Tourism and Parks Agency (MTPA) (provincial).
National Forests Act (Act No. 84 of 1998)	▪ Supports sustainable forest management and the restructuring of the forestry sector, as well as protection of indigenous trees in general. ▪ Section 15 – Authorisation required for impacts to protected trees. ▪ Authorisation type – Licence. It is not anticipated that a licence under this Act will be required for the Project. ▪ Authority – DFFE.
National Environmental Management: Protected Areas Act (Act No. 57 of 2003)	▪ Protection and conservation of ecologically viable areas representative of SA's biological diversity and natural landscapes. ▪ There are no formally protected areas in proximity to the project area.
Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)	▪ Equitable access to and sustainable development of the nation's mineral and petroleum resources and to provide for matters related thereto. ▪ Key sections (amongst others): o Section 22 – Application for mining right. o Section 27 – Application for, issuing and duration of mining permit. o Section 53 – Use of land surface rights contrary to objects of Act. ▪ Authorisation type – Mining Permit / Mining Right. It is not anticipated that authorisation under this Act will be required for the Project. ▪ Authority – Department of Mineral Resources and Energy (DMRE).
National Heritage Resources Act (Act No. 25 of 1999)	▪ Key sections: o Section 34 – protection of structure older than 60 years. o Section 35 – protection of heritage resources. o Section 36 – protection of graves and burial grounds. o Section 38 – Heritage Impact Assessment for linear development exceeding 300m in length; development exceeding 5 000m^2 in extent, etc. ▪ Authorisation type – Permit. It is not anticipated that a permit under this Act will be required for the Project. ▪ Authority – South African Heritage Resources Agency (SAHRA) (national) and Mpumalanga Provincial Heritage Resource Authority (MPHRA) (provincial).
Conservation of Agricultural Resources Act (Act No. 43 of 1983)	▪ Control measures for erosion. ▪ Control measures for alien and invasive plant species. ▪ Authority – DARDLEA.
Mpumalanga Nature Conservation Act (Act No. 10 of 1998)	▪ Deals with matters related to nature conservation in Mpumalanga. ▪ Authority – MTPA.
Occupational Health & Safety Act (Act No. 85 of 1993)	▪ Provisions for Occupational Health & Safety (OHS). ▪ Authority – Department of Employment and Labour (DEL). ▪ Relevant regulations, such as Construction Regulations, etc.
Hazardous Substances Act (Act No 15 of 1973) and Regulations	▪ Provides for the control of substances which may cause injury or ill-health to or death of human beings by reason of their toxic, corrosive, irritant, strongly sensitising or flammable nature or the generation of pressure thereby in certain circumstances, and for the control of certain electronic products. ▪ Provides for the division of such substances or products into groups in relation to the degree of danger. ▪ Provides for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.
Regulations for Hazardous Chemical	▪ Requirements for protecting employees who work with hazardous chemical substances in the workplace.

Legislation	Description and Relevance
Agents (GN No. R.280 of 29 March 2021)	

The relationship between the Project and certain key pieces of environmental legislation is discussed in the subsections to follow.

6.3.1.1 National Environmental Management Act, 1998

NEMA is the framework legislation regulating the environment in SA. According to Section 2(3) of NEMA, "*development must be socially, environmentally and economically sustainable*", which means the integration of these three factors into planning, implementation and decision-making so as to ensure that development serves present and future generations.

Some key definitions from NEMA include:

- "Environment" - the surroundings within which humans exist and that are made up of –
  - The land, water and atmosphere of the earth;
  - Micro-organisms, plant and animal life;
  - Any part or combination of (i) and (ii) and the interrelationships among and between them; and
  - The physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.
- "Pollution" - any change in the environment caused by –

  (i) substances;

  (ii) radioactive or other waves; or

  (iii) noise, odours, dust or heat;

  emitted from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or well-being or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future.

Section 2(4)(p) of NEMA requires that costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects are paid for by those responsible for harming the environment.

Section 28(1) of NEMA imposes a duty of care and remediation for environmental damage and requires that "*every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment*".

Section 24 of NEMA provides for the consideration, investigation, assessment and reporting of the potential consequences for, or impacts on, the environment of listed activities (or specified activities) to the competent authority. The EIA Regulations were promulgated to regulate the procedure and criteria as contemplated in Section 24 of NEMA relating to the preparation, evaluation, submission, processing and consideration of, and decision on, applications for Environmental Authorisations for the commencement of activities, subjected to an EIA, in order to mitigate detrimental impacts on the environment, and to optimise positive environmental impacts.

The EIA Regulations consist of the following:

- GN No. 326 of 7 April 2017 – EIA procedure;
- GN No. 327 of 7 April 2017 (Listing Notice 1) – activities that need to be subjected to a Basic Assessment Process, as prescribed in Regulations 19 and 20 of the EIA Regulations;
- GN No. 325 of 7 April 2017 (Listing Notice 2) – activities that need to be subjected to a Scoping and Environmental Impact Reporting (S&EIR) Process, as prescribed in Regulations 21 - 24 of the EIA Regulations; and
- GN No. 324 of 7 April 2017 (Listing Notice 3) – activities in specific identified geographical areas that need to be subjected to a Basic Assessment process, as prescribed in Regulations 19 and 20 of the EIA Regulations.

Table 10 below lists the activities from the EIA Listing Notices that are triggered by the Project. As shown, only activities in Listing Notice 1 are triggered and thus the Project must be subjected to a Basic Assessment Process.

Table 10: Listed activities triggered by the Project in terms of the EIA Listing Notices

Activity	Wording of Listed Activity	Relevance to the Project
	Listing Notice 1	
14	The development and related operation of facilities or infrastructure, for the storage, or for the storage and handling, of a dangerous good, where such storage occurs in containers with a combined capacity of 80 cubic metres or more but not exceeding 500 cubic metres.	*To support the operation of the CO_2 injection activity. The CO_2 on-site storage facility is estimated at a combined capacity of 200 tons or roughly 220 cubic metres (the estimation is based on the physical properties of liquid CO_2 at -34.6 °C and a density of 1101 kg/m^3).*
27	The clearance of an area of 1 hectares or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for - (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.	*This activity is triggered by the site establishment in the implementation area (of around 10 hectares).*
31	The closure of existing facilities, structures or infrastructure for - (i) any development and related operation activity or activities listed in this Notice, Listing Notice 2 of 2014 or Listing Notice 3 of 2014;	*This activity is triggered by the decommissioning of the CO_2 on-site storage facility at the end of the injection phase.*

Activity	Wording of Listed Activity	Relevance to the Project
	(ii) any expansion and related operation activity or activities listed in this Notice, Listing Notice 2 of 2014 or Listing Notice 3 of 2014; (iii) ……. (iv) any phased activity or activities for development and related operation activity or expansion or related operation activities listed in this Notice or Listing Notice 3 of 2014; or (v) any activity regardless the time the activity was commenced with, where such activity: (a) is similarly listed to an activity in (i) or (ii) above; and (b) is still in operation or development is in progress; excluding where - (aa) … (bb) the closure is covered by part 8 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) as decommissioning, in which case the National Environmental Management: Waste Act, 2008 applies; or (cc) such closure forms part of a mining application, in which case the requirements of the Financial Provisioning Regulations apply.	

In terms of S24C of NEMA, the DFFE is the Competent Authority to consider the application for this Project as the CGS (Applicant) is a schedule 3A public entity organisation as defined by the Public Finance Management Act (Act No. 1 of 1999).

6.3.1.2 Mineral and Petroleum Resources Development Act, 2002

The purpose of the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002) (MPRDA) is to make provision for equitable access to and sustainable development of the nation’s mineral and petroleum resources and to provide for matters related thereto. This Act defines mining as “any operation or activity for the purposes of winning any mineral on, in or under the earth, water or any residue deposit, whether by underground or open working or otherwise and includes any operation or activity incidental thereto”.

The Project does not entail the undertaking of any activities related to mineral and petroleum resources. It was thus not deemed necessary to apply for a Mining Permit or Mining Right in terms of the MPRDA. DMRE will be granted an opportunity to review the draft BAR to determine specific requirements that this Department may have in terms of the MPRDA.

In terms of Section 53 of the MPRDA, any person who intends to use the surface of any land in any way which may be contrary to any object of this Act or which is likely to impede any such object must apply to the Minister for approval in the prescribed manner. CGS needs to confirm whether Section 53 of the MPRDA applies to the proposed injection site.

6.3.1.3 National Environmental Management: Waste Act, 2008

Amongst others, the purpose of National Environmental Management: Waste Act (Act No. 59 of 2008) includes the following:

1. To reform the law regulating waste management in the country by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development;
2. To provide for institutional arrangements and planning matters;
3. To provide for specific waste management measures;
4. To provide for the licensing and control of waste management activities;
5. To provide for the remediation of contaminated land; and
6. To provide for compliance and enforcement.

"Waste" is defined in NEM:WA as "any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act".

Schedule 3 of the NEM:WA groups waste into two categories, namely hazardous waste and general waste. The classification of waste determines the associated management and licencing requirements. ''Hazardous waste'' is defined as "any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment and includes hazardous substances, materials or objects within business waste, residue deposits and residue stockpiles".

GN No. R. 921 of 29 November 2013 (as amended) contains a list of waste management activities that have, or are likely to have, a detrimental impact on the environment. If any of the waste management activities are triggered in Category A and Category B, a WML is required. It is not anticipated that the CCUS 3D seismic survey and drilling activities will trigger a WML.

In terms of Category C of GN No. R. 921 of 29 November 2013 (as amended), the following activities will need to comply with the National Norms and Standards for the Storage of Waste (GN R. 926 of 29 November 2013):

- The storage of general waste at a facility that has the capacity to store in excess of $100m^3$ of general waste at any one time, excluding the storage of waste in lagoons or temporary storage of such waste; and
- The storage of hazardous waste at a facility that has the capacity to store in excess of $80m^3$ of hazardous waste at any one time, excluding the storage of hazardous waste in lagoons or temporary storage of such waste.

Where relevant, waste generated during the drilling will need to be classified in terms of the Waste Classification and Management Regulations (GN R. 634 of 23 August 2013) ("Waste Classification and Management Regulations") (except if it is listed in Annexure 1) and analysed in terms the National Norms and Standards for the Assessment of Waste for Landfill Disposal (GN R. 635 of 23 August 2013).

The following principles will apply to the project's waste management strategy:

- The project will aim to adhere to the waste management hierarchy, which promotes the following order of priority: waste avoidance / reduction, re-use, recycling, recovery and disposal (last option).
- Waste must be separated at source, in accordance with the requirements of the NEM:WA, to maximise opportunities for re-use and recycling, and treatment efficiencies.
- The management and disposal of waste drilling fluids and cuttings shall comply with the NEM:WA.
- *Duty of Care Principle* – The industry that generates a waste is responsible for the fate of the generated waste in all circumstances. The generator of the waste is ultimately responsible for ensuring that the waste is handled, stored, transported and disposed of according to the legislation and in an environmentally sound and responsible manner; and
- *Polluter Pays Principle* – The person or organisation causing pollution is liable for any costs involved in cleaning-up or rehabilitating its effects. The generator of the waste is thus liable unless able to prove that the transferal of management of the waste was a responsible action.

6.3.1.4 National Water Act, 1998

The purpose of the NWA is to ensure that SA's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors:

- Meeting the basic human needs of present and future generations;
- Promoting equitable access to water;
- Redressing the results of past racial and gender discrimination;
- Promoting the efficient, sustainable and beneficial use of water in the public interest;
- Facilitating social and economic development;
- Providing for growing demand for water use; protecting aquatic and associated ecosystems and their biological diversity;
- Reducing and preventing pollution and degradation of water resources;
- Meeting international obligations;
- Promoting dam safety; and
- Managing floods and droughts.

Some key definitions from the NWA include:

- "Pollution" means the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it (a) less fit for any beneficial purpose for which it may reasonably be expected to be used; or (b) harmful or potentially harmful;

- "Waste" includes any solid material or material that is suspended, dissolved or transported in water (including sediment) and which is spilled or deposited on land or into a water resource in such volume, composition or manner as to cause, or to be reasonably likely to cause, the water resource to be polluted; and
- A "water resource" includes a watercourse, surface water, estuary, or aquifer.

Section 21 of the NWA lists the eleven types of water uses, which include taking and storing water, activities which reduce stream flow, waste discharges and disposals, controlled activities (activities which impact detrimentally on a water resource), altering a watercourse, removing water found underground for certain purposes, and recreation. In general, a water use must be licensed unless it is listed in Schedule I, is an Existing Lawful Use, is permissible under a General Authorisation, or if a responsible authority waives the need for a licence.

The Department of Water and Sanitation (DWS) is the custodian of SA's water resources. A meeting was held with the DWS Regional Office in March 2023 to discuss the overall CCUS Pilot Project. The were no indications that the Project will be associated with any water uses listed in Section 21 of the NWA. However, DWS will be granted an opportunity to review the draft BAR to determine specific requirements that this Department may have in terms of the NWA.

6.3.1.5 National Environmental Management: Air Quality Act, 2004

The purpose of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA) is to reform the law regulating air quality by providing measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development. This Act aims to promote justifiable economic and social development; to provide for national norms and standards regulating air quality monitoring, management and control by all spheres of government, and for specific air quality measures.

Some key definitions from this Act include:

- "Air pollution" means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances;
- "Atmospheric emission" or "emission" means any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution;
- A "non-point source" is a source of atmospheric emissions which cannot be identified as having emanated from a single identifiable source or fixed location, and includes veld, forest and open fires, mining activities, agricultural activities and stockpiles; and
- A "Point source" is a single identifiable source and fixed location of atmospheric emission, and includes smoke stacks and residential chimneys.

Section 21 of NEM:AQA provides for the listing of activities which result in atmospheric emissions that pose a threat to health or the environment. No person may conduct any such listed activity without an AEL. It is not anticipated that the Project will trigger an AEL.

The injection site is located within the Highveld Priority Area (HPA) which was declared by the Minister of Environmental Affairs at the end of 2007, in terms of Section 18(1) of NEM:AQA, requiring the development of an Air Quality Management Plan (AQMP) for the area. The plan includes the establishment of emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area.

National Dust Control Regulations (GN No. R. 827 of 1 November 2013), as amended, were gazetted in terms of NEM:AQA. The purpose of the regulations is to prescribe general measures for the control of dust in all areas. There Regulations prescribe acceptable dust fallout rates.

6.3.1.6 National Environmental Management: Biodiversity Act, 2004

The purpose of the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM:BA) is to provide for the management and conservation of SA's biodiversity within the framework of NEMA.

Some key definitions from this Act include:

- "Alien species" –
  - A species that is not an indigenous species; or
  - An indigenous species translocated or intended to be translocated to a place outside its natural distribution range in nature, but not an indigenous species that has extended its natural distribution range by natural means of migration or dispersal without human intervention.
- "Biological diversity" or "biodiversity" – the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part and also includes diversity within species, between species, and of ecosystems.
- "Indigenous species" – a species that occurs, or has historically occurred, naturally in a free state in nature within the borders of the Republic, but excludes a species that has been introduced in the Republic as a result of human activity.
- "Invasive species" – any species whose establishment and spread outside of its natural distribution range -
  - Threaten ecosystems, habitats or other species or have demonstrable potential; and
  - May result in economic or environmental harm or harm to human health.
- "Species" – a kind of animal, plant or other organism that does not normally interbreed with individuals of another kind, and includes any sub-species, cultivar, variety, geographic race, strain, hybrid or geographically separate population.

Some of the pertinent regulations under NEM:BA include:

- Threatened or Protected Species Regulations (23 February 2007);
- Threatened or Protected Marine Species Regulations (30 May 2017); and
- Alien and Invasive Species Regulations (30 September 2014).

NEM:BA allows for the publication of provincial and national lists of ecosystems that are threatened and in need of protection. The list should include:

- Critically Endangered Ecosystems, which are ecosystems that have undergone severe ecological degradation as a result of human activity and are at extremely high risk of irreversible transformation.
- Endangered Ecosystems, which are ecosystems that, although they are not critically endangered, have undergone ecological degradation due to human activity.
- Vulnerable Ecosystems, which are ecosystems that have a high risk of undergoing significant ecological degradation.
- Protected Ecosystems, which are ecosystems that are of a high conservation value or contain indigenous species at high risk of extinction in the wild in the near future.

NEM:BA also allows for the listing of endangered species, including critically endangered species, endangered species, vulnerable species and protected species. A person may not carry out a restricted activity (including trade) involving listed threatened or protected species without a permit. The Threatened or Protected Species Regulations (GN R152 of 2007), as made under the NEM:BA, provide for the protection and conservation of threatened species including marine plants and animals.

The Regulations on the management of Listed Alien and Invasive Species were promulgated on 1 August 2014. The Listed Invasive Species were also published on this date and were subsequently amended.

The implications of NEM:BA for the Project include *inter alia* the requirements for managing invasive and alien species, protecting threatened ecosystems and species, as well as for rehabilitating the areas affected by the Project activities.

The findings of the Terrestrial and Aquatic Ecological Impact Assessments that were undertaken for the Project are contained in this BAR.

6.3.1.7 National Heritage Resources Act, 1999

The purpose of the National Heritage Resources Act (Act No. 25 of 1999) (NHRA) is to protect and promote good management of SA's heritage resources, and to encourage and enable communities to nurture and conserve their legacy so it is available to future generations.

In terms of Section 34(1) of the NHRA, no person may alter or demolish any structure or part of a structure which is older than 60 years without a permit issued by the relevant provincial heritage resources authority. The NHRA defines a “structure’’ as meaning “any building, works, device or other facility made by people and which is fixed to land, and includes any fixtures, fittings and equipment associated therewith".

In terms of Section 38 of the NHRA, certain listed activities require authorisation from provincial agencies, which include:

- The construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;
- The construction of a bridge or similar structure exceeding 50m in length;
- Any development or other activity which will change the character of a site -
  - Exceeding 5 000m^2 in extent; or
  - Involving three or more existing erven or subdivisions thereof; and
- The re-zoning of a site exceeding 10 000m^2 in extent.

The findings of the Heritage Impact Assessment that was undertaken for the Project are contained in this BAR.

SAHRA (national) and MPHRA (provincial) will be granted an opportunity to review the draft BAR to determine specific requirements that they may have in terms of the NHRA.

6.3.1.8 Hazardous Substances Act, 1973

The Hazardous Substances Act (Act No 15 of 1973) (HSA) provides for the following:

- The control of substances which may cause injury or ill-health to or death of human beings by reason of their toxic, corrosive, irritant, strongly sensitizing or flammable nature or the generation of pressure thereby in certain circumstances, and for the control of certain electronic products; and
- The division of such substances or products into groups in relation to the degree of danger; to provide for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.

The HSA lists the categories of dangerous substances on Section 2 – Declaration of grouped hazardous substances, and on Section. The provisions on the management of hazardous substances are set out in Section 3 and the conditions for licensing and registration of activities and establishments handling these substances are set out in Section 4

The HSA seeks to categorise and classify certain hazardous substances and electronic products into groups in relation to their respective degrees of danger. The HSA lists four classes or groups of hazardous substances, namely Group I to Group IV.

Any person who uses any hazardous chemical substance must have in his or her possession a copy of the Material Safety Data Sheet (MSDS).

6.3.1.9 Mpumalanga Nature Conservation Act, 1998

The Mpumalanga Nature Conservation Act (Act No. 10 of 1998) (MNCA) makes provision with respect to nature conservation within the Mpumalanga Province. It provides for, among other things, protection of wildlife, hunting, fisheries, protection of endangered fauna and flora as listed in the Convention on international Trade in Endangered Species of Wild Fauna and Flora, the control of harmful animals, freshwater pollution and enforcement.

The MTPA derives its conservation mandate from the MNCA (amongst others)

6.3.1.10 Municipal By-Laws

The following municipal by-laws need to be adhered to by the Project (as relevant):

- GSDM –
  - Municipal Health By-Law;
  - Noise Control By-Law; and
  - Air Quality Management By-Law.
- GMLM –
  - Nuisance By-Law;
  - Disposal of Contaminated and Infectious Waste By-Law; and
  - Regulation of Storm water Management By-Law.

6.4 Guidelines

The following guidelines were considered during the preparation of the BAR:

- Guideline on Alternatives, EIA Guideline and Information Document Series (DEA&DP, 2010);
- Guideline on Need and Desirability (DEA, 2017);
- Integrated Environmental Management Guideline Series 7: Public Participation in the EIA Process (DEA, 2010); and
- Guidelines for Involving Specialists in the EIA Processes Series (Brownlie, 2005).

6.5 National and Regional Plans

The following regional plans were considered during the preparation of the BAR (amongst others):

- Spatial Development Frameworks for GSDM and GMLM;
- Integrated Development Plans for GSDM and GMLM; and
- The Mpumalanga Biodiversity Sector Plan (MTPA, 2014).

7 Basic Assessment Process

7.1 Environmental Assessment Authorities

In terms of S24C of NEMA, the DFFE is the Competent Authority to consider the application for this Project as the CGS (Applicant) is a schedule 3A public entity organisation as defined by the Public Finance Management Act (Act No. 1 of 1999). Due to the geographic location of the Project, DARDLEA is regarded as one of the key commenting authorities in terms of NEMA during the execution of the EIA, and all documentation will thus be copied to this Department.

Various other authorities with jurisdiction over elements of the receiving environment or project activities (refer to Section 6.3 above) were also consulted during the course of the Basic Assessment. Refer to the database of Interested and Affected Parties (I&APs) contained in Appendix E for a list of the government departments.

7.2 Environmental Assessment Practitioner

Nemai Consulting was appointed as the independent Environmental Assessment Practitioner (EAP) to undertake the Basic Assessment for the proposed Project.

In accordance with Appendix 2, Section 2(1)(a) of the EIA Regulations, this section provides an overview of Nemai Consulting and the company's experience with EIA's, as well as the details and experience of the EAP that is undertaking the Basic Assessment.

Nemai Consulting is an independent, specialist environmental, social development and Occupational Health and Safety (OHS) consultancy. The company is directed by a team of experienced and capable environmental engineers, scientists, ecologists, sociologists, economists and analysts. The company has offices in Randburg (Gauteng) and Durban (KwaZulu-Natal).

The core members of Nemai Consulting that are involved with the Basic Assessment Process for the Project are captured in Table 11 below, and the Curricula Vitae of the registered EAP is contained in Appendix C. The oath of the EAP is contained in Appendix G.

Table 11: Basic Assessment Core Team Members

Name	Qualifications & Registration	Selected Experience
D. Henning (22 years' experience)	• MSc (River Ecology) • Registered EAP (EAPASA Reg. no. 2020/1217) • Professional Natural Scientist (SACNASP	▪ Matjhabeng 400 MW Solar PV Power Plant with 80 MW (320 MWh) Battery Energy Storage Systems, Free State Province, SA. ▪ Beaufort West 75MW Solar PV Project, Western Cape, SA. ▪ Extraction of Gas and Electric Power Production Plant in the Rubavu District, Rwanda. ▪ Impompomo Hydropower Plant, Mpumalanga, SA. ▪ uMkhomazi Water Project Phase 1 with hydropower facilities, KwaZulu-Natal, SA. ▪ Neptune-Poseidon Transmission Line, including 200km of 400 kV transmission line, Eastern Cape, SA.

Name	Qualifications & Registration	Selected Experience
	Reg no: 400108/17).	▪ Makalu B (Igesi) Substation and Associated Transmission Loop-In Lines, Free State Province, SA. ▪ Anderson Dinaledi Transmission Line, including 80km of 132 kV transmission line with substations, North-West Province, SA.
D. Naidoo (26 years' experience)	• BSc Eng (Chem) • ECSA	▪ Bronkhorstspruit Biogas Plant, Gauteng Province, SA. ▪ Construction of the Xina Solar One Parabolic Trough Technology 100MW Solar Plant, Northern Cape Province, SA. ▪ Construction of the Biotherm Solar Photovoltaic Power Plants, Northern Cape, SA. ▪ Construction of the Roodeplaat Wind Farm, Eastern Cape, SA. ▪ North-South Strengthening Scheme, including 300km of 400 kV transmission line with substations, Mpumalanga, SA. ▪ Mookodi-Mahikeng 400 kV Transmission Line, North-West Province, SA. ▪ Watershed 275/88/132 kV Substation, North-West Province, SA.

7.3 Environmental Screening

According to GN 960 of 5 July 2019, an application for Environmental Authorisation must be accompanied by the report generated by the National Web Based Environmental Screening Tool ("Screening Tool"), as contemplated in Regulation 16(1)(b)(v) of the EIA Regulations.

The aims of the Screening Tool include the following:

- To screen a proposed site for any environmental sensitivity;
- To provide site specific EIA process and review information;
- To identify related exclusions and/or specific requirements including specialist studies applicable to the proposed site and/or development, based on the national sector classification and the environmental sensitivity of the site; and
- To allow for a Screening Report to be generated.

The Screening Report for the proposed Project is appended to the Application Form, which is included in Appendix B. The Site Sensitivity Verification Report is contained in Appendix D7.

7.4 Environmental Assessment Triggers

The Project triggers activities listed in Listing Notice 1 of the EIA Regulations (refer to Table 10 above) and a Basic Assessment Process is thus being undertaken.

The Application Form makes provision for all the activities associated with the Project's life-cycle. The activities triggered in terms of Listing Notices 1 were confirmed based on the following:

- An understanding of the project description and the receiving environment;
- The findings from the National Web Based Environmental Screening Tool;
- Discussions held with DFFE during the pre-application meeting; and
- Technical input received from the Applicant and project team.

7.5 Basic Assessment Process

7.5.1 Formal Process

The objectives of the Basic Assessment, based on the EIA Regulations, are captured in Section 1 above. An outline of the Basic Assessment Process is provided in Figure 11 below.

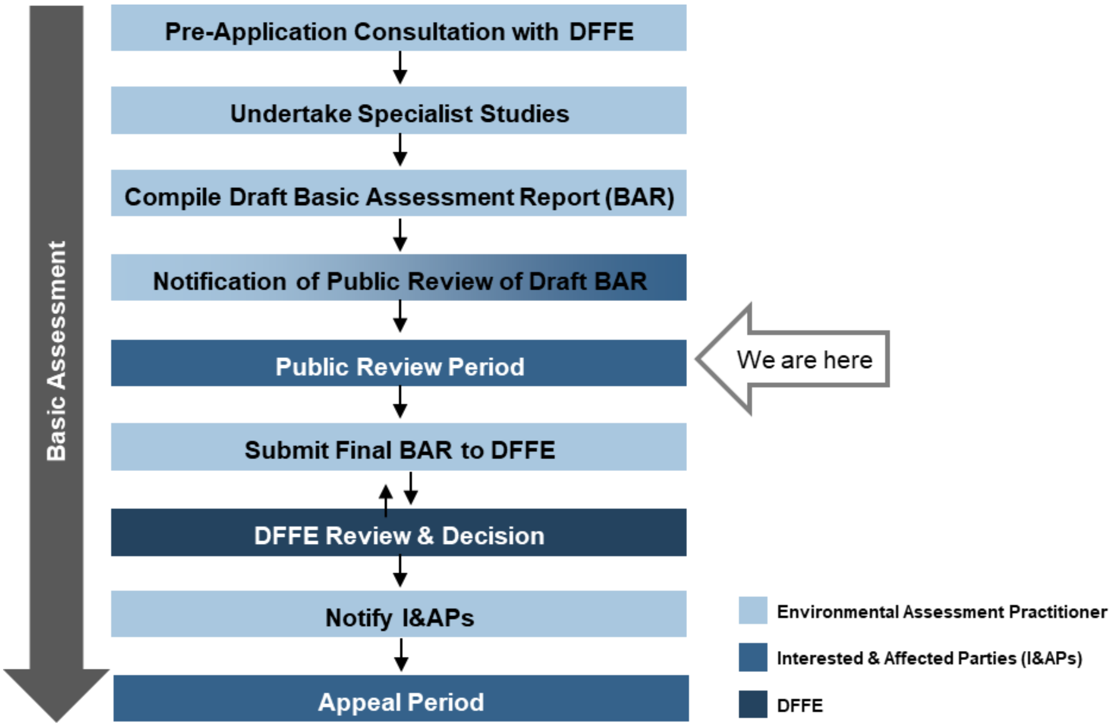

Figure 11: Basic Assessment Process

7.5.2 Approach to Impact Assessment and Specialist Studies

Considering the Project's scope and objectives, the BAR identifies the environmental and social impacts, including direct and indirect, short, and long term, as well as cumulative impacts. The focus is on both positive and negative impacts on the biophysical, social, economic, and cultural features of the receiving environment associated with the construction, operational and decommissioning phases of the Project.

The following factors were taken into consideration (amongst others):

- Biophysical environment -
  - Possible effects on biodiversity;
  - Possible effects on existing or proposed protected areas or other sites of conservation or special management interest;
  - Effects on the hydrology and water quality of local surface water resources; and,
  - Impact on geological and hydrogeological characteristics;
- Socioeconomic environment -
  - Induced development around the project area (investment and job creation);

- Effects on physical cultural resources;
- Public health (including exposure to vector-borne diseases and temporary exposure to abnormal levels of CO_2);
- Worker and public safety during Project construction and operation:
  - Addressing the security issues of the site and the proposed activities associated with the Project; and
  - Addressing the Project implementation risk, considering how it can be assessed and controlled/minimized); and,
- National and global strategies for the mitigation of emissions of CO_2 and climate change in general.

Regarding the study of the biophysical environment (ecology) and the socio-economic environment (cultural heritage and security threats) it should be noted that visits were made by specialist to the study area to analyse each of the themes individually. The following specialist studies were undertaken as part of the Basic Assessment:

- ❑ Freshwater Assessment (contained in Appendix D1);
- ❑ Terrestrial Biodiversity Compliance Statement (contained in Appendix D2);
- ❑ Heritage Impact Assessment (contained in Appendix D3);
- ❑ Desktop Palaeontological Impact Assessment (contained in Appendix D4);
- ❑ Air Quality Modelling (contained in Appendix D5); and
- ❑ Hydrogeological Study (contained in Appendix D6).

7.5.3 DFFE Pre-application Consultation

A Pre-Application Meeting was held with DFFE on 22 March 2023 (refer to the minutes of the meeting appended to the Application Form in Appendix B). The purpose of the meeting included the following:

- ❑ To present an overview of the Project to DFFE;
- ❑ To seek clarification regarding certain matters that pertain to the EIA Process; and
- ❑ To determine DFFE's requirements.

7.5.4 Landowner Consent & Landowner Notification

According to Regulation 39(1) of the EIA Regulations, if the proponent is not the owner or person in control of the land on which the activity is to be undertaken, the proponent must, before applying for an Environmental Authorisation in respect of such activity, obtain the written consent of the landowner or person in control of the land to undertake such activity on that land. This requirement does not apply *inter alia* for linear developments (e.g., pipelines, power lines, roads) or if it is a Strategic Integrated Project (SIP) as contemplated in the Infrastructure Development Act, 2014.

The written consent of the landowner for the property on which the CO_2 injection site is proposed is appended to the Application Form, which is included in Appendix B.

8 Need and Desirability

This section serves to expand on the motivation for the proposed development that is provided in Section 3 above. The format contained in the Guideline on Need and Desirability (DEA, 2017) was used in Table 12 below.

Table 12: Need for and desirability of the proposed Project

Question No.	Response

1. How will this development (and its separate elements/aspects) impact on the ecological integrity of the area?
 	
1.1. How were the following ecological integrity considerations taken into account?:
1.1.1. Threatened Ecosystems.
1.1.2. Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.
1.1.3. Critical Biodiversity Areas ("CBAs") and Ecological Support Areas ("ESAs").
1.1.4. Conservation targets.
1.1.5. Ecological drivers of the ecosystem.
1.1.6. Environmental Management Framework.
1.1.7. Spatial Development Framework.
1.1.8. Global and international responsibilities relating to the environment (e.g. RAMSAR sites, Climate Change, etc.).
	The following key findings from the ecological specialist studies are highlighted:
	▪ Freshwater Assessment (contained in Appendix D1) –
	  ○ A drainage line flows across the injection site in a southerly direction towards a small dam located near Lebohang. This drainage line and its buffer area of 32 m can be avoided with the implementation of the mitigation measures from the Freshwater Assessment. Three wetlands were observed within a 500 m radius of the injection site, namely two small depressions and one large channelled valley bottom wetland
	▪ Terrestrial Biodiversity Compliance Statement (contained in Appendix D2) –
	  ○ The area has experienced long-term and continuous disturbance, mostly due to the agricultural grazing practices and associated impacts. The project area is modified and as such is assigned a sensitivity rating of 'Low'.
	
	The project implementation area is vacant. Although the land cover in Figure 81 below shows the site to consist of commercial croplands, from historical aerial imagery it appears that the site has not been cultivated in at least the last 20 years.
	
	In terms of the GMLM SDF, the proposed injection site is located within an area designated for future residential development. It is currently an open field with no activity.
	
	Management objectives are included in the BAR and EMPr to safeguard the receiving environment.
	
	SA has a coal-based energy economy and hence emits CO_2 into the atmosphere at approximately 400 million tons per year. Recognising the anthropogenic forcing of global climate change, the country has committed itself to undertake steps to minimise such emissions in concert with other nations. Notwithstanding the recent advances made in the deployment of energy efficiency measures and renewable energies, it is envisaged that coal will remain a significant component of primary energy supply in SA.
	
	CCUS has been acknowledged by SA as one of the technologies to mitigate the emissions of CO_2 into the atmosphere and forms one of the NAMA. It is also one of the national flagship projects. CCUS forms part of a just transition to a future low-carbon energy economy.

Question No.	Response
	The Mpumalanga Province area, where the piloting of CCUS is proposed, is home to mining and petrochemical industries and, as a result, the area is where the country's CO_2 emissions are most prevalent.
1.2. How will this development disturb or enhance ecosystems and/or result in the loss or protection of biological diversity? What measures were explored to firstly avoid these negative impacts, and where these negative impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts? What measures were explored to enhance positive impacts?	Potential disturbances to ecosystems may include the following (amongst others): ▪ Loss of flora and fauna; ▪ Isolation and fragmentation of habitats; ▪ Disturbance of faunal communities (e.g, by noise and continuous human presence); ▪ Contamination of the habitat with hazardous materials; and ▪ Proliferation of alien and invasive species. Mitigation measures are included in the BAR and EMPr to manage the above impacts, according to the mitigation hierarchy.
1.3. How will this development pollute and/or degrade the biophysical environment? What measures were explored to firstly avoid these impacts, and where impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts? What measures were explored to enhance positive impacts?	The Project may cause surface water, groundwater, soil, air, noise and light pollution during the construction and operational phases. Mitigation measures were identified and included in the BAR and EMPr to manage these impacts.
1.4. What waste will be generated by this development? What measures were explored to firstly avoid waste, and where waste could not be avoided altogether, what measures were explored to minimise, reuse and/or recycle the waste? What measures have been explored to safely treat and/or dispose of unavoidable waste?	Refer to Section 11.8 below regarding the waste types to be generated during the project life-cycle. Mitigation measures to manage all waste and wastewater during the Project phases are discussed in Section 12.8 below and included in the EMPr.
1.5. How will this development disturb or enhance landscapes and/or sites that constitute the nation's cultural heritage? What measures were explored to firstly avoid these impacts, and where impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts? What measures were explored to enhance positive impacts?	The following findings from the Heritage Impact Assessment are noted: • The impact significance of the proposed Project on protected historical structures is low (with mitigation). Two extant historical structures and two sites with possible historical structure remains were identified, either on or just outside the southern boundary of the proposed injection site. These sites are avoidable. • The impact significance of the Project on graves is low (with mitigation). A potential grave site was identified as possibly located within or just outside the eastern boundary of the proposed injection site. This site is avoidable. • The impact significance of the Project on intangible and living heritage resources is negligible as no living heritage sites were identified within or adjacent to the proposed injection site. • The impact significance of the proposed Project on archaeological resources is negligible to low as no archaeological sites or material were identified within or adjacent to the proposed Injection site. It was concluded in the desktop Palaeontological Impact Assessment that the proposed development will not lead to detrimental impacts on the palaeontological resources of the area. Mitigation measures are included in the EMPr to safeguard cultural heritage and palaeontological features, as well as to manage visual impacts.

<table>
<tr><th>Question No.</th><th>Response</th></tr>
<tr><td>1.6. How will this development use and/or impact on non-renewable natural resources? What measures were explored to ensure responsible and equitable use of the resources? How have the consequences of the depletion of the non-renewable natural resources been considered? What measures were explored to firstly avoid these impacts, and where impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts? What measures were explored to enhance positive impacts?</td><td>During the Project phases electricity will be obtained from diesel generators. No alternative energy sources were considered for the generation of electricity.</td></tr>
<tr><td>1.7. How will this development use and/or impact on renewable natural resources and the ecosystem of which they are part? Will the use of the resources and/or impact on the ecosystem jeopardise the integrity of the resource and/or system taking into account carrying capacity restrictions, limits of acceptable change, and thresholds? What measures were explored to firstly avoid the use of resources, or if avoidance is not possible, to minimise the use of resources? What measures were taken to ensure responsible and equitable use of the resources? What measures were explored to enhance positive impacts?

1.7.1. Does the proposed development exacerbate the increased dependency on increased use of resources to maintain economic growth or does it reduce resource dependency (i.e. de-materialised growth)? (note: sustainability requires that settlements reduce their ecological footprint by using less material and energy demands and reduce the amount of waste they generate, without compromising their quest to improve their quality of life).

1.7.2. Does the proposed use of natural resources constitute the best use thereof? Is the use justifiable when considering intra- and intergenerational equity, and are there more important priorities for which the resources should be used (i.e. what are the opportunity costs of using these resources this the proposed development alternative?)

1.7.3. Do the proposed location, type and scale of development promote a reduced dependency on resources?</td><td>The potential impacts to the receiving environment were assessed through various specialist studies that are summarised in Section 12 below.

Opportunity costs are associated with the net benefits forgone for the development alternative. In terms of the GMLM SDF, the proposed injection site is located within an area designated for future residential development. It is currently an open field with no activity. Due to the temporary nature of the Project, and the restoration of the site following CO_2 injection, the affected area can be developed for housing.

The rationale for the siting of the Project is based the following:
• The Mpumalanga Province, where the piloting of CCS is proposed, is home to power stations, mining and petrochemical industries and, as a result, the area is where the country’s CO_2 emissions are most prevalent;
• The project area is characterized by a basaltic geological nature with CO_2 storage potential;
• The project area is located near to the Sasol Secunda Plant from where it is intended to source CO_2 for the pilot project; and
• The targeted site is vacant and the use of the property for the pilot project has been secured through a lease agreement between GMLM (landowner) and CGS (Applicant).</td></tr>
<tr><td>1.8. How were a risk-averse and cautious approach applied in terms of ecological impacts?

1.8.1. What are the limits of current knowledge (note: the gaps, uncertainties and assumptions must be clearly stated)?

1.8.2. What is the level of risk associated with the limits of current knowledge?

1.8.3. Based on the limits of knowledge and the level of risk, how and to what extent was a risk-averse and cautious approach applied to the development?</td><td>As mentioned in the response to question no. 1.1 above, the site is not deemed to be ecologically sensitive.

The assumptions and limitations that accompany the specialist studies are captured in the respective specialists’ reports.</td></tr>
<tr><td>1.9. How will the ecological impacts resulting from this development impact on people’s environmental right in terms following:</td><td>The nearest dwellings within the Project’s direct area of influence are more than 800 m from the injection site.</td></tr>
</table>

Question No.	Response
1.9.1. Negative impacts: e.g. access to resources, opportunity costs, loss of amenity (e.g. open space), air and water quality impacts, nuisance (noise, odour, etc.), health impacts, visual impacts, etc. What measures were taken to firstly avoid negative impacts, but if avoidance is not possible, to minimise, manage and remedy negative impacts? *1.9.2. Positive impacts: e.g. improved access to resources, improved amenity, improved air or water quality, etc. What measures were taken to enhance positive impacts?*	Refer to the assessment of the Project's potential impacts to the socio-economic environment and public health in Section 11.13 below.
1.10. Describe the linkages and dependencies between human wellbeing, livelihoods and ecosystem services applicable to the area in question and how the development's ecological impacts will result in socio-economic impacts (e.g. on livelihoods, loss of heritage site, opportunity costs, etc.)?	Refer to response to question no. 1.7 above. The project area is vacant and rural in nature.
1.11. Based on all of the above, how will this development positively or negatively impact on ecological integrity objectives/targets/considerations of the area?	Refer to the response to question no. 1.1 above.
1.12. Considering the need to secure ecological integrity and a healthy biophysical environment, describe how the alternatives identified (in terms of all the different elements of the development and all the different impacts being proposed), resulted in the selection of the "best practicable environmental option" in terms of ecological considerations?	Given the site selection requirements associated with the Project, and the suitability of the land available on the preferred site, adding the fact that no initial fatal flaws are present on the site, no other site alternatives were considered. The proposed Project site is deemed feasible and selected as the preferred site. Technology alternatives for the Project (i.e., injection of supercritical CO_2 or water-CO_2 solution) are discussed in Section 5.7 above. Both these alternatives are based on successful pilot projects that are discussed in the BAR. At this stage, there is no preference to either of these alternatives.
1.13. Describe the positive and negative cumulative ecological/biophysical impacts bearing in mind the size, scale, scope and nature of the project in relation to its location and existing and other planned developments in the area?	Cumulative impacts in relation to the Project are assessed in Section 11.16 below and mitigation measures were developed for each of the impact categories.
2.1. What is the socio-economic context of the area, based on, amongst other considerations, the following considerations?: *2.1.1. The IDP (and its sector plans' vision, objectives, strategies, indicators and targets) and any other strategic plans, frameworks of policies applicable to the area,* *2.1.2. Spatial priorities and desired spatial patterns (e.g. need for integrated of segregated communities, need to upgrade informal settlements, need for densification, etc.),* *2.1.3. Spatial characteristics (e.g. existing land uses, planned land uses, cultural landscapes, etc.), and* *2.1.4. Municipal Economic Development Strategy ("LED Strategy").*	The socio-economic environment is discussed in Section 10.12 below. The implications of the Project from a planning perspective, considering also the municipal IDP and SDF, are presented in Section 10.11 and Section 11.12 below.
2.2. Considering the socio-economic context, what will the socio-economic impacts be of the development (and its separate elements/aspects), and specifically also on the socio-economic objectives of the area? *2.2.1. Will the development complement the local socio-economic initiatives (such as local economic development (LED) initiatives), or skills development programs?*	Refer to the response to question no. 1.9 above.
2.3. How will this development address the specific physical, psychological, developmental, cultural and	

Question No.	Response
social needs and interests of the relevant communities?	
2.4. Will the development result in equitable (intra- and inter-generational) impact distribution, in the short- and long-term? Will the impact be socially and economically sustainable in the short- and long-term?	
2.5. In terms of location, describe how the placement of the proposed development will: *2.5.1. result in the creation of residential and employment opportunities in close proximity to or integrated with each other,* *2.5.2. reduce the need for transport of people and goods,* *2.5.3. result in access to public transport or enable non-motorised and pedestrian transport (e.g. will the development result in densification and the achievement of thresholds in terms public transport),* *2.5.4. compliment other uses in the area,* *2.5.5. be in line with the planning for the area,* *2.5.6. for urban related development, make use of underutilised land available with the urban edge,* *2.5.7. optimise the use of existing resources and infrastructure,* *2.5.8. opportunity costs in terms of bulk infrastructure expansions in non-priority areas (e.g. not aligned with the bulk infrastructure planning for the settlement that reflects the spatial reconstruction priorities of the settlement),* *2.5.9. discourage "urban sprawl" and contribute to compaction/densification,* *2.5.10. contribute to the correction of the historically distorted spatial patterns of settlements and to the optimum use of existing infrastructure in excess of current needs,* *2.5.11. encourage environmentally sustainable land development practices and processes,* *2.5.12. take into account special locational factors that might favour the specific location (e.g. the location of a strategic mineral resource, access to the port, access to rail, etc.),* *2.5.13. the investment in the settlement or area in question will generate the highest socio-economic returns (i.e. an area with high economic potential),* *2.5.14. impact on the sense* The socio-economic environment is discussed in Section 10.12 below. *history, sense of place and heritage of the area and the socio-cultural and cultural-historic characteristics and sensitivities of the area, and* *2.5.15. in terms of the nature, scale and location of the development promote or act as a catalyst to create a more integrated settlement?*	2.5.1. The Project will result in increased economic activity, as well as limited increased opportunities for employment and for SMMEs. 2.5.2. Not deemed to be relevant, due to the nature of the development. 2.5.3. Not deemed to be relevant, due to the nature of the development. 2.5.4. Impacts from a planning perspective are discussed in Section 11.12. 2.5.5. Refer to the response to question no. 2.1 regarding planning. 2.5.6. In terms of the GMLM SDF, the proposed injection site is located within an area designated for future residential development. It is currently an open field with no activity. Due to the temporary nature of the Project, and the restoration of the site following CO_2 injection, the affected area can be developed for housing. 2.5.7. The resources and services required for construction and operation are discussed in 4. 2.5.8. The Project does not include the expansion of any bulk infrastructure. 2.5.9. Not deemed to be relevant, due to the nature of the development. 2.5.10. Not deemed to be relevant, due to the nature of the development. 2.5.11. Provision is made in the EMPr's to manage the impacts associated with the Project. 2.5.12. Locational factors that favour the proposed site are discussed in Section 5.4 in Section 5.5. 2.5.13. Not deemed to be relevant, due to the nature of the development. 2.5.14. Refer to the response to question no. 1.5 above. 2.5.15. Refer to the response to question no. 2.1 above regarding planning.
2.6. How were a risk-averse and cautious approach applied in terms of socio-economic impacts? *2.6.1. What are the limits of current knowledge (note: the gaps, uncertainties and assumptions must be clearly stated)?* *2.6.2. What is the level of risk (note: related to inequality, social fabric, livelihoods, vulnerable communities, critical resources, economic vulnerability and sustainability) associated with the limits of current knowledge?*	Refer to the assessment of the Project's potential impacts to the socio-economic environment in Section 11.13 below.

Question No.	Response
2.6.3. Based on the limits of knowledge and the level of risk, how and to what extent was a risk-averse and cautious approach applied to the development?	
2.7. How will the socio-economic impacts resulting from this development impact on people's environmental right in terms following: *2.7.1. Negative impacts: e.g. health (e.g. HIV-Aids), safety, social ills, etc. What measures were taken to firstly avoid negative impacts, but if avoidance is not possible, to minimise, manage and remedy negative impacts?* *2.7.2. Positive impacts. What measures were taken to enhance positive impacts?*	Refer to the responses to questions no. 1.9 and 2.1 above.
2.8. Considering the linkages and dependencies between human wellbeing, livelihoods and ecosystem services, describe the linkages and dependencies applicable to the area in question and how the development's socio-economic impacts will result in ecological impacts (e.g. over utilisation of natural resources, etc.)?	Refer to the response to question no. 1.9 above.
2.9. What measures were taken to pursue the selection of the "best practicable environmental option" in terms of socio-economic considerations?	Refer to Section 5 and Section 14 for discussions on the Projects alternatives.
2.10. What measures were taken to pursue environmental justice so that adverse environmental impacts shall not be distributed in such a manner as to unfairly discriminate against any person, particularly vulnerable and disadvantaged persons (who are the beneficiaries and is the development located appropriately)? *Considering the need for social equity and justice, do the alternatives identified, allow the "best practicable environmental option" to be selected, or is there a need for other alternatives to be considered?*	
2.11. What measures were taken to pursue equitable access to environmental resources, benefits and services to meet basic human needs and ensure human wellbeing, and what special measures were taken to ensure access thereto by categories of persons disadvantaged by unfair discrimination?	The project area is vacant and rural in nature. Consent has been provided by the landowner for the proposed development in terms of the Lease Agreement.
2.12. What measures were taken to ensure that the responsibility for the environmental health and safety consequences of the development has been addressed throughout the development's life cycle?	Mitigation measures related to environmental health and safety are included in the BAR and EMPr. Also refer to the response to question no. 1.9 above.
2.13. What measures were taken to: *2.13.1. ensure the participation of all interested and affected parties,* *2.13.2. provide all people with an opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation,* *2.13.3. ensure participation by vulnerable and disadvantaged persons,* *2.13.4. promote community wellbeing and empowerment through environmental education, the raising of environmental awareness, the sharing of knowledge and experience and other appropriate means,* *2.13.5. ensure openness and transparency, and access to information in terms of the process,* *2.13.6. ensure that the interests, needs and values of all interested and affected parties were taken into account, and that adequate recognition were given to*	Section 16 below provides an overview of the public participation process to date, which includes the following: ▪ Developing a database of I&APs; ▪ Lodging the draft BAR for public review; ▪ Notification of review of the draft BAR; ▪ Means of accessing the draft BAR; ▪ Commenting on the draft BAR; and ▪ Details of the public meeting to present the draft BAR. The Comments and Responses Report (CRR) will be updated with all comments received from organs of state and I&APs during the review period of the draft BAR. The updated CRR will be appended to the final BAR that will be submitted to DFFE.

Question No.	Response
all forms of knowledge, including traditional and ordinary knowledge, and *2.13.7. ensure that the vital role of women and youth in environmental management and development were recognised and their full participation therein were be promoted?*	
2.14. Considering the interests, needs and values of all the interested and affected parties, describe how the development will allow for opportunities for all the segments of the community (e.g.. a mixture of low-, middle-, and high-income housing opportunities) that is consistent with the priority needs of the local area (or that is proportional to the needs of an area)?	The Project will result in increased economic activity, as well as limited increased opportunities for employment and for SMMEs. These positive impacts will be temporary in nature.
2.15. What measures have been taken to ensure that current and/or future workers will be informed of work that potentially might be harmful to human health or the environment or of dangers associated with the work, and what measures have been taken to ensure that the right of workers to refuse such work will be respected and protected?	Health and safety related risks associated with the Project during the construction and operational phases are addressed through measures contained in the EMPr. Additional management requirements will be included in the Project's Occupational Health and Safety system.
2.16. Describe how the development will impact on job creation in terms of, amongst other aspects: *2.16.1. the number of temporary versus permanent jobs that will be created,* *2.16.2. whether the labour available in the area will be able to take up the job opportunities (i.e. do the required skills match the skills available in the area),* *2.16.3. the distance from where labourers will have to travel,* *2.16.4. the location of jobs opportunities versus the location of impacts (i.e. equitable distribution of costs and benefits), and* *2.16.5. the opportunity costs in terms of job creation (e.g. a mine might create 100 jobs, but impact on 1000 agricultural jobs, etc.).*	Labour required for the project is discussed in Section 4.2.7. The Project will result in increased economic activity, as well as limited increased opportunities for employment and for SMMEs. These positive impacts will be temporary in nature.
2.17. What measures were taken to ensure: *2.17.1. that there were intergovernmental coordination and harmonisation of policies, legislation and actions relating to the environment, and* *2.17.2. that actual or potential conflicts of interest between organs of state were resolved through conflict resolution procedures?*	CCUS has been acknowledged by SA as one of the technologies to mitigate the emissions of CO_2 into the atmosphere and forms one of the NAMA. It is also one of the national flagship projects. CCUS forms part of a just transition to a future low-carbon energy economy. The CGS has been engaging with the various spheres of government regarding the pilot project.
2.18. What measures were taken to ensure that the environment will be held in public trust for the people, that the beneficial use of environmental resources will serve the public interest, and that the environment will be protected as the people's common heritage?	The positive impacts of the pilot project include the following: • Opportunity for additional employment in an area, where job creation is a priority; • Opportunity for a further understanding of the site potential for the CO_2 Storage; • Contribution to and assist the government to achieve its commitment to implement climate change mitigation measures through CCUS; • Opportunity to contribute to achieving the government target for reducing carbon dioxide emissions; • Opportunity to implement a pilot technology and contribute to the research currently being carried out at national level; and • Opportunity to have positive impacts on local people and surrounding ecosystems by being able to capture CO_2 that would otherwise go into the atmosphere. The potential impacts to the receiving environment were assessed through various specialist studies that are summarised in Section 12 below.

Question No.	Response
2.19. Are the mitigation measures proposed realistic and what long-term environmental legacy and managed burden will be left?	The mitigation measures included in the BAR and EMPr are considered to be realistic. The mitigation measures proposed reduce the residual risks to an acceptable level. The main negative impact identified is associated with the potential risk of CO_2 leakage, which was assessed in the BAR, including the risk assessment in Section 11.17. To ensure the proper implementation of mitigation measures and that all possible accidents are addressed; continuous monitoring is required of air quality as well as surface - and groundwater. This continuous monitoring must occur throughout the operational phase and for a minimum of three years after the end of the Project. Once the Project is complete, the site will be reinstated to a pre-project state.
2.20. What measures were taken to ensure that the costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects will be paid for by those responsible for harming the environment?	
2.21. Considering the need to secure ecological integrity and a healthy bio-physical environment, describe how the alternatives identified (in terms of all the different elements of the development and all the different impacts being proposed), resulted in the selection of the best practicable environmental option in terms of socio-economic considerations?	Refer to the response to question no. 1.12 above.
2.22. Describe the positive and negative cumulative socio-economic impacts bearing in mind the size, scale, scope and nature of the project in relation to its location and other planned developments in the area?	Cumulative impacts in relation to the Project are assessed in Section 11.16 below and mitigation measures were developed for each of the impact categories.

9 FINANCIAL PROVISIONS

In terms of section 3(1)(s) of Appendix 1 of the EIA Regulations, this section discusses details of any financial provisions for the rehabilitation, closure, and ongoing post decommissioning management of negative environmental impacts.

Due to the sensitive nature of financial provisions, the Applicant cannot provide the exact amounts but can confirm that there will be sufficient funds available to ensure that the Project can be successfully completed.

Provision will be made in the bill of quantities for the Contractor for the implementation of mitigation measures included in the EMPr (contained in Appendix F), including requirements for reinstatement and rehabilitation.

10 Description of the Environment

10.1 Introduction

This section was supplemented with information from the ESIA Report that was compiled by NEMUS for the Project.

A sensitivity analysis was conducted using the Screening Tool. For the respective analysis, the - Infrastructure => Localized infrastructure => Storage => Dangerous Good => Chemical category - was selected.

The project area is included in the Olifants Environmental Management Framework (EMF). The study area also intersects with Air Quality - Highveld Priority Area and with the Strategic Gas Pipeline Corridors-Phase 8: Rompco Pipeline Corridor. These zones may contain development incentives, restrictions, exclusions, or prohibitions that apply to the proposed development footprint.

In addition, the site is located in areas of environmental sensitivity. Table 13 below summarizes the environmental sensitivities - only the highest environmental sensitivity is indicated. The Site Sensitivity Verification Report is contained in Appendix D7.

Table 13: Sensitivity of environmental themes based on Screening Tool

Theme	Very High Sensitivity	High Sensitivity	Medium Sensitivity	Low Sensitivity
Agriculture		x		
Animal Species			x	
Aquatic Biodiversity				x
Archaeological and Cultural Heritage				x
Civil Aviation		x		
Defence				x
Palaeontology			x	
Plant Species			x	
Terrestrial Biodiversity	x			

In accordance with the Protected Areas Register that was prepared in terms of the National Environmental Management: Protected Areas Act (Act No. 57 of 2003), there is no intersection of the project area with Protected Areas, Conversion Areas, or Biosphere Reserve Zones.

For a better understanding of the affected environment, this chapter provides a description of the project and surrounding areas. The receiving environment is considered to include biophysical and socioeconomic environmental characterization, with a view to analysing possible impacts of the proposed Project. The following features were studied, selected according to the type of Project and area of study:

- Climate and meteorology;
- Geology and topography;
- Soils;
- Groundwater hydrology;
- Surface hydrology;
- Waste management;
- Environmental quality;
- Fauna and flora;
- Sensitive habitats;
- Land use and spatial planning;
- Socioeconomics and public health;
- Cultural heritage and palaeontology; and
- Land capability.

To complete and support the assessment, the findings from the following specialist studies are incorporated into this section:

- Freshwater Assessment (contained in Appendix D1);
- Terrestrial Biodiversity Compliance Statement (contained in Appendix D2);
- Heritage Impact Assessment (contained in Appendix D3);
- Desktop Palaeontological Impact Assessment (contained in Appendix D4);
- Air Quality Modelling (contained in Appendix D5); and
- Hydrogeological Study (contained in Appendix D6).

The main sources of information for establishing the baseline characterization included the following:

- Site visits and inputs from the specialists that form part of the project team;
- Screening Tool, where applicable;
- Policies and Legal Framework;
- Information provided by the CGS;
- Statistics, studies, and publications available on the topics under analysis; and
- Existing and available cartography (among others).

It is noted that the environmental sensitivities identified in Table 13 are analysed in this Chapter.

10.2 Climate and Meteorology

This section provides a brief description of the climate framework, identifying the climatic Köppen-Geiger Climate Classification, and an approach to climate projections. Data from the Government of SA and the WB are used as inputs.

10.2.1 Climate and Meteorology

10.2.1.1 National and Provincial

SA generally has a typical subtropical climate moderated by the ocean (located between two oceans, Atlantic and Indian). Being a relatively dry country, the rainy season start around October/November and last until March/April (Jones, et al., 2013). Although a dry country, due to the elevation above the sea level, the temperatures tend to be lower than in other countries at similar latitudes (https://www.gov.za/about-sa/geography-and-climate). The Mpumalanga monthly climatology is presented in Figure 12**Error! Reference source not found.**.

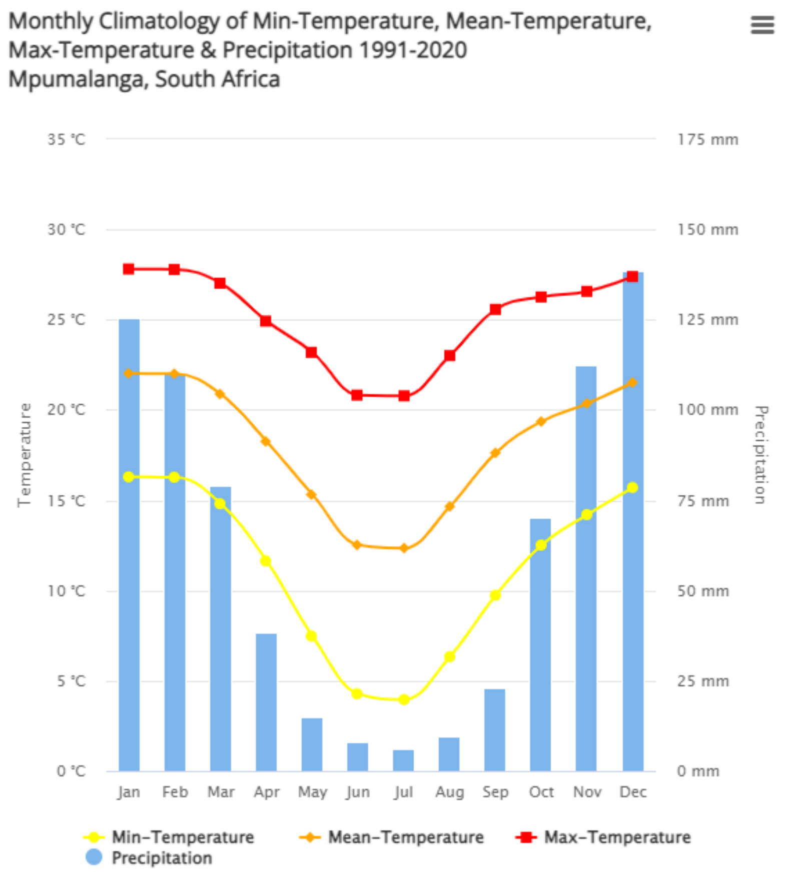

Figure 12: Monthly Climatology in Mpumalanga from 1991-2020 (World Bank Group, 2023)

In Mpumalanga Province, the observed mean temperature in 2021 was 17.88ºC, with a mean-minimum of 10.79ºC and a mean-maximum of 25.02ºC. Additionally, the observed annual precipitation in 2021 was 827.51 mm (World Bank Group, 2023).

For a better understanding of the mean temperature evolution trend along the years, **Error! Reference source not found.** is presented.

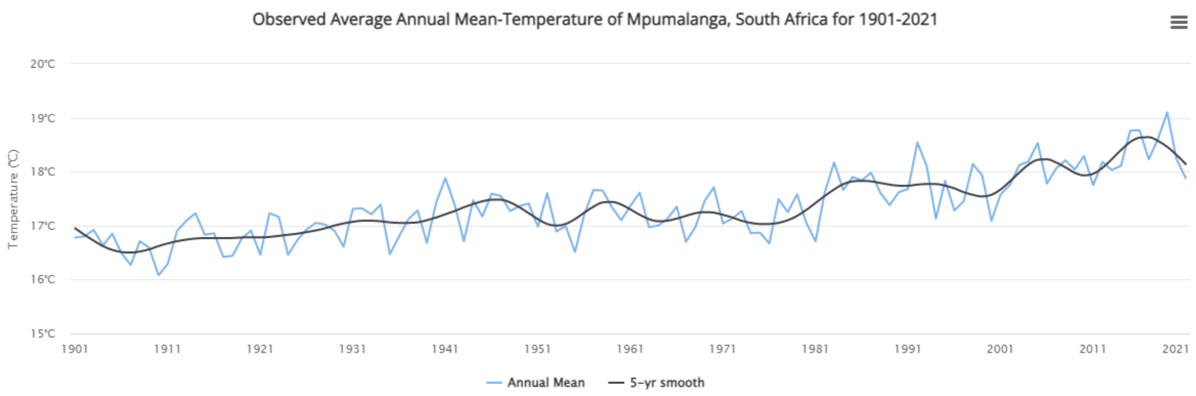

Figure 13: Mean temperature in Mpumalanga between 1901 and 2021 (World Bank Group, 2023)

Although the predominant direction varies throughout the year, the main wind direction is NW-SE (Global Wind Atlas, 2023).

According to the Köppen-Geiger Climate Classification, 1991-2020, the project area is in a Cwb area - warm temperate with dry winter and warm summer - usually found in subtropical highland climate (World Bank Group, 2023).

10.2.1.2 Local

Climatic conditions in Leandra are presented below. It is noted that a weather station is located in Leandra (station id: 1182).

The warmest month with the highest average high temperature is February (26.5°C). The month with the lowest average high temperature is June (17.4°C) (see Figure 14 below).

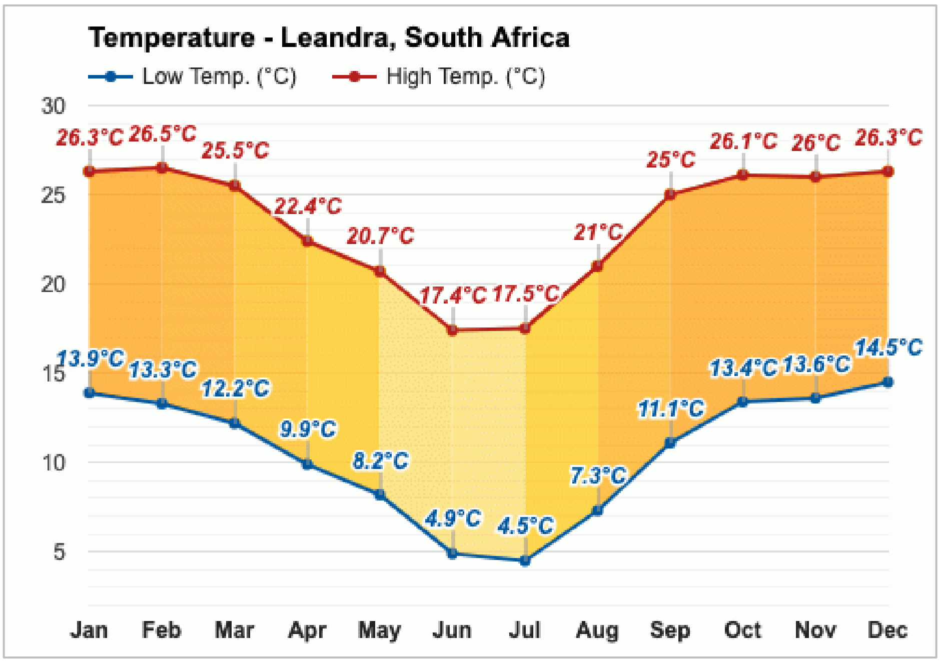

Figure 14: Average temperature Leandra
(https://www.weather-atlas.com/en/south-africa/leandra-climate#temperature)

The windiest month with the highest average wind speed is September (12.5km/h). The calmest month with the lowest average wind speed is March (8.9km/h) (see Figure 15 below).

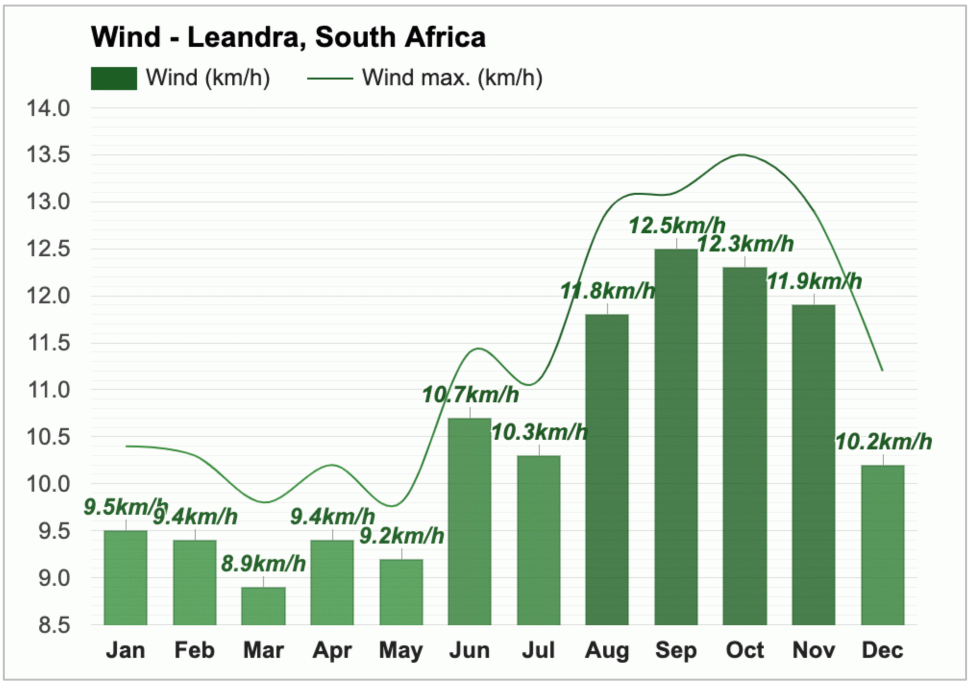

Figure 15: Average wind speed Leandra
(https://www.weather-atlas.com/en/south-africa/leandra-climate#temperature)

The wettest month with the highest rainfall is December (109mm). The driest month with the least rainfall is July (0mm) (see Figure 16 below).

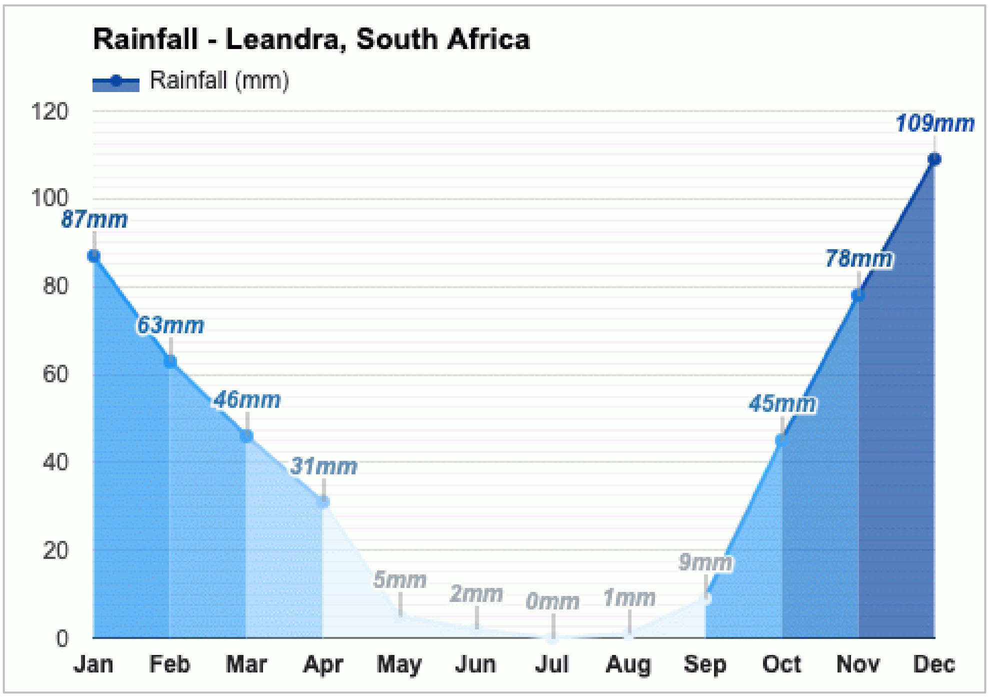

Figure 16: Average rainfall Leandra
(https://www.weather-atlas.com/en/south-africa/leandra-climate#temperature)

The month with the most sunshine is October (Average sunshine: 11h and 30min) and the month with the least sunshine is April (Average sunshine: 7h and 18min) (see Figure 17 below).

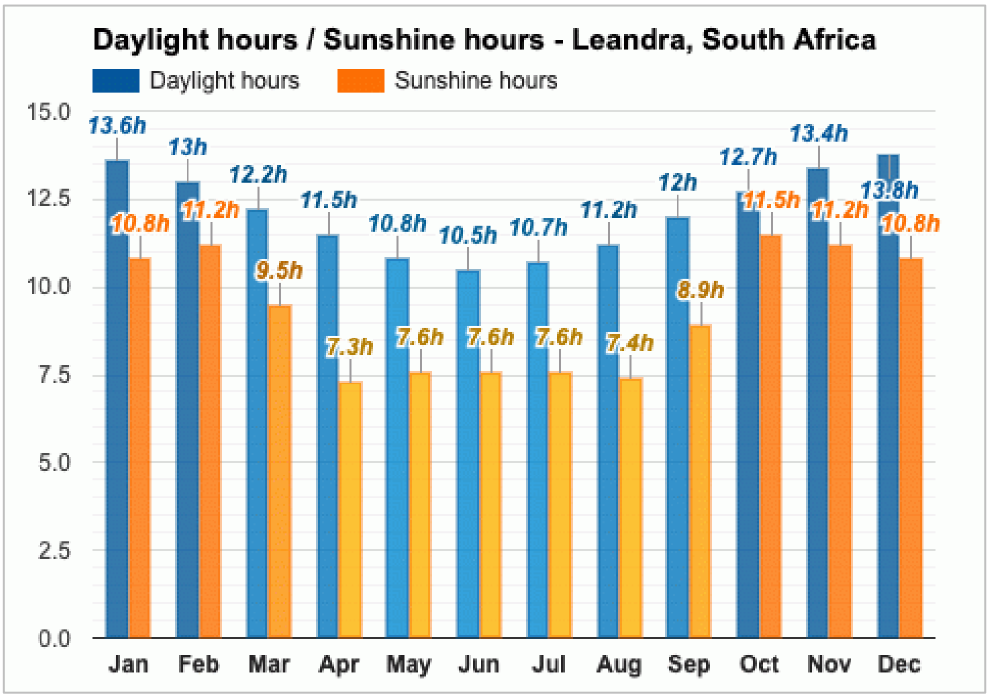

Figure 17: Average daylight / Average sunshine Leandra
(https://www.weather-atlas.com/en/south-africa/leandra-climate#temperature)

10.2.2 Climate Change

SA is likely to become hotter and drier in the future. The climate projections indicate an average annual mean temperature increase of +4.2°C and a decrease in average rainfall of -5.9mm by 2099 under the more severe scenario (RCP8.5) (World Bank Group, 2021).

Overall, the most frequent natural disaster in SA is floods, with an annual average of 36 occurrences between 1980 and 2020, and storms with an annual average of 29 occurrences (World Bank Group, 2023).

The climate projections for Mpumalanga, considering the five future scenarios presented in the Climate Report AR6 IPCC (2021), are presented in Figure 18.

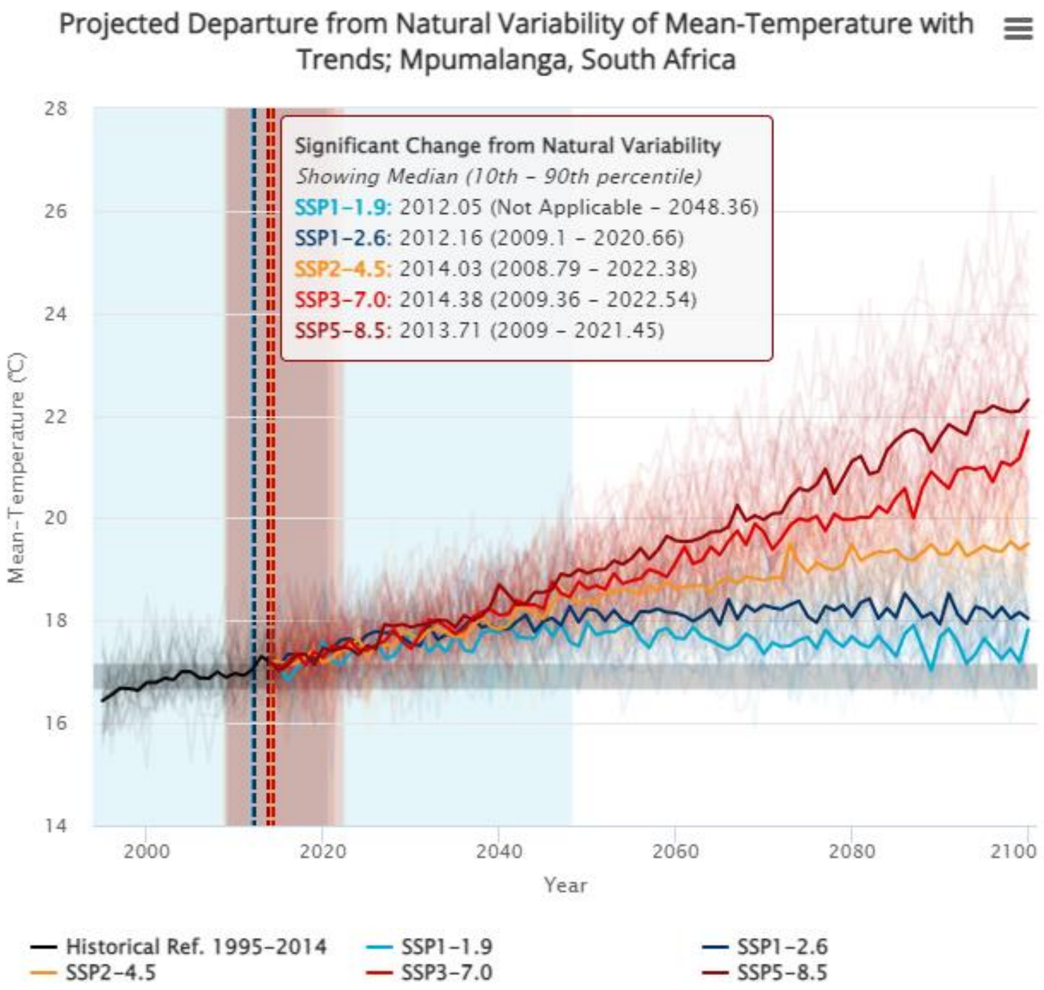

Figure 18: Projected Departure from Natural Variability of Mean-Temperature with trends in Mpumalanga (World Bank Group, 2023)

According to Statista data, SA is the world's 14th largest emitter of carbon dioxide. In 2021 the country recorded 436 million metric tons of CO_2 emitted, which reflects a slight reduction compared to 2010 (where the record was 463 million metric tons) (Statista, 2023).

For further understanding of the trend of carbon dioxide emissions throughout the years and the main sources of emissions, **Error! Reference source not found.** and **Error! Reference so urce not found.** are presented.

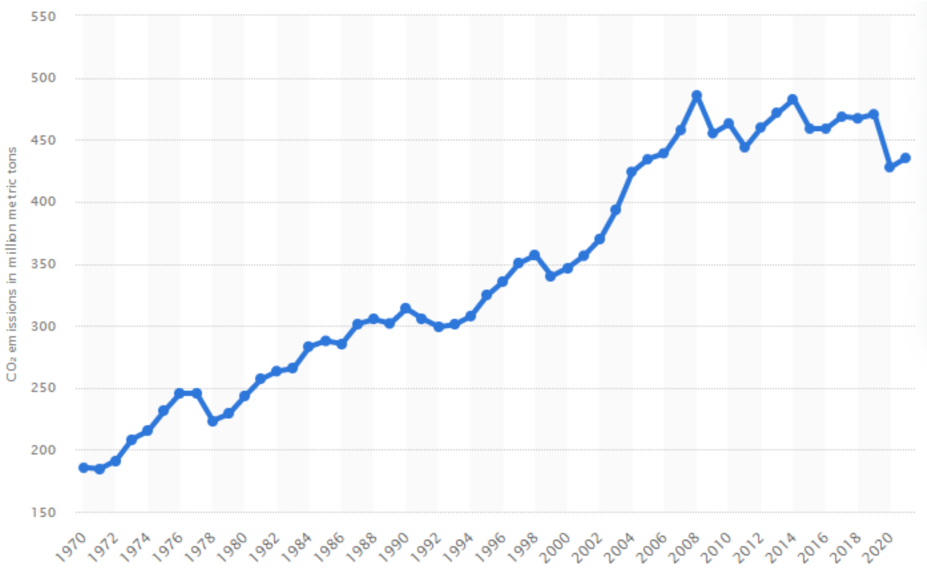

Figure 19: CO_2 emissions in South Africa from 1970 to 2021 (in million metric tons) (Statista, 2023)

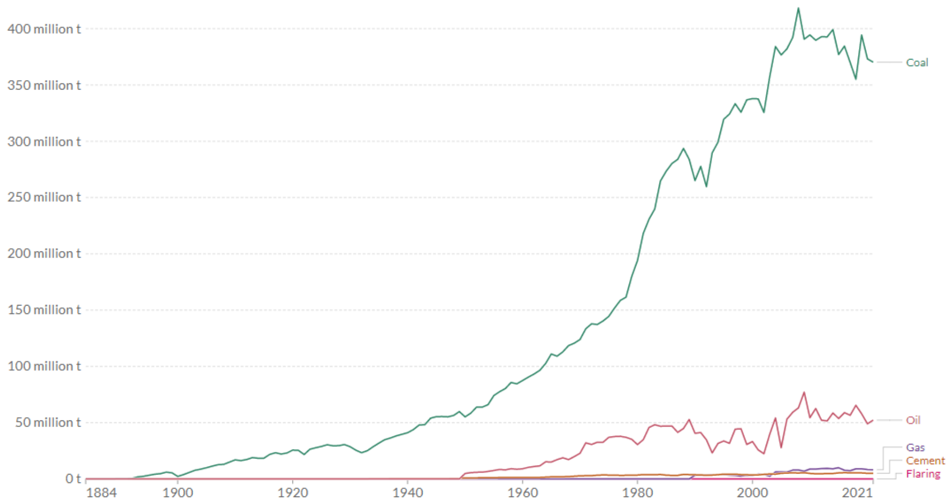

Figure 20: CO_2 emissions by source in SA (in million tons) (Our World in Data, 2022)

10.2.3 Summary

Considering the information presented, it is expected that the Mpumalanga Province will tend to become hotter and drier, with a current mean temperature of about 18ºC.

Regarding CO_2 emissions, in SA, being one of the countries with the highest levels of emissions in the world, currently about 84% of total CO_2 emissions are generated by coal.

10.3 Geology and Topography

10.3.1 Introduction

The Pilot CO_2 Storage Project is grounded in the geological knowledge and characteristics of the region. Therefore, the present characterization, in addition to a geological and topographical framework, aims to highlight why the project area has the potential to store CO_2.

10.3.2 Geology Overview

10.3.2.1 GMLM Geology

According to the available data on the GMLM Spatial Development Framework (SDF) 2014-2034 (GMLM, 2014), the general geological patterns of the Municipality are presented in below.

Table 14: Geology of GMLM (GMLM, 2014)

Geological Formation	ha	%
Arenite	134405.04	45.41%
Dolerite	156699.83	52.94%
Granite	38.93	0.01%
Rhyolite	4868.37	1.64%
Total	296012.18	100.00%

Overall, the geology of GMLM is dominated by sedimentary rocks of the Vryheid Formation of the Ecca Group, Karoo Supergroup. These rocks are extensively intruded by dolerites of the Jurassic Age, and consist of sandstones, shales, and coal beds. Quaternary alluvial deposits are found in lower lying areas of the Municipality, near the major surface water drainage bodies (GMLM, 2014).

Therefore, the two rock types of the Karoo Supergroup predominant in the spatial distribution of the municipality are the Dolerite as the formation with greater expression and the Arenite with a dispersed occurrence in the region (GMLM, 2014).

For a better understanding of the local geology and based on the GMLM SDF 2014-2034 data information, below is presented the geological map with the location of the study area.

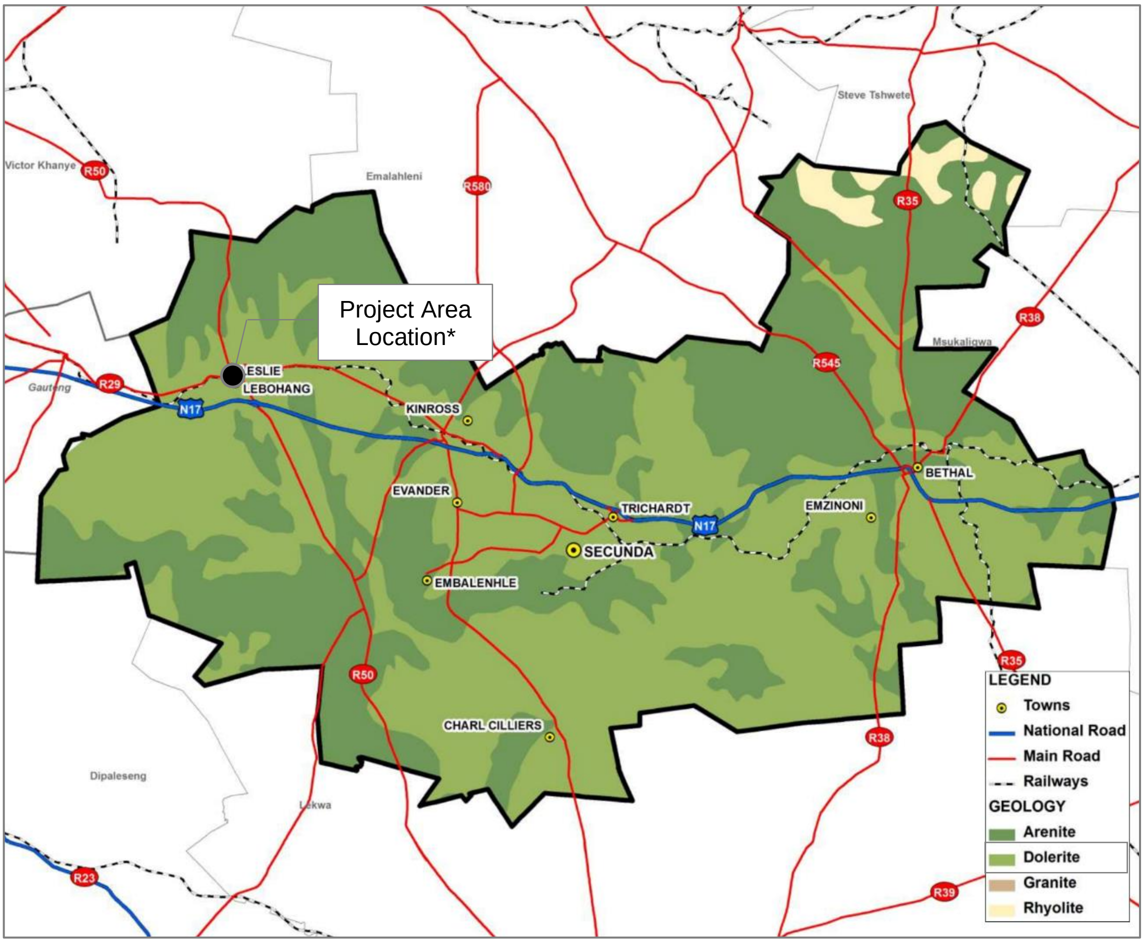

Figure 21: Municipal geological characterization (GMLM, 2014)

The information above refers very broadly to the geological formation occurring locally. However, the Project to be undertaken is mainly dependent on the geological formations in depth. As such, an analysis of the geological profile of the study area is provided hereafter.

10.3.2.2 Project Area Geological Profile

In accordance with the information from the CGS, the following geological profile of the project area can be defined (indicated from least to deepest formation):

Table 15: Geological profile

Thickness	Geology
Approximately 1 meter	Cenozoic sediments

Thickness	Geology
2 metres to 27 metres	Dolerite sills
Up to 160 metres	Thick bed of Lower Karoo sandstones and shales
Approximately 10 metres	Diamictite, which will act as the aquiclude (seal)
Up to 357 metres	Dolmite
Variable	Ventersdorp Ultramafic lava being the lower parts porphyritic lavas

The subsurface geology profile of the project area thus suggests the existence of Karoo and Ventersdorp and Supergroups occurrences. The Karoo Supergroup comprises the coal seams of the Vryheid formation that are mined in the area. On the other hand, the Ventersdorp Supergroup porphyritic lava, Ultramafic lava layer (deeper than 800 m) is the target for the CO_2 storage. Therefore, a brief approach to Ventersdorp Supergroup characterization is presented below.

Ventersdorp Supergroup

The Ventersdorp Supergroup (in which Ultramafic lava is integrated) is one of the oldest volcano-sedimentary successions on earth (Dhansay, *et al*., 2022).

Composed mainly of mafic to ultramafic volcanic sequences interbedded with felsic and siliciclastic sequences, the Ventersdorp Supergroup covers an area of 200,000 km^2 (mainly in the northern region of SA) and is more than 5 km thick (Dhansay, *et al*., 2022).

Stratigraphically, the deepest part of the Ventersdorp Supergroup consists of basalt of the Ma Klipriviersberg Group about 2 km thick, which in turn encompasses volcanic rocks, including fine-grained mafic and ultramafic sequences, agglomerates, and vesicular porphyritic lava (Dhansay, *et al*., 2022).

10.3.2.3 Justifying the Potential - Basaltic and Ultramafic Units

For the Project to be successful and for the carbon dioxide to be stored, the mineralization process must take place. This Section provides a brief justification for the potential of the Ventersdorp Supergroup (ultramafic lava layer).

Carbon mineralization involves the formation of solid carbonate minerals, such as calcite, magnesite, and dolomite, through the reaction of CO_2 (regardless of its state - gas, liquid, dissolved in water, or supercritical) with calcium- or magnesium- rich rocks. Among the best sources of Mg and Ca are the mafic and ultramafic rocks (mantle peridotite, basaltic lava, and ultramafic plutons) (Kelemen, *et al*., 2019).

Given this, a brief description of why the potential of these rocks considering the two injection technologies follows.

Injection of supercritical CO_2

So far, most of the existing subsurface Carbon Storage projects have injected supercritical CO_2 into large sedimentary basins. Possibly, the best-known project is the Sleipner project in western Norway, where about a million tons of CO_2 has been injected annually since 1996 and stored at more than 700 m below the ocean floor in Utsirasandstone (Gislason, *et al*., 2014).

Although the process of injection into sedimentary basins is being implemented, there are limitations - recent studies show that in these geological environments the process of transformation of CO_2 into carbonate minerals can take at least tens of thousands of years - due to both the slow reactivity of silicate minerals in sedimentary rocks and the lack of the calcium, magnesium, and iron required to make carbonate minerals. Therefore, an alternative designed to overcome these limitations, is the injection of CO_2 into reactive basaltic rocks rich in these elements (Gislason, et al., 2014).

Injection into basaltic rocks (mafic and ultramafic rocks) represent an alternative since (Gislason, et al., 2014):

- Approximately 25% of the weight of basalt is made of calcium, magnesium, and iron oxides;
- Basaltic rocks are much more reactive in water than silicate sedimentary rocks - this factor leads to the metals contained in basalts being readily available to be combined with injected CO_2 to form carbonate minerals; and
- Basaltic rocks are highly abundant on the Earth's surface.

Injection of water-CO_2 solution

According to the "CCUS Project Progress Report for Geological CO_2 Storage in the Ventersdorp Supergroup, Mpumalanga, South Africa" the basaltic and ultramafic units are *"rich in divalent cations (e.g. Ca2+, Mg2+, and Fe 2+) and provide a unique advantage over other geological storage options due to their potential of chemically reacting with CO_2 (dissolved in water) to produce stable, non-toxic, void-filling carbonate minerals such as calcite, magnesite, and siderite"* (Kamrajh, *et al.*, 2022).

Once CO_2 reacts with the minerals identified above and remains immobile, storage on the geological time scale is considered to occur. Overall, the reaction breaks down silicates into clays, and precipitates carbonates. As a result, this reaction (geochemical conversion) decreases the risk of leakage over time, so long as sufficiently large volumes of CO_2 can be stored in these formations and retained long enough to allow the chemical reactions and mineral precipitation to occur. However, it should be noted that carbonate precipitation can, over time, reduce *in situ* porosity and permeability within basaltic reservoirs. Furthermore, the effectiveness of the reservoir depends strongly on the parameters of storage capacity (i.e. porosity and permeability), retention time, reservoir stability, and the risk for leakage (Kamrajh, *et al.*, 2022).

10.3.2.4 Geological Characteristics for Potential Reservoir

For the definition of a safe and potentially permanent storage reservoir, geological conditions shall be thoroughly investigated, mainly regarding,

- **Layer thickness**: which shall be reasonably thick;
- **Permeability and porosity:** to allow controlled movement of CO_2 -containing fluids;
- **Ability to react with carbon dioxide**: the reservoir should be made of components which are naturally liable to react with the injected CO_2, ensuring the occurrence of the conversion of the injected CO_2 to solid state;
- **Layer homogeneity**: the layer across the reservoir should be homogeneous to ensure a greater possibility of storage;
- **Over and under-layer typology**: the chosen reservoir should be confined between two impermeable, non-porous geological layers that will act as reservoir seals to restrict the movement and possible escape of the injected CO_2;
- **Seismicity:** It should be a seismically stable region without major tectonic deformation, limiting the possibility of seismic activity and the existence of geological structures that promote undue movement of the injected CO_2.

10.3.2.5 Justifying the Potential - Reservoir

Considering the characteristics identified above, the studies carried out and the current geological knowledge of the region, a schematic geological profile is presented in the Research Article “CO_2 storage potential of basaltic rocks, Mpumalanga: Implications for the Just Transition” (Dhansay, *et al*., 2022), which is shown in Figure 2 above.

According to the article, whose geological profile generally corresponds to the approximate geological profile of the study area, *"Basaltic sequences are showing promise as additional CO_2 storage reservoirs"* (Dhansay, et al., 2022).

Furthermore, the research article concludes that the sequence of layers existing in the Mpumalanga region can possibly meet the characteristics required for the existence of a potential reservoir, and the layer studied as possible was the one proposed in this project as a reservoir - Ventersdorp Supergroup. Although there is an uncertainty associated with the geological nature and the characteristics of a research work, the article accentuates the geological potential of the project area.

10.3.2.6 Geosites

The CGS Platform for Geosite Search was consulted regarding the existence of geosites in the project area and surroundings. It was concluded that, considering a buffer of 5 km from the project area, there was no evidence of an identified geosite.

10.3.3 Topography

According to the GMLM data, the overall topography is characterized as flat, with no areas where the slope is greater than 9%. The altitudes may vary from 1,500 to 1,820 m above the sea level (GMLM, 2014). Based on the Mpumalanga topographic map, available from the World Topographic map it is understood that the project area comprises a relatively uniform elevation throughout the area as identified in the figure below. Therefore, the study area is considered flat.

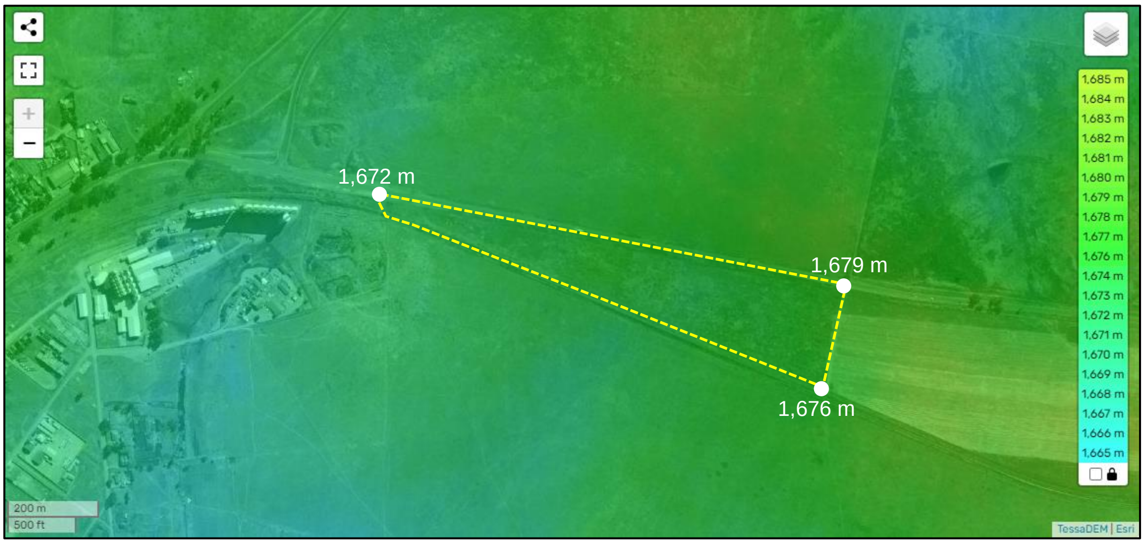

Figure 22: Topography of the project area (https://en-za.topographic-map.com/map/)

10.3.4 Summary

Given the information described in this Section, it is concluded that the project area topography is considered to be flat, with the superficial geological layer consisting of Dolerite. The Ventersdorp Supergroup, in which Ultramafic lava is integrated, is the target for the CO_2 storage since the constituent rocks are sources of Mg and Ca and thus susceptible to promptly react with CO_2 (via both injection technologies). Moreover, the chosen site is considered to fulfil the geological characteristics of a potential reservoir, with Diamictite the sealing layer.

10.4 Soils

10.4.1 Introduction

The Project is in a semi-urban area with farms and urban settlements, in an altered and artificialized Grassland Biome due to commercial and subsistence crop cultivation, commercial forest plantation, large- and small-scale mining, human settlement and urban physical infrastructure (CGS, 2022).

As indicated in the geological characterization, most of the area is covered by dolerite. The dolerite, in turn, comprises black clay soil. The clay is underlain by shale and fine sandstone, that weathers to residual expansive clay (CGS, 2022).

This chapter aims to briefly describe the type of soil existing in the project area and its surroundings. For the present analysis and as the main source of information, the document developed by the European Commission "Soil Atlas of Africa" is considered.

10.4.2 South African Soil Overview

Overall, the southernmost region of the African continent is characterized by an ancient geology (comprising some of the oldest rocks on Earth) and a warm and dry climate that results in, generally, thin, and moderately fertile soils. The main soil types found in SA are Arenosols, Calcisols, Cambisols, Leptosols, Luvisols and Planosols (Jones, *et al*., 2013).

In the southernmost region of the African continent, some of the factors that lead to degradation include contamination, water erosion and compaction. Besides human activity as one of the factors in the loss of soil capacity, other factors must be considered, namely the effects of climate change. SA key soil issues are related to prolonged droughts, low rainfall, soil contamination (including acidification from industrial emissions), soil erosion and desertification (Jones, *et al*., 2013). A soil analysis of the project area is presented below.

10.4.3 Project area Soil Overview

For an understanding regarding the existing soil types in the study area, the available information from the European Commission was analysed. Figure 23 represents the existing soils in the project area, and in the direct and indirect area of influence.

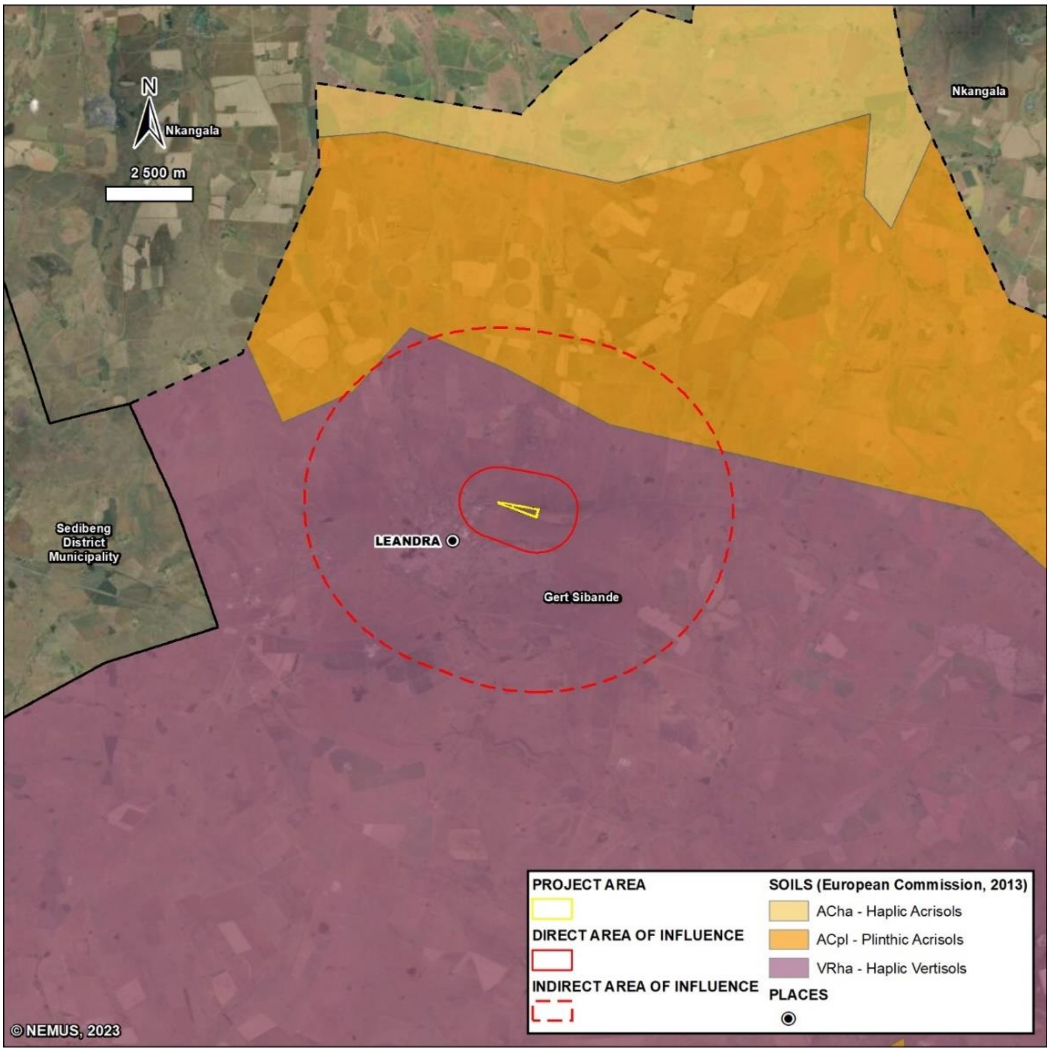

Figure 23: Data Source: Existing soil framework (Jones, *et al*., 2013)

According to Figure 23, the following soils can be identified:

- Project area: Haplic Vertisols
- DAI: Haplic Vertisols
- IAI: Plinthic Acrisols and Haplic Vertisols

In accordance with a general approach, (Jones, *et al*., 2013), the two soils distinguished are:

- **Haplic Vertisols:** Soils with shrunken and swollen clays that lack major characteristics.
- **Plinthic Acrisols:** Very acid soil with a clay-rich subsoil and an iron-rich, humus-poor, clay-rich horizon that hardens irreversibly.

A photo of the existing soil in the project area (Haplic Vertisols) is presented in Figure 24.

Figure 24: Project area existing soil (photo taken at the site visit on 21st to 23rd March)

Table 16 and Table 17 below provide a brief overview of the main characteristics of the two types of soil through the analysis of Strengths, Weaknesses, Opportunities, and Threats.

Table 16: Vertisols analysis (Jones, *et al*., 2013)

Vertisols	
Strengths	**Weaknesses**
– If the right measures are taken, these soils can be productive.	– Occurring mostly in flat areas, water movement in the soil is limited, and during wet periods water may stagnate on the surface. – It is heavy to work with when wet. – Swelling and shrinkage can destroy the foundation of structures (e.g., roads, irrigation canals).
Opportunities	**Threats**
– Raised beds made of the surface layer, often being crumbly, are good seed beds as the water drains quickly into the adjacent furrows.	– This type of soil can be susceptible to drought.

Table 17: Acrisols analysis (Jones, *et al*., 2013)

Acrisols	
Strengths	**Weaknesses**
– It is typically under natural vegetation, although it can support some agriculture if properly managed.	– These soils can become hard in climates with a pronounced dry season, making land preparation for the wet season tough, especially by hand.
Opportunities	**Threats**
– If fertilizer is applied, this soil can be productive. However, as they do not have the capacity to retain large amounts of nutrients, fertilizers should be applied close to the plants in small regular amounts.	– Left bare these soils are susceptible to erosion and capping. Having low productivity, they are best left under natural vegetation.

Acrisols	
Strengths	**Weaknesses**
– Acid-tolerant crops, such as pineapple or tea, and undemanding crops, such as cassava, can do well in the soil. Care is needed to protect the soil when the surface is left bare for significant periods. – Frequent loosening of the topsoil, together with removal of weeds, will permit rain to infiltrate thus preventing erosion by sheetwash.	

10.4.4 Summary

In accordance with the above considerations, the project area (and DAI) comprises Haplic Vertisols - characterized as soils with shrink and swollen clays without key features. In general, these soils are susceptible to drought and although naturally lacking in capacity, through the implementation of measures they can be productive.

10.5 Groundwater Hydrology

10.5.1 Hydrogeological Framework

SA's hydrogeology is closely related to geological conditions. The country has an ancient land-surface made up of a range of geological formations which differ in their geological ages, history, and lithology (Colvin, 2008) and, therefore, in their hydrogeology interest.

The ground surface where the project is located encompasses rocks from the Karoo Supergroup, mainly represented by hard metasedimentary and meta-volcanic outcrops from the Ecca (sandstones, shales and coal) and Dwyka (tillite, diamictite, minor sandstones) Groups. The passage from this geological unit with approximately 300 m thickness to older geological units occurs by an unconformity.

From the base of the Karoo Supergroup, the following units are represented in depth:

- **Transvaal:** with around 700 m thick, this unit has metavolcanic rocks represented by black shales with intercalated lava flows, dolomites, and cherts, quartzites with a poorly developed basal conglomerate;
- **Ventersdorp**: an unconformity establishes a transition from the Transvaal Supergroup to this unit. It is constituted by amygdaloidal, non-amygdaloidal and porphyritic andesitic lavas with ca 800 m extent;
- **Witwatersrand:** This unit laying in unconformity with the ones above and below has almost 1 km thick of quartzites, shales and conglomerates, quartzites, conglomerates and lavas, greywackes, quartzites, poorly developed conglomerates, tillites and magnetic shales and magnetic shales and quartzites;

- **Archaean:** the older rocks from the basement are schists, gneisses, granites, phyllites and shales.

Figure 2 above shows the main rocks that dominate each one of the geological units referred to.

Overall, in the project area, the main encompassed geological formations are from metasedimentary and volcanic crystalline hard rocks, including the intrusive basaltic lavas where carbon dioxide will be stored. In general, these rocks have little hydrogeological interest as a result of low primary porosity, permeability, storage and transmissivity.

Nevertheless, local, and discontinuous secondary aquifers may be formed, with their water storage and productivity dependent on fracturing and weathering.

Because of different degrees of weathering and fracturing, unconfined to semi-confined shallow aquifers occur on the first metres of weathered Karoo formations, followed in depth by semi-confined to confined fractured multi-layered aquifer.

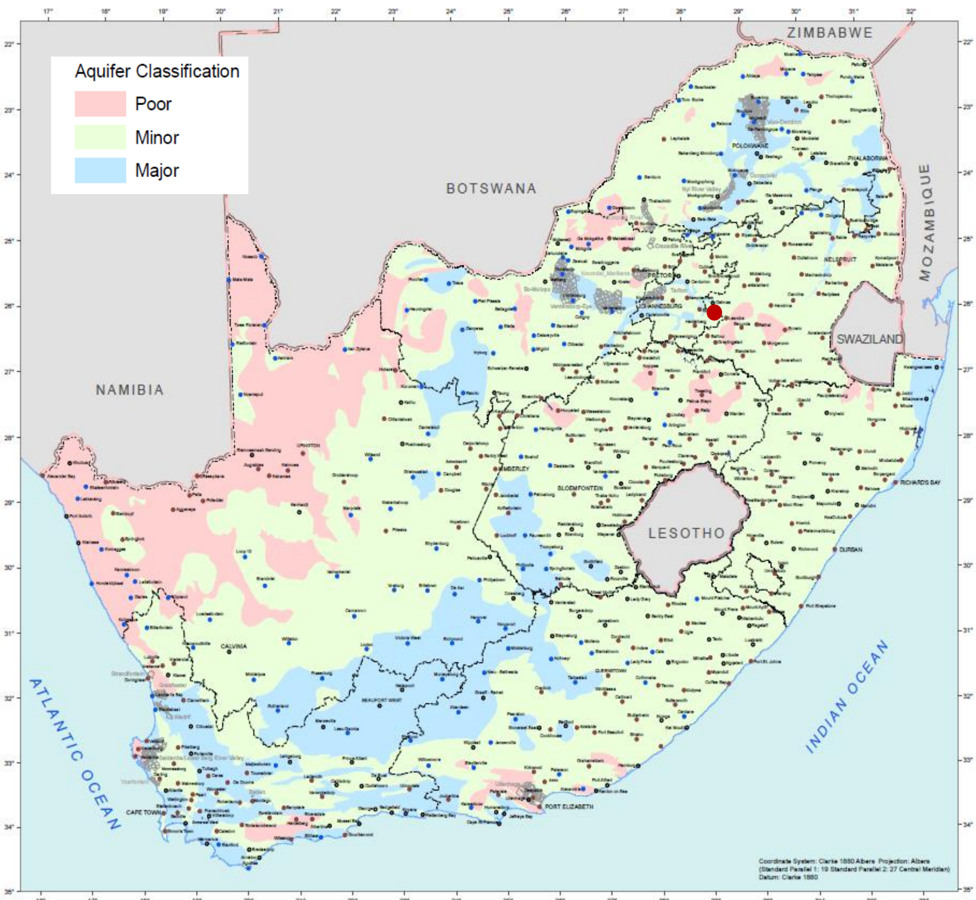

Figure 25: Hydrogeological setting (Matoti & Conrad, 2012) (red dot located in project area)

In low-lying areas, the groundwater table is shallow, recorded at 1.2 m below surface (JKC, 2014; Smith & Lea, 2018; *in* Dhansay, 2022). In comparison, in higher-lying areas, the average depth to groundwater in the shallow weathered aquifer is 3.7 m. The depth to groundwater in the weathered aquifer varies between 1.45 and 10.13 m, with an average depth of 4.5 m.

The shallow aquifers characterized by fissured flow media have a low to variable yield. According to (Matoti & Conrad, 2012), the permeability of these aquifers is highly variable as it is dependent on the nature and extent of the secondary features mentioned (Smith and Lea, 2018, *in* Dhansay, 2022). The variable productivity makes these aquifers of merely local interest, approaching the characteristics of aquitards.

Yield decreases rapidly with depth because groundwater movement and recharge also depend on fractures, cracks and joints, secondary structures developed in the hard rocks beneath the Karoo Group. It is important to note that with depth, the hard rocks are less weathered and the fractures are widely spaced, so the aquifers are less developed and the yield is very low. The presence of carbonated rocks from the Transvaal Supergroup (dolomite), due to karstification, should have a higher yield than the main hard crystalline rocks (around 2 to 5 l/s).

The groundwater recharge results from the infiltration of precipitation over the ground surface, and natural discharge areas correspond to springs, seeps or wetlands, depending on the lithology and structural history of the Karoo rocks.

The shallow Karoo aquifers recharge is estimated between 2 % and 5 % of the mean annual precipitation, being the average typically assumed to be around 3 %.

According to Dhansay (2022), the presence of wetlands in the landscape can be linked to the presence of both surface water and perched groundwater. The wetlands in the Leandra area are often associated with areas of shallow groundwater table conditions, as well as with the pans and streams present.

The Freshwater Assessment, which included the delineation and assessment of wetlands, is contained in Appendix D1.

The wetlands' interdependence of groundwater is usually related to springs that occur in areas where rock weathering is variable, or a barrier exists between rocks with different permeabilities. For instance, dolerite sills will likely form a barrier between the upper weathered and deeper fractured rock aquifers. Springs develop in the weathered aquifer where groundwater seeps to the surface along areas of lower permeability, for example, against a dolerite intrusion or a paleogeographic high or where the topography cuts into the water table.

10.5.2 Groundwater Use

Since aquifer development has high spatial variability, due to the high dependence on the recharge grade and groundwater circulation of the rocks, surface water is significantly more used than groundwater to satisfy the population’s main water demands.

Groundwater is of local importance. The majority of the groundwater abstracted in the Project’s region is used to agriculture, followed by domestic use. Groundwater is also particularly important to the province's mining industry.

The main targets for groundwater wells are often dolerite dyke contacts and fault zones in the Dwyka and Ecca formations.

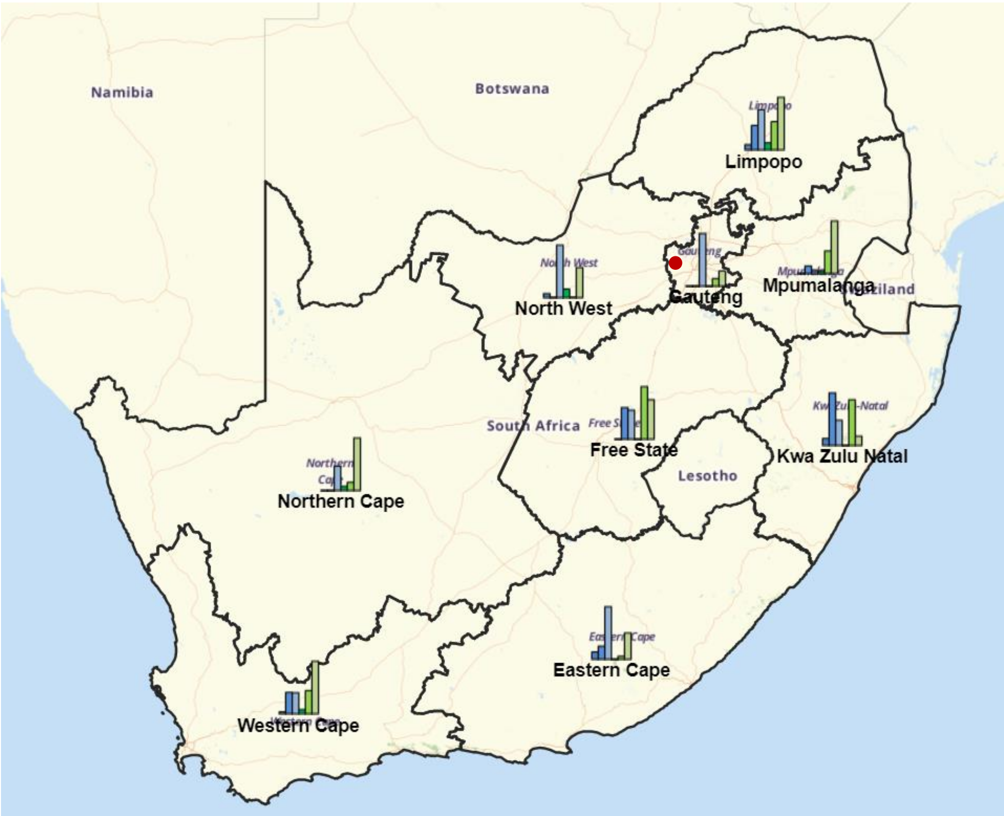

Figure 26: Groundwater main usages (National Integrated Water Information System, 2023). Red dot located in the project’s area. Green uses for agriculture and blue for domestic use

The utilisable groundwater exploitation potential for SA, i.e., the total volume of available renewable groundwater, is variable between 4 and 6 m³/km2/year.

The National Integrated Water Information System classify groundwater aquifers from the project with very low yield, estimating variable productivities of 0.1 to 0.5 l/s.

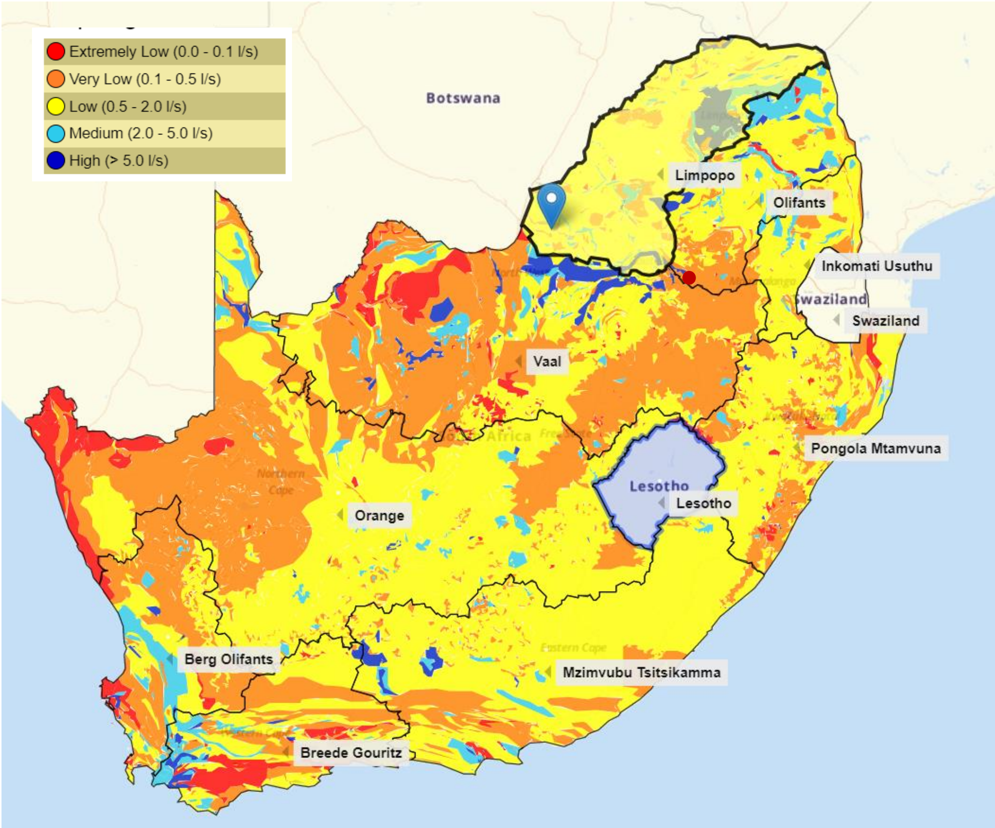

Figure 27: Groundwater productivity (National Integrated Water Information System, 2023) (red dot located in the project area)

Even though the more superficial aquifer supported by the Karoo rocks is not considered significant in terms of water supply, it does play an important role in terms of recharge to the underlying fractured rock aquifer and to the base flow of streams, especially in the dry season.

SA's reduced average annual rainfall results in a water-stressed country. Increasing demands justify groundwater to be considered a future water source for stressed surface water systems. According to Balzer (2020), the three surface water supply systems may have groundwater to improve water availability for the main uses in Mpumalanga (see Table 18 below).

Table 18: Water supply systems where groundwater will improve water availability

Water supply system	Major water users	Major dams in the system
Upper Usuthu	Chief Albeit Luthuli LM; Eskom; irrigation; Gauteng; Mkhondo	Heyshope, Morgenstoond, Westoe, Jericho
Lower Inkomati	Nkomazi LM, international, irrigation	Driekoppies dam and various smaller dams
Sabie	Bushbuckridge	Inyaka, Mwarite (and various small dams

10.5.3 Groundwater's Quality

Available data from the National Integrated Water Information System show good groundwater quality in the project's region. Overall, parameter exceedances for a long time are absent.

Since 1999, electrical conductivity has been below 10 mS/m, highlighting the low groundwater mineralization.

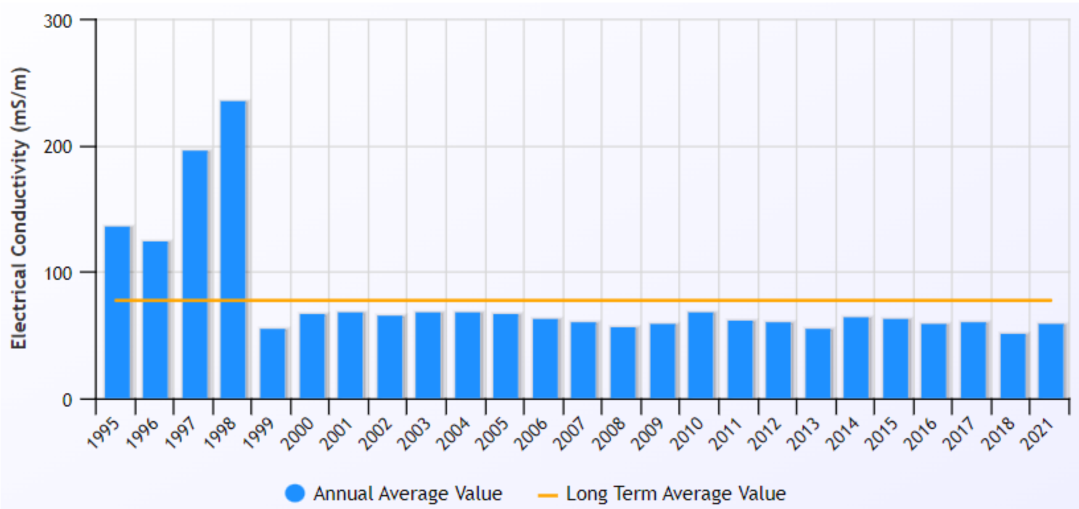

Figure 28: Electrical conductivity (National Integrated Water Information System, 2023)

The nitrate and nitrite nitrogen sum have been present in low concentrations, with the long-term average value (2007/2018) under 2 mg/l. The low concentration highlights that agriculture and wastewater have not been contributing to groundwater contamination.

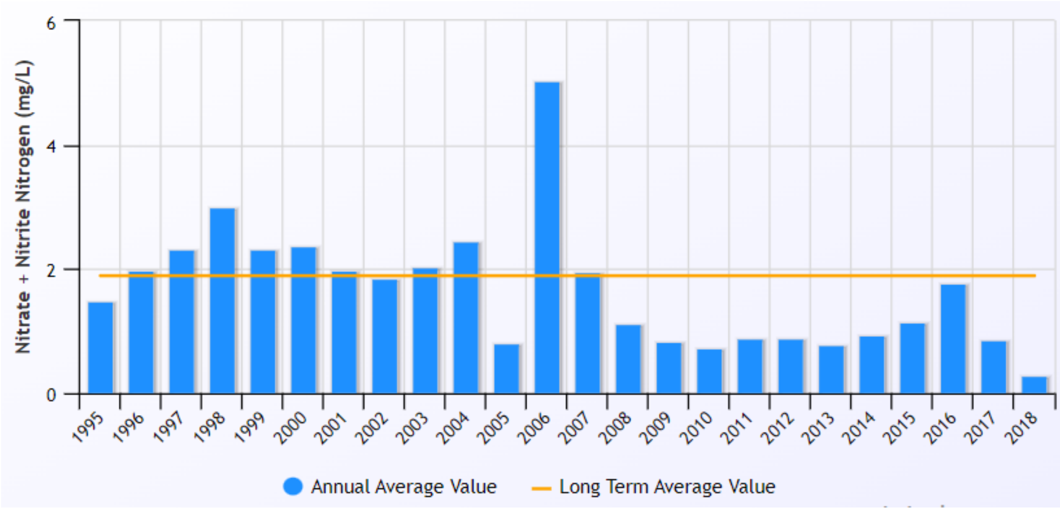

Figure 29: Nitrate plus nitrite nitrogen (National Integrated Water Information System, 2023)

Sulphate has a long-term average value of quite below 60 mg/l. In recent years, the maximum concentration was reached, in 2017. Low sulphate concentrations over the years are in line with nitrate+nitrite nitrogen, meaning that agriculture and wastewater do not affect groundwater quality.

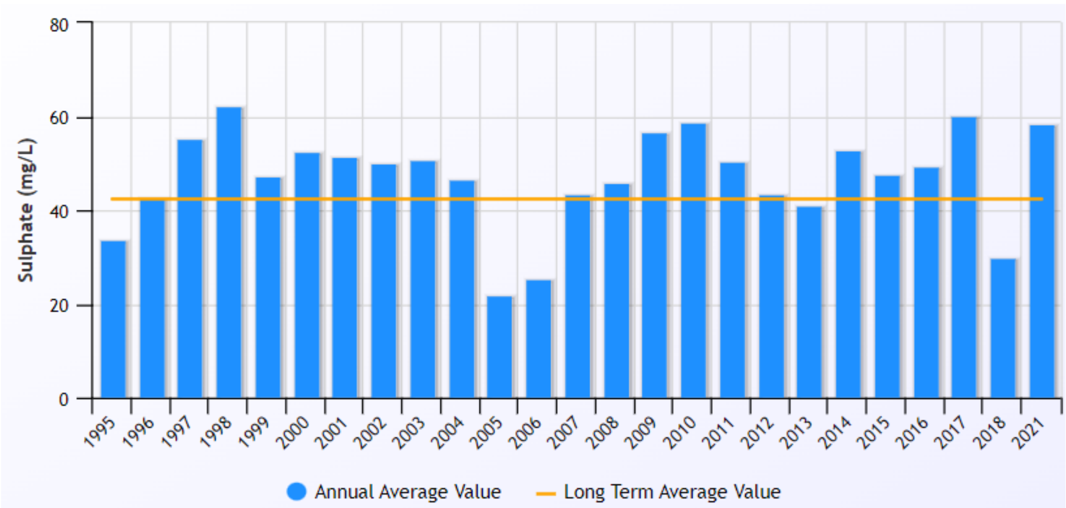

Figure 30: Sulphate (National Integrated Water Information System, 2023)

Dhansay (2022) presented results from the physicochemical analysis of 2 groundwater samples (FN06/017 and MV 98) taken at wells located in the south-eastern part of the project area.

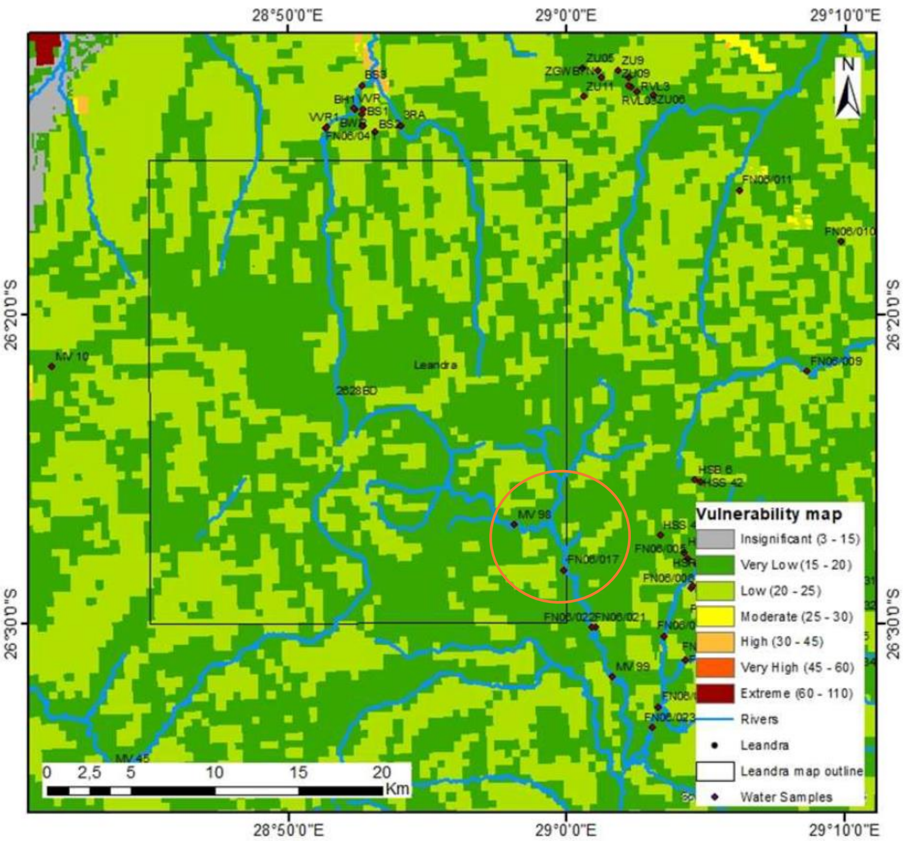

Figure 31: Groundwater samples location (Dhansay, 2022)

According to the available data, groundwater has a pH included in the standards, ranging from 8.3 (FN06/017) and 7.6 (MV 98), and high mineralization, highlighted by high electrical conductivity, between 736 µS/cm (FN06/017) and 743 µS/cm (MV 98). Total dissolved solids in only one sample (sample FN06/017) show groundwater quality is of quality for drinking.

Groundwater has low calcium (45.78 mg/l/FN06/017 and 41.58 mg/l/MV 98) and magnesium (32.25 mg/l/ FN06/017) concentrations, being water hardness under 60 mg/l. Sodium concentration is also low, falling well below 200 mg/l (FN06/017/40.43 mg/l). The same was recorded regarding potassium, with the sample collected on the FN06/017 with a concentration of 2.01 mg/.

Apart from electrical conductivity, iron was the only parameter with exceedances records (in one sample). Iron concentrations within the samples ranged from 0.10 (FN06/017) to 0.73 mg/l (sample MV 98).

Table 19: Physic-chemical analyses summary

	EC	pH	Mg	Ca	Na	K	Fe
FN06/017	736	8.26	32.25	45.78	40.43	2.01	0.10
MV98	743	7.63	0	41.58	0	0	0.73
WHO Recommended standards	400	8.5	50	75	200	12	0.3

EC – Electrical conductivity (µS/cm); Ca – Calcium (mg/l); Na – Sodium (mg/l); K – Potassium (mg/l); Fe – Iron (mg/l); Mg – Magnesium (mg/l)

The above data indicate that the groundwater in the vicinity of the Project site is more mineralized than that observed in the region. According to available data from the CCUS Project, electrical conductivity in the vicinity of Leandra ranges from 124 to 181 µS/cm from four wells.

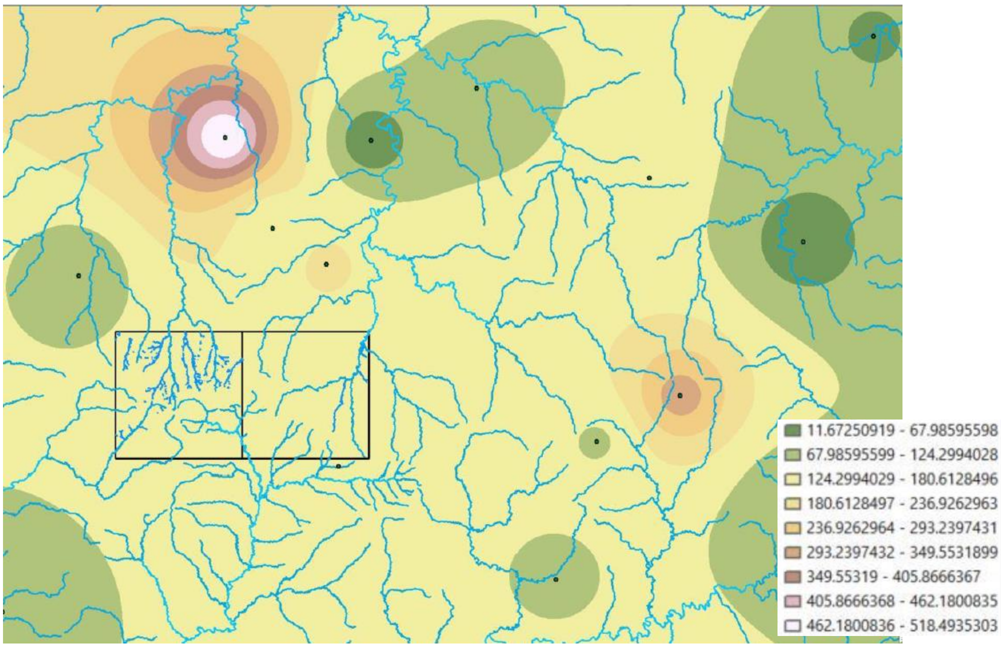

Figure 32: Electrical conductivity (µS/cm) around Leandra

There are also data for sulphate which show low concentrations for this parameter. The values range from 42 to 81 mg/l.

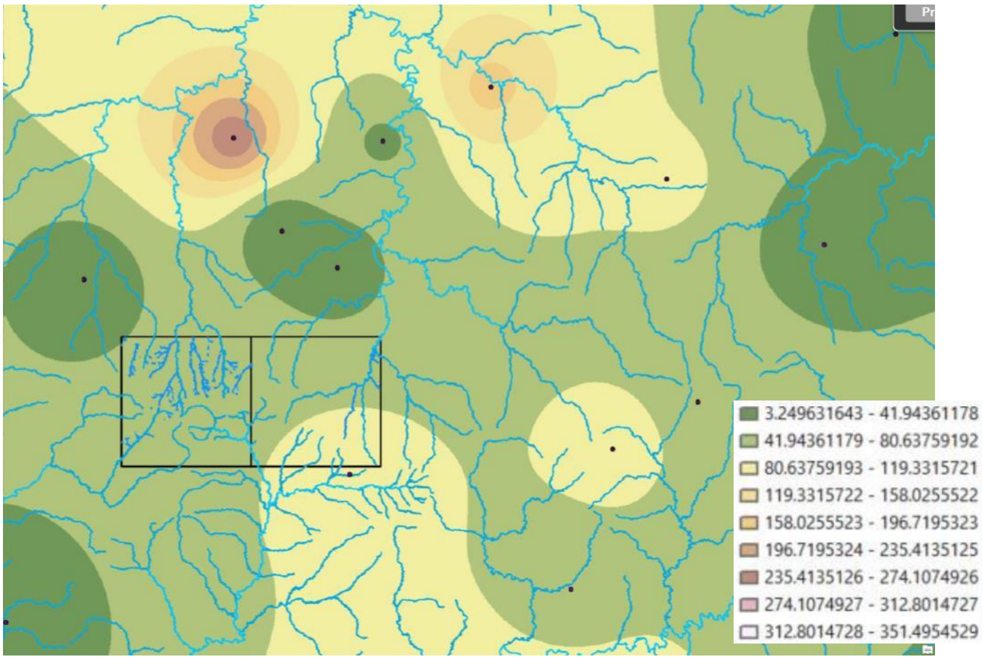

Figure 33: Sulphate concentration (mg/l) around Leandra

10.5.4 Vulnerability to Pollution

There is a close correlation between aquifer lithology and their potential vulnerability to pollution. Considering the types of aquifers encompassed by the Project, it is possible to consider the following situations regarding vulnerability pollution:

- **Low to variable vulnerability to pollution** for the shallow aquifers that are developed on the hard metasedimentary and metavolcanic rocks of the Karoo Supergroup. Vulnerability to pollution depends on the fracturing and weathering extension. The higher the fracturing and weathering grade, the higher the likelihood of groundwater being polluted once the mobilization capability of pollutants is increased.
- **Low vulnerability to pollution** for the in-depth aquifers supported by metavolcanic and volcanic rocks that are poorly fractured and weathered and, therefore, with low permeability and pollutant mobilization capability.
- **High to very high vulnerability to pollution** for the dolomites of the Transvaal Group. The permeability acquired by karstification may be reflected in the dispersion of pollutants at very high speeds in groundwater.

According to Matoti & Conrad (2013), the aquifer vulnerability of the project area is classified as moderate once there is a tendency or likelihood for some pollutants' contamination to reach a specified position in groundwater after introduction at some location above the uppermost aquifer.

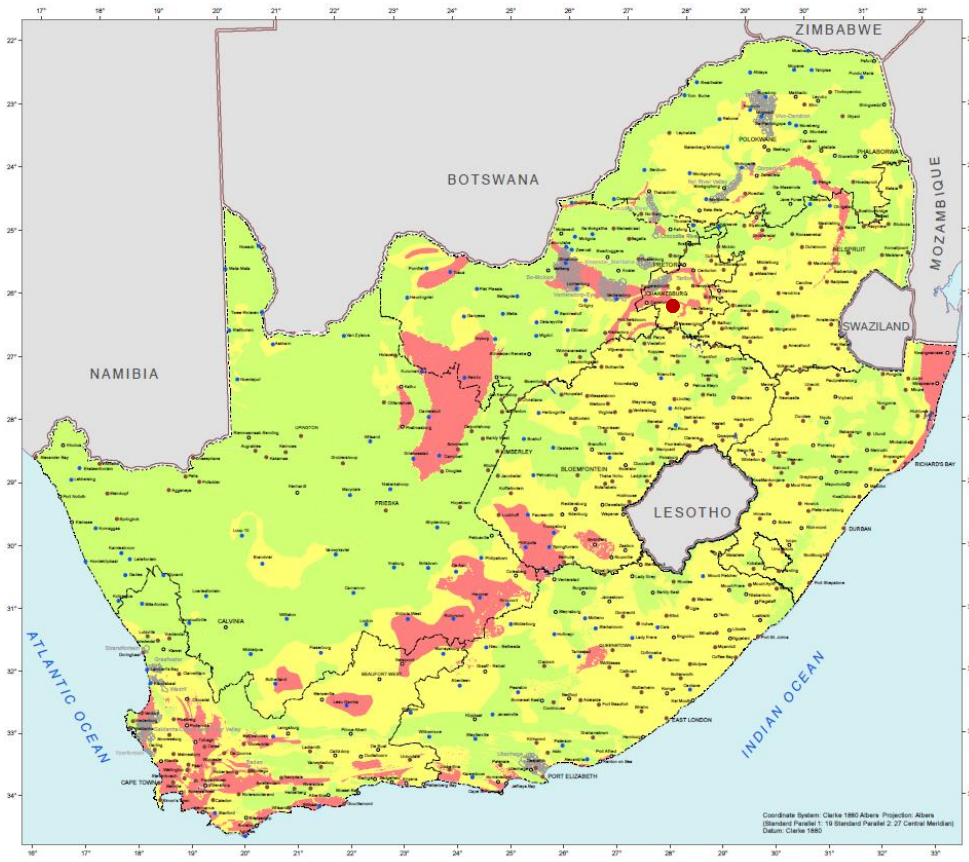

Figure 34: Aquifer vulnerability (Matoti & Conrad, 2013) (red dot located in the project area)

10.5.5 Summary

The region where the Project is located is generally of low hydrogeological importance and does not contain any aquifers of national or regional importance. However, groundwater is of local interest, providing water for irrigation, domestic use and mining activities.

The local hydrogeological interest depends on the state of fracturing/weathering of metasedimentary and metavolcanic rocks. Although fracturing and weathering may locally favour water depth circulation, the average productivity of the aquifer formations is low to very low, in general, less than 1 l/s, not allowing the individualisation of any important aquifer.

Overlying the basalts where the CO_2 will be stored, however, are the dolomites of the Transvaal Supergroup, which are of greater hydrogeological interest.

10.6 Surface Hydrology

10.6.1 Introduction

This section presents the characterization of the surface water resources in the study area, including the following subjects:

- Hydrology;
- Water use;
- Water quality.

This characterization is based on reporting, documentation, strategies, and other information made available by the DWS, GMLM, GSDM, and the Association for Water and Rural Development (AWARD). These sources were complemented with additional bibliographical research and information gathered in a field survey in December 2022.

10.6.2 Hydrology

The National Water Resource Strategy (NWRS) provides the framework within which water resources should be managed at regional or catchment level, within defined Water Management Areas (WMA). The hydrological context of the Project is defined as a ridge of the Olifants Catchment near the Vaal Catchment, as represented in the following figure.

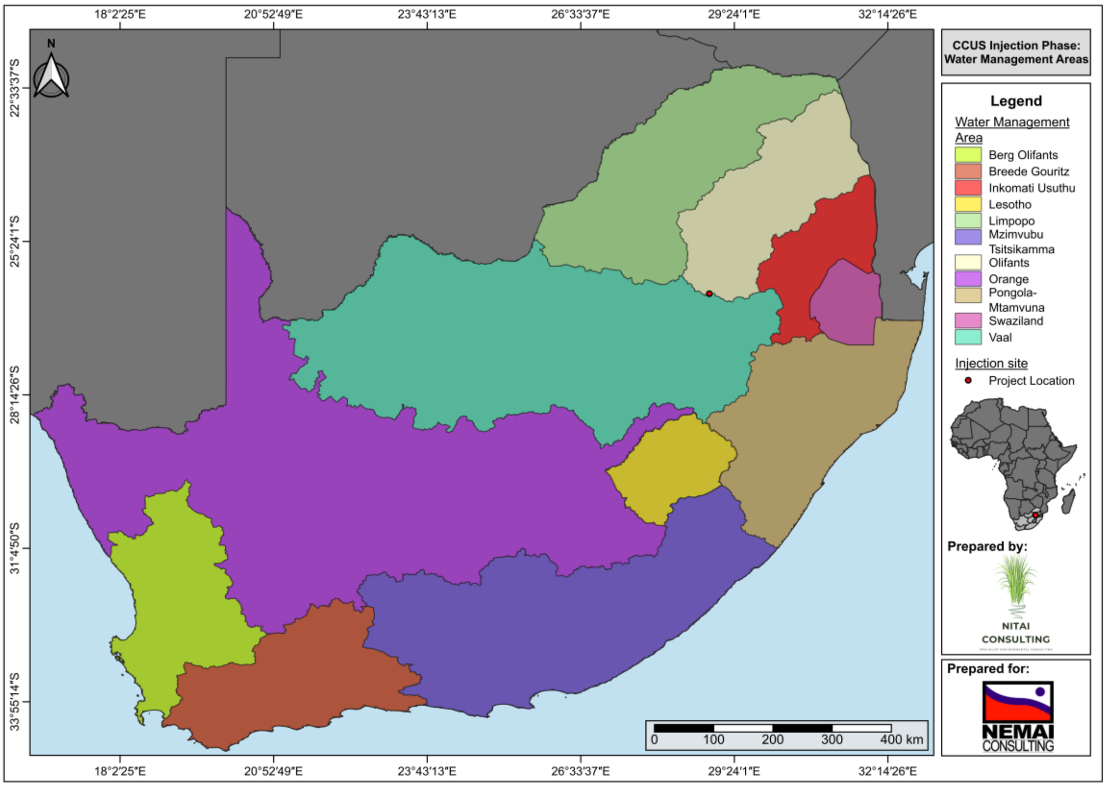

Figure 35: SA WMA's (red dot shows project site)

The study area is located within the Olifants WMA in the context of the 2012 Water Management Areas. On a smaller scale, the project area is located within the B20E and C12D Quaternary Catchments.

In terms of the NWRS, the study area is situated in the Upper Olifants WMA Sub Area according to the Integrated Water Quality Management Plan (IWQMP) (DWS, 2018). The following is noted in terms of the study area (DWS. 2020):

- At the local scale: quaternary catchment B20E corresponding to a local tributary of the Kromdraaispruit, with an area of 619.88 km^2;
- At the drainage region scale: secondary catchment B2/tertiary drainage region B20 corresponding to the Wilge river, which share extents given the regional hydrological characteristics, with an area of 4,356.42 km^2; and
- At the river catchment scale: Olifants catchment B, with an area of 73,633.16 km^2.

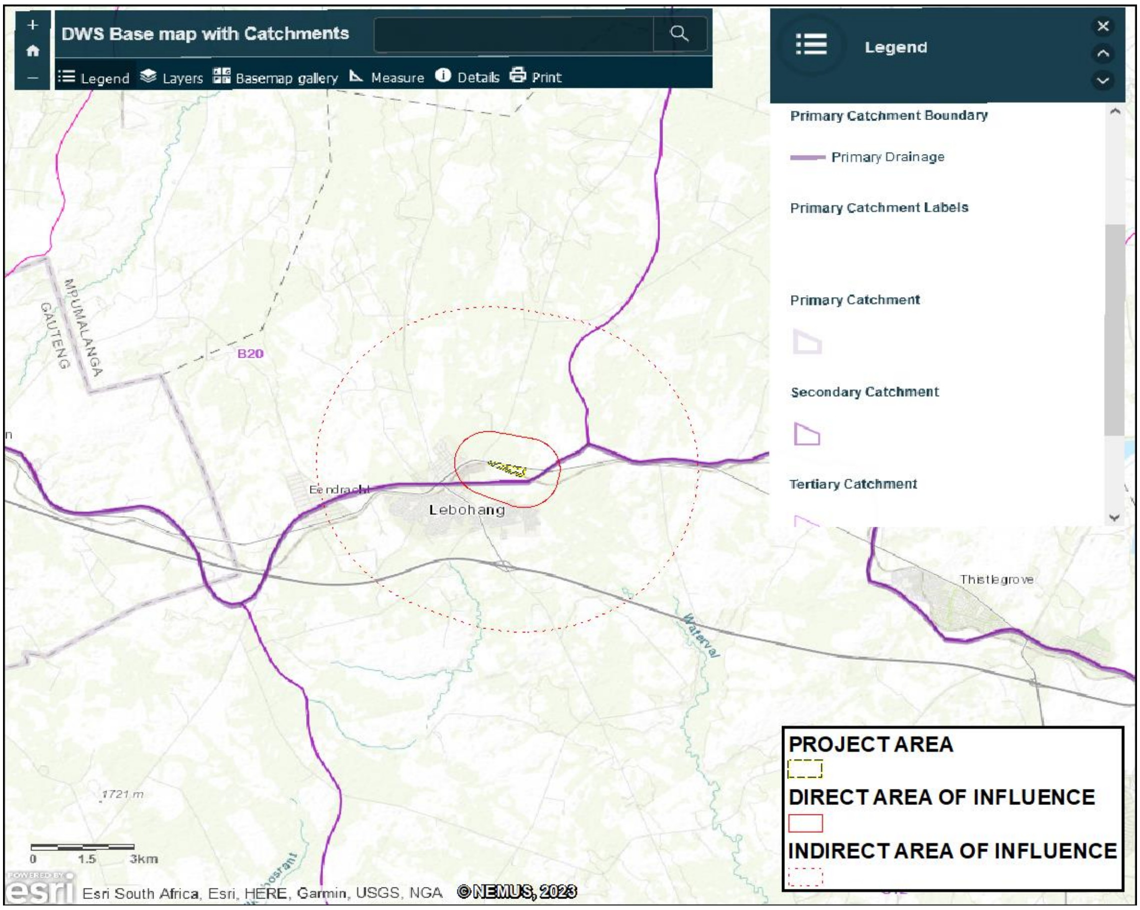

Figure 36: Catchment boundaries near the project area (adapted from DWS, 2020)

The Olifants River Catchment (ORC) as a whole is a major tributary to the Limpopo River Basin, as it is the largest contributor and the only tributary that sustains flows of the Limpopo River during dry season (AWARD, 2022).

Ridge areas such as the study area typically do not display structured hydrological features, as they are the uppermost sections of the catchment. As such, the only visible water features in the study area amount to man-made reservoirs and weirs for agricultural and livestock activities.

In this context, during field survey, water-field pits were documented within the study area. These pits presumably resulted from abandoned earthworks which accumulated rainfall and superficial runoff, with no visible superficial outflows.

Figure 37: Water-filled pits in the study area

Notwithstanding these local small-scale topographical anomalies, the local drainage network leads to the nearby Kromdraaispruit, a tributary of the Wilge River and the main water feature of the B20E catchment area (**Error! Reference source not found.**).

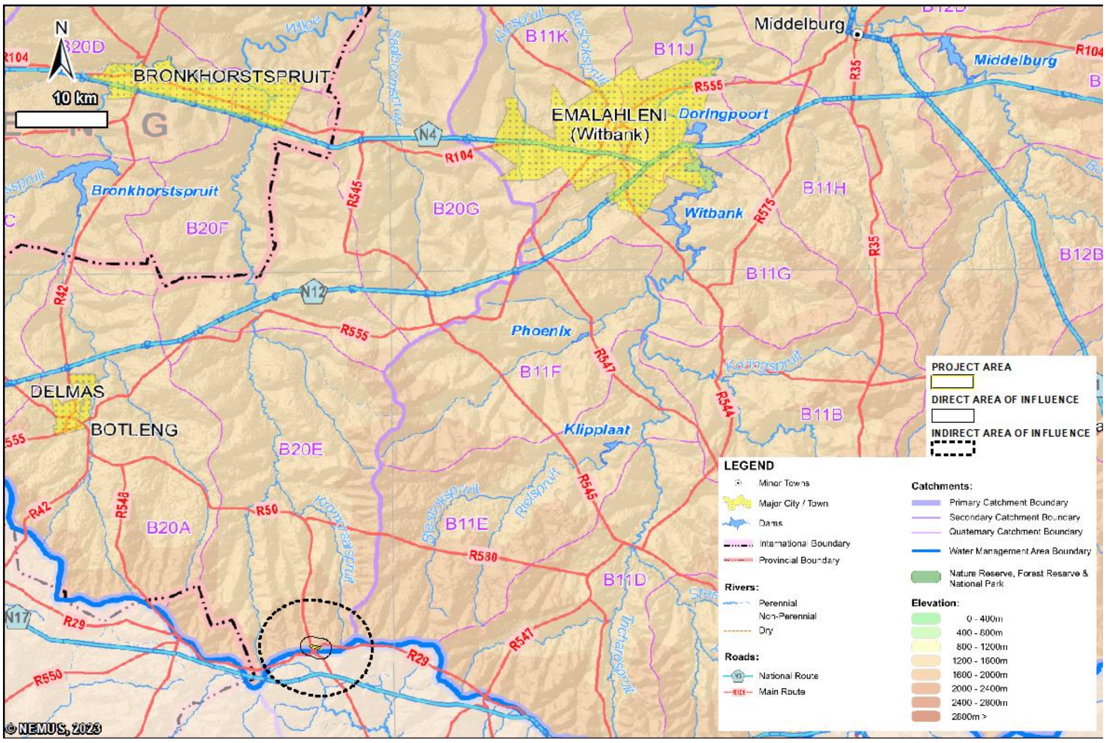

Figure 38: Local drainage of the Olifants Water Management Area near the project area (adapted from WMA 2 (OLIFANTS) [DWS, 2015])

Given the hydrological context of the study area, the National Integrated Water Information System (DWS, 2023) does not have locally representative monitoring for water quantity or for the surface water monitoring network.

10.6.3 Extreme events

The historical increase in atmospheric concentrations for greenhouse gases has led to a gradual increase in average temperature, which lead to heterogenous changes in surface and atmospheric distribution of properties such as temperature, humidity, and pressure. Ultimately, these effects contribute to the increase in likelihood of extreme events such as floods and droughts (SAWS, 2021).

The South African Weather Service (SAWS) presented a downscaling of an ensemble of global climate models of the low (RCP4.5) and high (RCP8.5) representative concentration pathways to a higher resolution (SAWS, 2017), more suitable to regional analysis. The predicted regional changes in climate variables were:

- Temperature: median annual mean temperature change of about +2°C in 2095, particularly during the spring months (up to +3°C) - according to RCP4.5 scenario; and

- Rainfall: median annual total rainfall changes of about -5 mm/year in 2095, with a median increase of over +20 mm during the summer months and a median decrease of about -20 mm during the spring months.

The SAWS also presents annual nation-wide local trend analyses of extreme climate indices. Throughout the 1947-2021 period, the trends significant at the 5% level at the most representative station for the study area were respectively (SAWS, 2022):

- Increase in 0.03°C/year for minimum value of daily minimum temperature and decrease in -0.068 days/year of cold spell duration (at the Johannesburg station, about 70 km West of the study area);
- Increase in 0.031 per year of the simple precipitation intensity index (at the Witbank Strehla station, about 55 km North of the study area).

These trends point to an expected increase in occurrence of extreme events in the study area, given the general increase in temperature and higher concentration of rainfall. Concurrently, a regional assessment of extremely high rainfall likelihood for the eastern SA has shown a decrease of about half of the return time for a maximum 2-day rainfall, to 1-in-20-year frequency (WWA, 2022).

In the Mpumalanga Province, climate change has been associated with increased risks for water resource availability, lower agricultural productivity and livelihood support (Maponya, *et al*., 2013), as well as industrial and commercial sector productivities (Kundu, *et al*., 2014).

Several flood events have occurred in the Mpumalanga Province, particularly in the Lowveld area, northeast of the study area, in 2011 (SANews, 2011), 2012 (SAG, 2012), 2017 (Floodlist, 2017) and 2021 (News24, 2021) (Mpumalanga News, 2021), with associated life loss and damages of housing, infrastructure, livelihoods and the potential for secondary events such as mudslides, soil erosion (The South African, 2021) and dam discharges (Floodlist, 2021).

On the other end of the climatological spectrum, drought events typically occur in the summer months and are defined as temporally compressed hot and dry conditions leading to declining soil moisture. Several of these events were registered in 2015, 2018, 2020 and 2021 affecting the region. These events affect water resource availability and vegetation growth (NASA, 2015), affecting food availability (Aljazeera, 2015), (SABC News, 2018), in several cases leading to the pronunciation of national disaster status (Business Insider SA, 2021).

10.6.4 Water use

Water scarcity may result from increasing demand, decreasing resource availability, decreasing resource quality or a combination of these factors. At the national level, the water scarcity can be generally attributable to physical causes, although uneven investment in water infrastructure and geospatial disparities lead to rural areas also being subject to economic limitation in water access (Mnisi, 2020).

In order to meet legitimate current and future water requirements at the catchment level, a water reconciliation strategy for the Olifants River Water Supply System was proposed by the DWS (2015). This system provides water for domestic (more than 3 million people), industrial, irrigation, mining, and power generation purposes. The system, however, does not appear to include the local water supply within GMLM or Leandra in particular.

The water supply services in the study area are supported indirectly by Rand Water, through raw water extraction and purification from the Vaal River and Vaal Dam (on the Vaal River catchment) and reticulation by the municipal services. In the Leandra area, reticulation has been identified as a challenge (GMLM, 2022). Information gathered during field survey point to the main use of water resources in the study area being for agriculture and livestock production, with unconnected communities traditionally using borehole water.

The GMLM provides technical and community services including water, sanitation, stormwater drainage system maintenance, environment management and disaster management (GMLM, 2023). According to a Community Survey from 2016, almost 94% and 95% of municipal households have access to water (municipal tap) and sanitation (flush/chemical), respectively. This contrasts with the lower province-wide statistic of 63% of reliability of access to water supply and sanitation services, according to the National Water and Sanitation Master Plan (DWS, 2019).

Sanitation services are locally supplied through Leandra Wastewater Treatment Works and sewers, operated by the GMLM and in need of relevant upgrades (GMLM, 2022). This plant discharges the resulting effluent into the Waterval River.

Nonetheless, according to the local-scale documentation portal made available by the DWS (2023) there is no specific water resource strategy for the GMLM, within which the study area is located.

The 2011 Reconciliation Strategy for Amersfoort Town Area, although not directly applicable to the study area, pointed out the relevance of the TEKS area (Trichardt/Evander/Kinross/Secunda, southeast of the study area), within the GMLM, as one of the 21 functional urban areas with the largest contribution to the national economy (DWAF, 2011) in the context of the National Spatial Development Perspective. Concurrently, the TEKS area is identified as the primary focus area for infrastructure investment within the District. Surrounding areas that display both high levels of economic potential and poverty (which includes Leandra – where the study area is located), should also be the focus of more extensive infrastructure spending, including what pertains to water treatment and use (DWAF, 2011).

The GSDM and its local Municipalities have developed Environmental Management Frameworks (EMF) in the context of the EMF Regulations 2010 (GNR547 of 2 August 2010) and the NEMA. The GSDM outlines the following simplified set of relevant challenges for water management and aquatic ecology management (GSDM, 2018):

- Proposed development and community activities limit the protection of riparian areas and wetlands;
- Population growth/internal challenges and resource constrains limit improvement of access to quality services;
- Incipient sustainable economic activity environment;
- Increased capacity and staff needs to properly promote water awareness, to provide resource management and to strengthen monitoring and enforcement;
- Growing demand for coal mining, exposing local wetland and pans;
- Upstream and downstream pollution highlighting the need for the improvement of wastewater and waste management and treatment.

The Freshwater Assessment, which included the delineation and assessment of wetlands, is contained in Appendix D1.

10.6.5 Water quality

Environmental water quality is subject to a multitude of competing drivers and pressures, given its relevance to a number of systems and services. The management of water resources follows the dispositions of the applicable Integrated Water Quality Management Plan (IWQMP), which in the study area corresponds to the Olifants River System, Upper Olifants Sub-catchment Plan (DWS, 2018).

The upper Olifants River Catchment (ORC) has been transformed through agriculture, mining (AWARD, The Olifants River Catchment in a nutshell, 2022) and dams for dry land agriculture, minor irrigation and livestock (DWS, 2018). These reflect on local water quality by the introduction of significant nutrient and sediment loads. The mining effluents generally contribute towards acidification and an increase of heavy metal concentrations, sulphates and other contaminants from acid mine drainage (AWARD, 2014).

In what pertains to mining pressures on water quality, the IWQMP (DWS, 2018) lists the following mines contributing to a total sulphate salinity load of 1 673 kg/d across the Wilge River management unit: Leeuwfontein/Lakeside Colliery; Side Minerals; Bankfontein Colliery; Kendal Power Station; Kusile Power Station; New Largo. Although these are not located in the immediate study area, they demonstrate the level of mining pressure felt on downstream water resources.

Likewise, the Upper Olifants WMA is the most urbanized of the Olifants catchment sub-catchments (DWS, 2018), which presents specific pressures and demands on surface water resources.

In and near the study area, the identified main water quality pollution sources are diffuse pressures from urban areas and agriculture activities. Recent georeferenced surface water quality reporting, by the CGS (2023) for the third quarter of 2021, is summarized on the following table.

Table 20: Approximate water quality results for the project area (CGS, 2023)

Parameter	Value	Unit
Electroconductivity	550 to 650	µS/cm
Oxidation-reduction potential	-90 to -60	mV
pH	8-8,4	Sorensen scale
Rugged dissolved oxygen	3,9 to 7,8	mg/l
Resistivity	500 to 600	Ohm.cm
Total Dissolved Solids	850 to 1000	ppm

According to AWARD (2023), the local river threat status is “endangered”, as represented near the southernmost border of the catchment on the following figure.

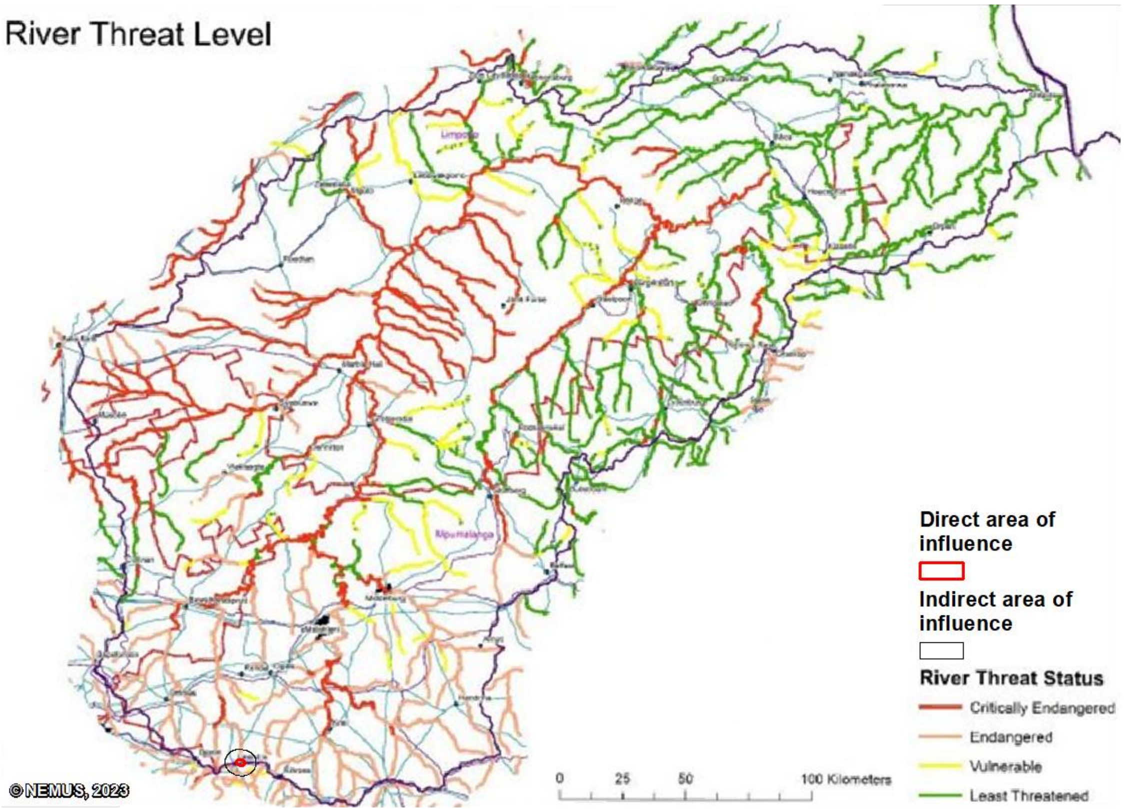

Figure 39: Map of the threat level to rivers of the Olifants River Catchment (adapted from AWARD, 2023)

Nonetheless, the drainage area of the study area has no locally established Ecological Water Requirement (EWR) sites (DWS, 2018) which, if established, could contribute to sustaining ecological values of water dependent ecosystems at a low level of risk. The nearest EWR site is located just upstream from the Loskop Dam, on the Wilge River (AWARD, 2014), about 120 km north of the study area.

Given the hydrological context of the project area, the National Integrated Water Information System (DWS, 2023) does not have locally representative monitoring for resource water quality objective compliance nor for raw water quality monitoring.

The drainage catchment resource quality of the study area is monitored downstream at the B20J quaternary catchment, on the Wilge River (DWS, 2018). The fitness for use assessment developed by the IWQMP in the context of the SA Quality Guidelines showed that the Wilge River met the guidelines "except for ammonia and ortho-phosphate, indicative of urban and agricultural pollution" (Management Unit – MU22 in the IWQMP).

The Blue Drop Progress Report 2022 assesses the level of compliance and core competencies of the drinking water management sector across varying geographies. For the Greater Govan

Mbeki system, most levels of compliance were found to be excellent with the exception of chemical monitoring and compliance (DWS, 2022a).

Drinking water quality compliance with the SANS 241:2015 is also continuously assessed for the whole GMLM, with relevant recent shortcomings in what pertains to chronic health and disinfectant parameters, as shown in the following figure.

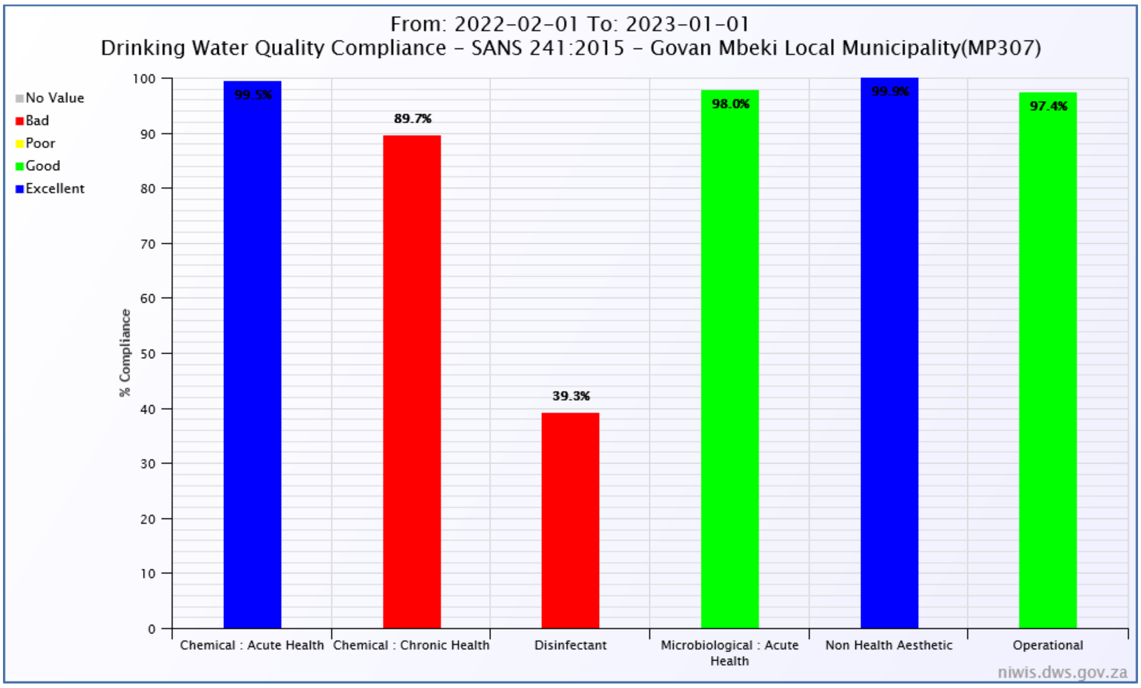

Figure 40: Drinking water quality compliance for the GMLM [National Integrated Water Information System, (DWS, 2023)]

Similarly to the water supply system, the Green Drop Progress Report 2022 assesses the level of compliance and core competencies of the wastewater management sector. The Mpumalanga Province reports a degradation of Green Drop score for the GMLM from 2013 (48%) to 2021 (39%), with wastewater treatment works of Evander being classified as in high risk (DWS, 2022b). This location is outside the study area and as such is presumed to have negligible effect on it. The GMLM Wastewater Treatment Works in Leandra was classified as a low-risk structure (Green Drop Score in 2021 of 43%), nonetheless with low score for the Technical Management (20%) key performance area.

The municipality-wide assessment of wastewater quality compliance continuously made available through the National Integrated Water Information System (DWS, 2023), and represented in the following figure, shows significant challenges across the board with the exception of physical parameters (the only subject classified as good or superior).

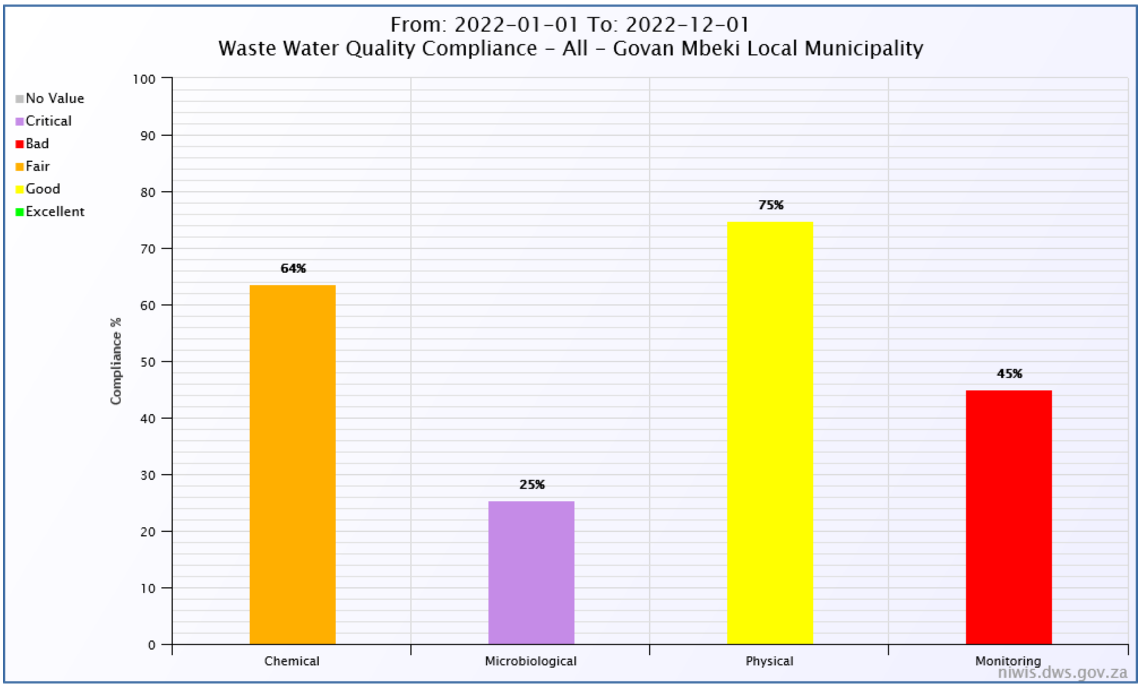

Figure 41: Waste water quality compliance for the GMLM [National Integrated Water Information System (DWS, 2023)]

In order to adequately support regional water resources, the IWQMP establishes a set of management measures from which the following were selected given their relevance for the sub-catchment area of the study area:

- Specific Strategic Measure M-4 is established to "reduce increased salinity trend in the Wilge River catchment", and includes actions to map mines, to collaborate with government departments to strict authorization processes, and to consider opportunities for the declaration of protected areas; and
- Specific Measure I-3 is established to include monitoring of metals and heavy metals given the existence of power stations within the management unit (Kendal Power Station; Kusile Power Station).

10.6.6 Expected Trends

In the near future, water availability in the study area is expected to decrease given the effects of climate change with the concentration of rainfall during summer months.

Water uses and pressures are also expected to intensify with regional economic growth (DWS, 2018), although the resulting consequences are presumed to be somewhat controlled by the implementation of the Integrated Water Quality Management Plan for the Olifants River System (IWQMP), namely through:

- "*Reduction of load due to seepages from the mine, industrial and power station waste storage facilities and mining operations in the Upper Olifants sub-catchment, some load from the Steelpoort sub-catchments and the Ga-Selati in the lower Olifants sub-catchments;*
- *Reduction of load due to excess mine water on the mining operations threatening to decant or starting to flood the coal reserves in the Upper Olifants sub-catchment;*
- *Reduction of load from irrigation return flows in the Upper and Middle Olifants;*
- *Reduction of nutrient load from domestic WWTW that discharge to the water resources, by considering a reduction of the orthophosphate concentration to 1 mgP/l;*
- *Reduction of nutrient and sediment load from agricultural areas and areas where changing land uses may be occurring;*
- *Reduction of nutrient and sediment load from run-off from urban/ densely populated areas; and*
- *Improved reuse of effluent from domestic wastewater treatment works not designed to meet the general discharge limits."*

In this context, the recent increase in mining permits for additional exploration, prospecting and mining activities, particularly for coal deposits, should introduce significative stresses on land use and water resource quality (DWS, 2018).

These pressures are estimated to be more intensely felt in the context of climate change and its effects, namely increase in median temperature, decrease in median annual rainfall, increase in median summer rainfall, increase in occurrence of extreme events and variable water resource availability.

10.6.7 Summary

The study area is located at the ridge of the Olifants catchment near the Vaal catchment, draining locally to a local tributary of the Kromdraaispruit, which itself is a tributary to the Wilge River. This area is hydrologically unstructured, with no relevant features and no quantity or quality monitoring capabilities.

According to recent climate models, throughout the rest of the century the likelihood of extreme events such as floods and droughts will increase, in a local context of higher temperatures and more concentrated rainfall during summer months. In the Mpumalanga region, these events have previously led to life loss and damages, as well as lower water availability and cross-sector productivity.

Local water resources are subject to agriculture and livestock production, while at the regional scale these uses compete with additional domestic, industrial, mining and power generation uses. Given the hydrological characteristics of the study area, the structured water supply is met locally through Rand Water supply, with water abstracted from resources in the neighbouring Vaal River catchment. Local reticulation in the Leandra has been identified as a challenge, with unconnected communities using borehole water.

Although there are no specific water resource strategies, the study area should be the focus of more extensive infrastructure spending, namely for water treatment and use.

The study area is located in the Upper Olifants region which has a great variety of water quality and quantity pressures, namely mining, urban areas, agriculture, irrigation and livestock. These sources introduce relevant demands as well as nutrient, sediment and chemical contamination loads through the resulting effluents. This level of pressure led to the classification of river threat as endangered or critically endangered for the majority of regional rivers.

Local surface water quantity and quality are unmonitored, with the most proximal stations being located on the Wilge River, which was recently found to meet the fitness for use guidelines except for ammonia and ortho-phosphate, which indicates urban and agricultural pollution.

The drinking water in the GMLM was found to comply at the excellent level except for chemical monitoring and compliance subjects, with relevant shortcomings registered for chronic health and disinfectant parameters.

The wastewater management services for the GMLM have lower Green Drop scores in 2021 (39%) compared to 2013 (48%), with significant challenges for all parameters with the exception of physical parameters, although locally the Leandra wastewater treatment works was classified as a low-risk structure.

The IWQMP, set at the Olifants catchment and specified at the Upper Olifants WMA, establishes a set of management measures aimed at reduce salinity and monitor metal and heavy metal content in water resources.

The foreseeable trends of the surface water resources is highly conditioned by the effects of climate change, with more concentrated rainfall during summer months and lower resource availability. On the other hand, increases in water demand and water quality pressures are expected, given the planned development of regional economic growth. The IWQMP establishes several implementation measures to reduce pollutant load from mining, industrial, waste management and irrigation activities which may help control the associated pressures.

10.7 Aquatic Biodiversity

The information contained in the sub-sections to follow was extracted from the Freshwater Assessment (van Rooyen, 2023) (contained in Appendix D1).

10.7.1 National Freshwater Ecosystem Priority Areas Rivers

The National Freshwater Ecosystem Priority Areas (NFEPA) rivers map in Figure 42 highlights the NFEPA rivers, non-perennial rivers and dams associated with the study area. The Kromdraaispruit begins just north-east of the project site and flows in a northerly direction, draining into the Wilge River. Moreover, one unnamed non-perennial river is situated well south of the project area and drains into the Waterval River further south. The study area is not situated within any river FEPA catchments (areas that achieve biodiversity targets for river ecosystems and fish species) and these catchments are identified in rivers that are currently in good condition (Ecological Category of A or B).

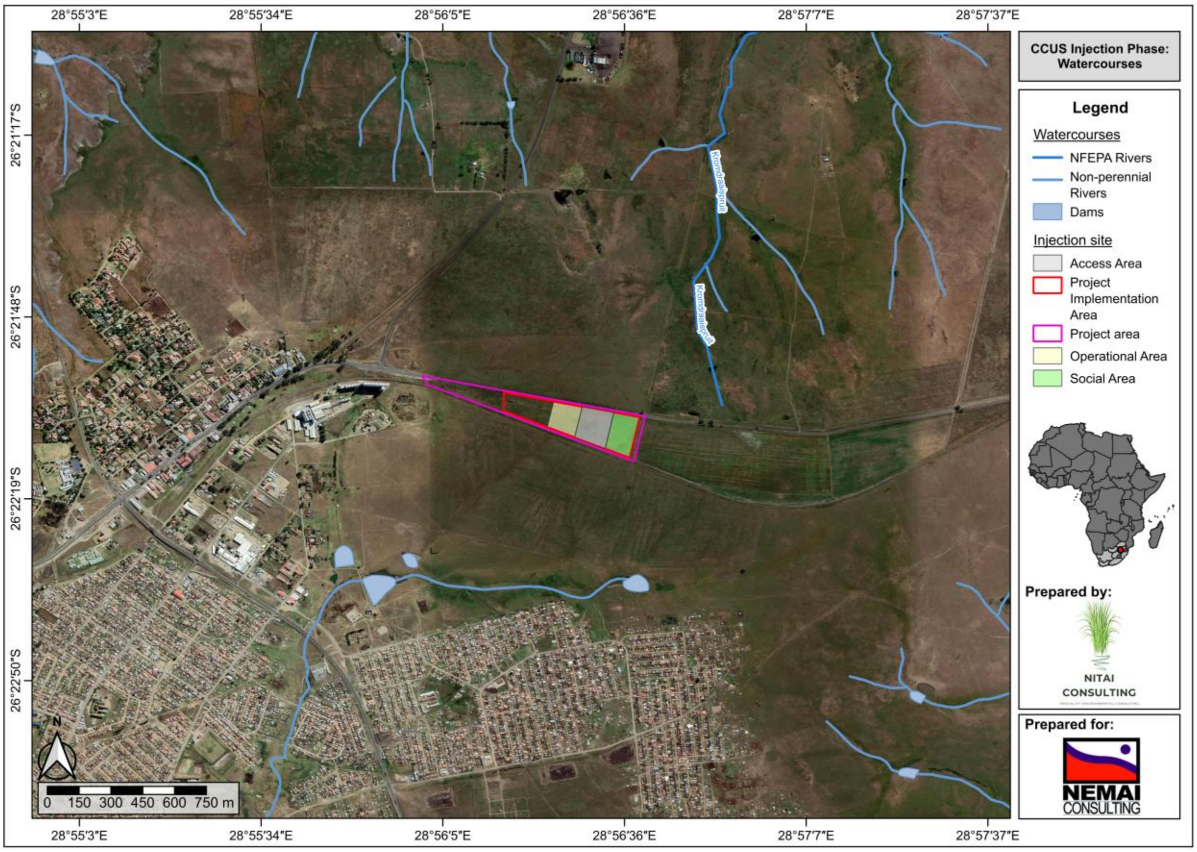

Figure 42: Map showing watercourses (NFEPA rivers, non-perennial rivers and dams) associated with the study area

10.7.2 National Biodiversity Assessment 2018 National Wetland Map 5

A South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was established in 2018 during the National Biodiversity Assessment (NBA) (Van Deventer *et al*., 2019). This inventory highlights a collection of data layers pertaining to ecosystem types and pressures for rivers and inland wetland types. This includes the different wetland hydrogeomorphic (HGM) units, which include unchanneled valley bottom wetland (UCVB), channelled valley bottom wetland (CVB), seep (S), floodplain (F), depression (Dep), and flat (FL). The aforementioned inventory also includes the protection level (Well protected, Moderately protected, Poorly protected and Not protected) and threat status (Critical, Endangered, Vulnerable and Least Concern).

Within the footprint of the study area, there are no HGM units according to the NBA 2018 National Wetland Map (NWM) 5 spatial data (Figure 43). There are several large S, CVB's and a FL that is situated outside the injection site. From the NWM 5 spatial data, all wetlands within the study area are in critical condition (Figure 44). Skowno *et al*. (2019) has further indicated that inland wetlands have the lowest overall protection in SA compared to other ecosystem realms. A total of 60% is classified as not protected while as less as 10% is classified as well protected and moderately protected (Figure 45). This has been attributed to their poor ecological condition (Skowno *et al*., 2019). Wetlands are essential ecological infrastructure for water and food security, tourism, recreation and disaster risk reduction (Skowno *et al*., 2019). Therefore, the need for protection of these watercourses is essential.

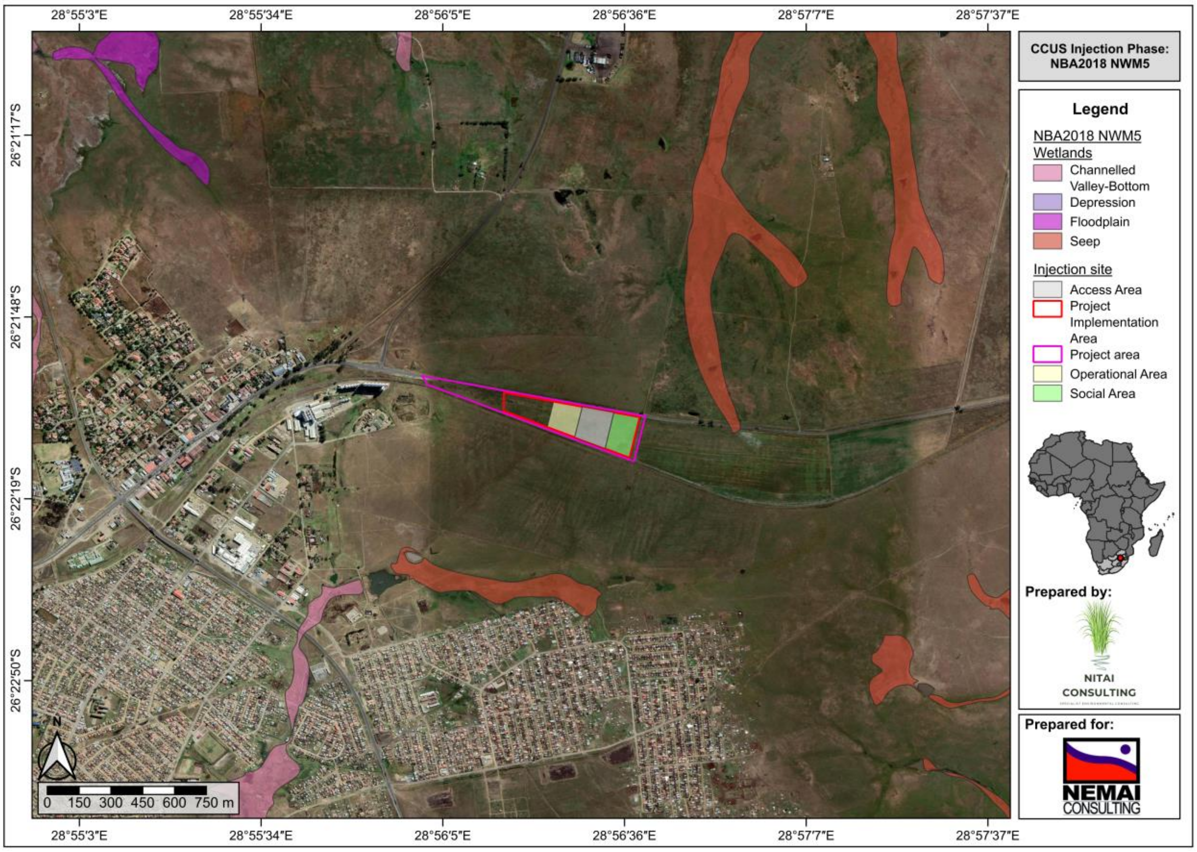

Figure 43: Map indicating the wetland HGM units associated with the study area

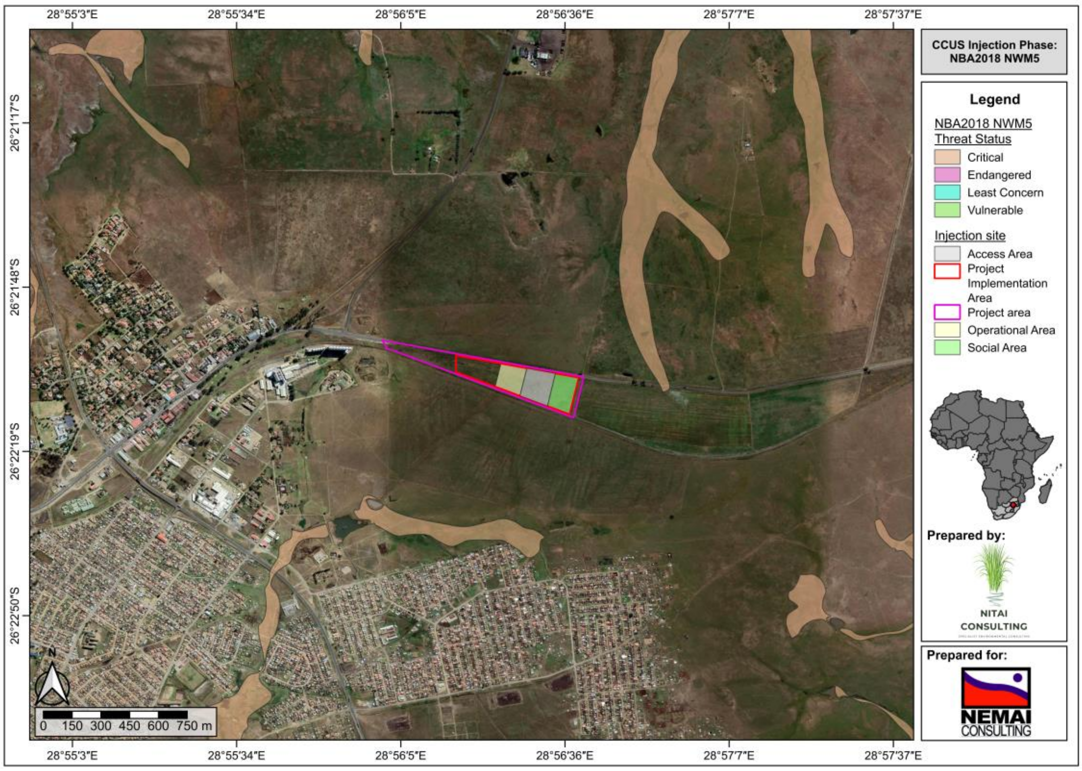

Figure 44: Map indicating the threat status of all the wetlands surrounding the study area

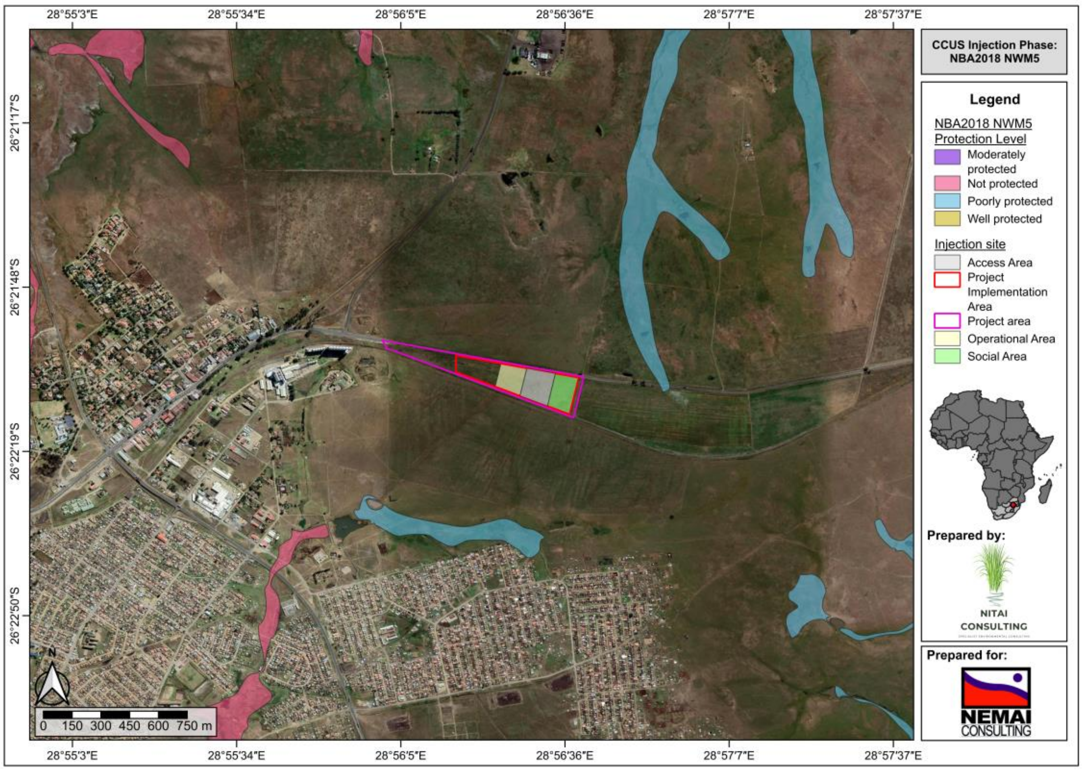

Figure 45: Map indicating the protection level of all the wetlands surrounding the study area

10.7.3 Strategic Water Source Areas

Strategic Water Source Areas (SWSA) are either (a) areas that supply an uneven (large quantity) amount of mean annual surface water runoff in relation to their size and are therefore considered to be nationally important or (b) have high groundwater recharge and where the groundwater forms nationally important resource or (c) areas that meat both criteria (a) and (b) (Nel *et al*., 2013; Le Maitre *et al*., 2018). Areas that supply these disproportionate amounts of water can be because of climatic conditions such as high rainfall, or physical properties (ability of the soils and underlying weathered material and rocks to store water as groundwater) (Le Maitre *et al*., 2018). In SA, 22 SWSA surface water and 37 SWSA groundwater areas has been identified to be strategically important at national level for water and economic security (Le Maitre *et al*., 2018).

The study is situated outside the surface water SWSA (Figure 46). Within the Vaal Water Supply Scheme (WSS), SWSA-sw accounts for 67% of the total volume of water whereas the Olifants regional WSS accounts for the lowest (Le Maitre *et al*., 2018).

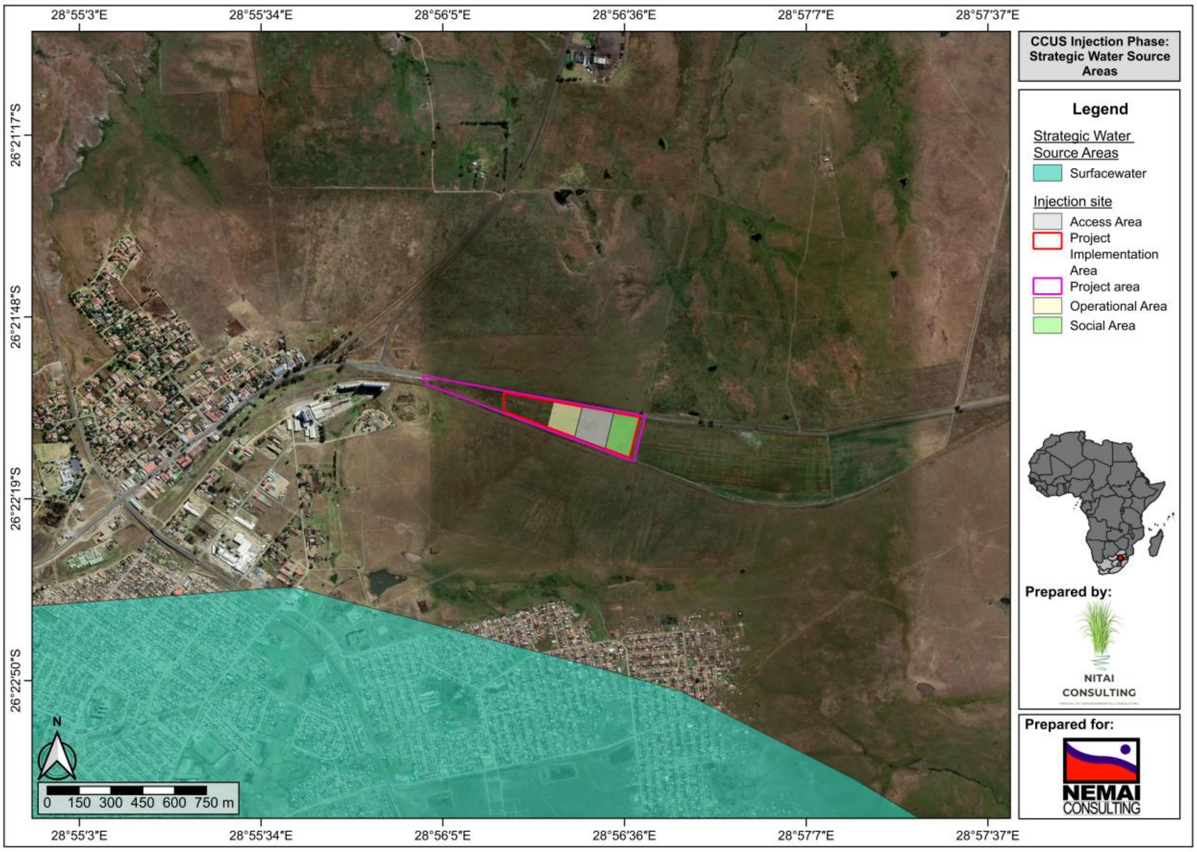

Figure 46: Map indicating the SWSA in relation to the study area

10.7.4 Mpumalanga Biodiversity Sector Plan

10.7.4.1 Critical Biodiversity Areas

On a regional scale, terrestrial and aquatic biodiversity conservation priorities are highlighted in the Mpumalanga Biodiversity Sector Plan (Lotter *et al*., 2014). A Biodiversity Sector Plan provides a map (or maps) of terrestrial and freshwater areas that are important for conserving biodiversity pattern and ecological process – these are called Critical Biodiversity Areas (CBA's) and Ecological Support Areas (ESA's) (Lotter *et al*., 2014). Furthermore, the Biodiversity Sector Plan includes two separate maps (terrestrial and freshwater CBA's).

CBA's are areas that are required to meet each ecosystem's biodiversity target while being maintained in an appropriate ecological condition for their category, referred to as the land management objective. These include all areas required to meet biodiversity pattern targets and to ensure continued existence and functioning of species and ecosystems, special habitats and species of conservation concern. In addition, these areas also include critical endangered ecosystems and critical linkages to maintain connectivity. The CBA map of the Mpumalanga relies on the NFEPA project and includes three sub-categories of CBA's (CBA Aquatic species, CBA Rivers and CBA Wetlands) (Lotter *et al*., 2015).

The spatial dataset from Lotter *et al*. (2014) highlights that the study area does not fall within a CBA (Figure 47). The study area is rather situated heavily modified areas with a very small portion situated in other natural areas (Lotter *et al*., 2015).

10.7.4.2 Ecological Support Areas

ESA's are terrestrial and freshwater areas that are not essential for meeting biodiversity representation targets, but which nevertheless play an important role in supporting the ecological functioning of CBA's (Lotter *et al*., 2014). Furthermore, ESA's need to be maintained in a functional or near natural state, supporting the purpose for which they are identified. These include natural features such as riparian habitat surrounding rivers or wetlands, corridors, over-wintering sites for Blue Cranes (Lotter *et al*., 2014).

According to the Mpumalanga Biodiversity Sector Plan, ESA's are categorised into five sub-groups namely: Wetlands, Wetland Clusters, Important Sub-Catchments, Fish Support Areas and SWSA (Lotter *et al*., 2015).

From the Mpumalanga Biodiversity spatial data, the study area is not situated within any ESA's (Figure 47). To the south of the injection site, there is an ESA and is as a result of being a wetland.

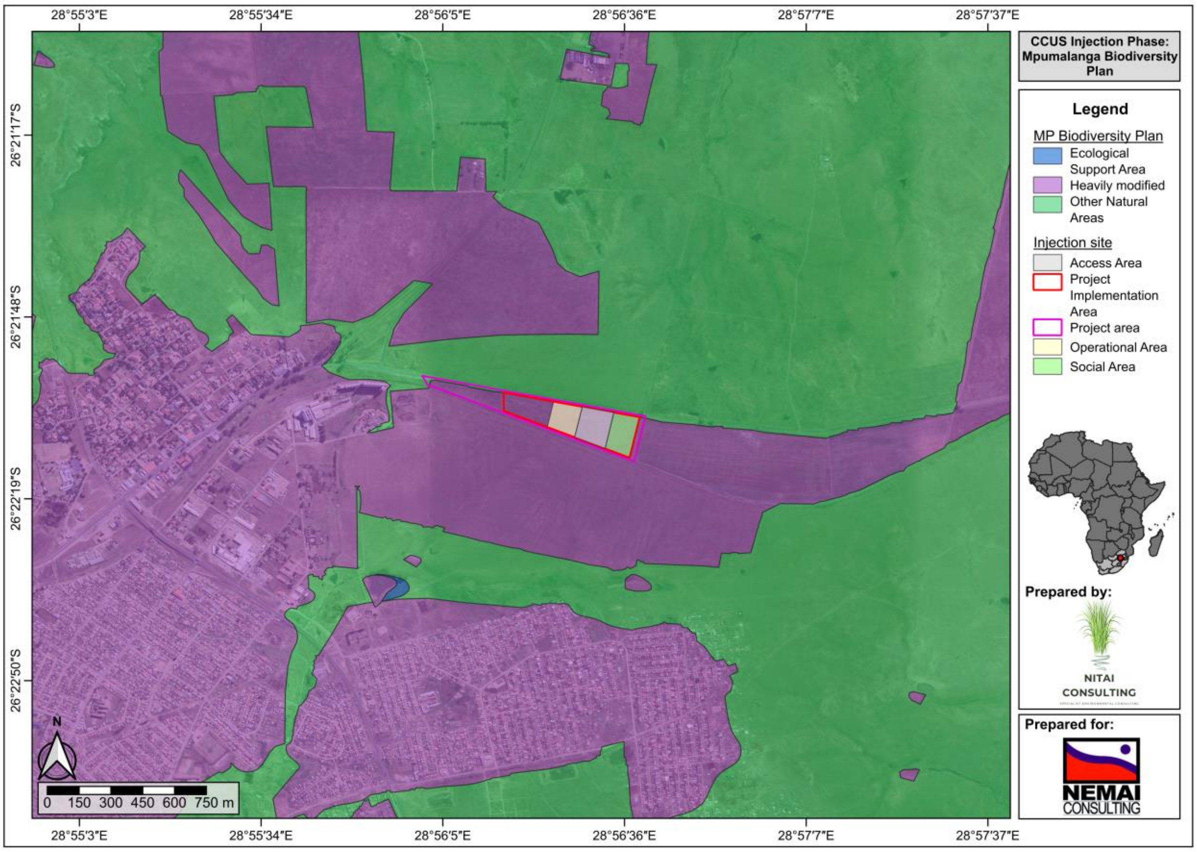

Figure 47: Map indicating the Aquatic CBA's Levels 1 and 2 in relation to the study area

10.7.5 Findings from the Field Assessment

10.7.5.1 Watercourses in the Study Area

During the site visits to the study area, several watercourses (wetlands, a river, and a drainage lines) were identified within 500 m of the injection site (Figure 48). However, no wetlands or rivers were observed and only one drainage line was found on the site. The Kromdraaispruit, which is a perennial river, is located north of the injection site and flows in a northerly direction away from the site. A drainage line flows across the injection site in a southerly direction towards a small dam located near Lebohang. Three wetlands were observed within a 500 m radius of the injection site, namely two small Dep and one large CVB (Figure 48). Figure 49 depicts the general environment of the injection site and highlights the terrestrial environment.

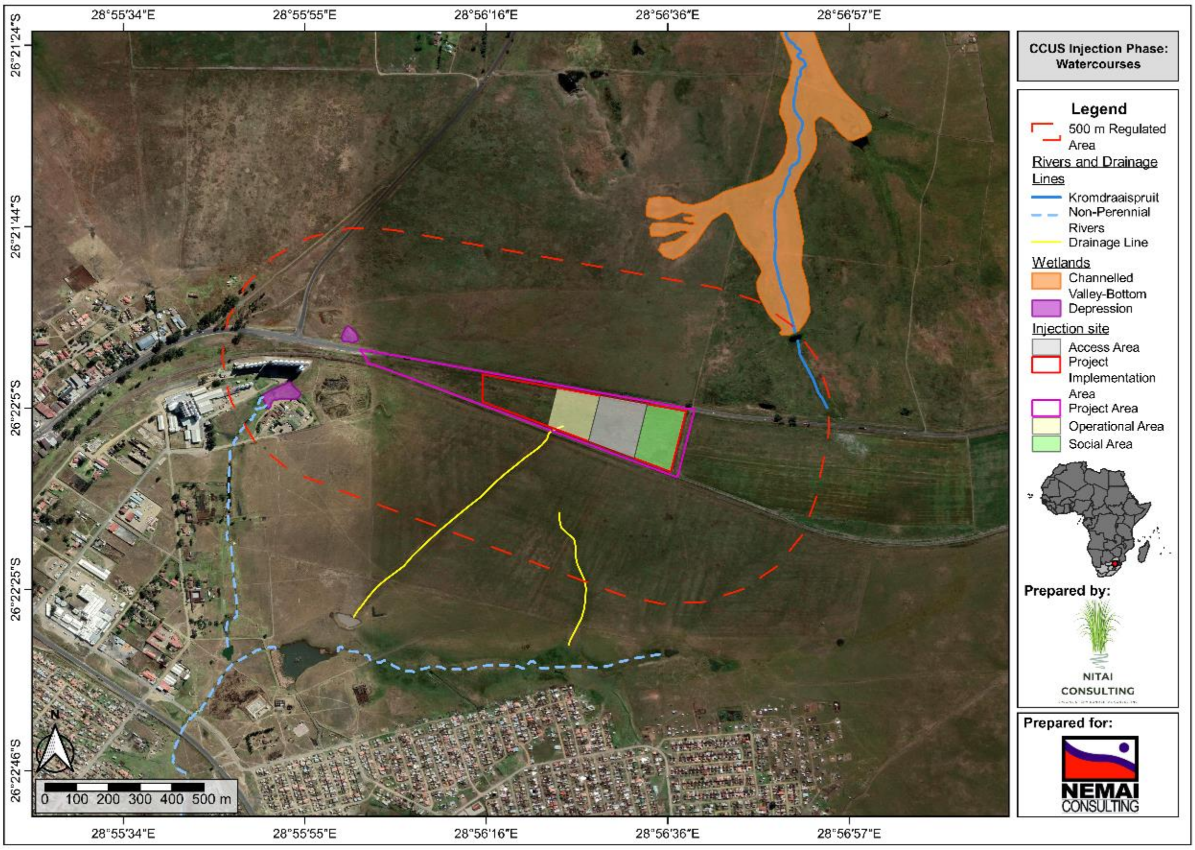

Figure 48: Watercourses associated with the injection site as well as the 500 m regulated area

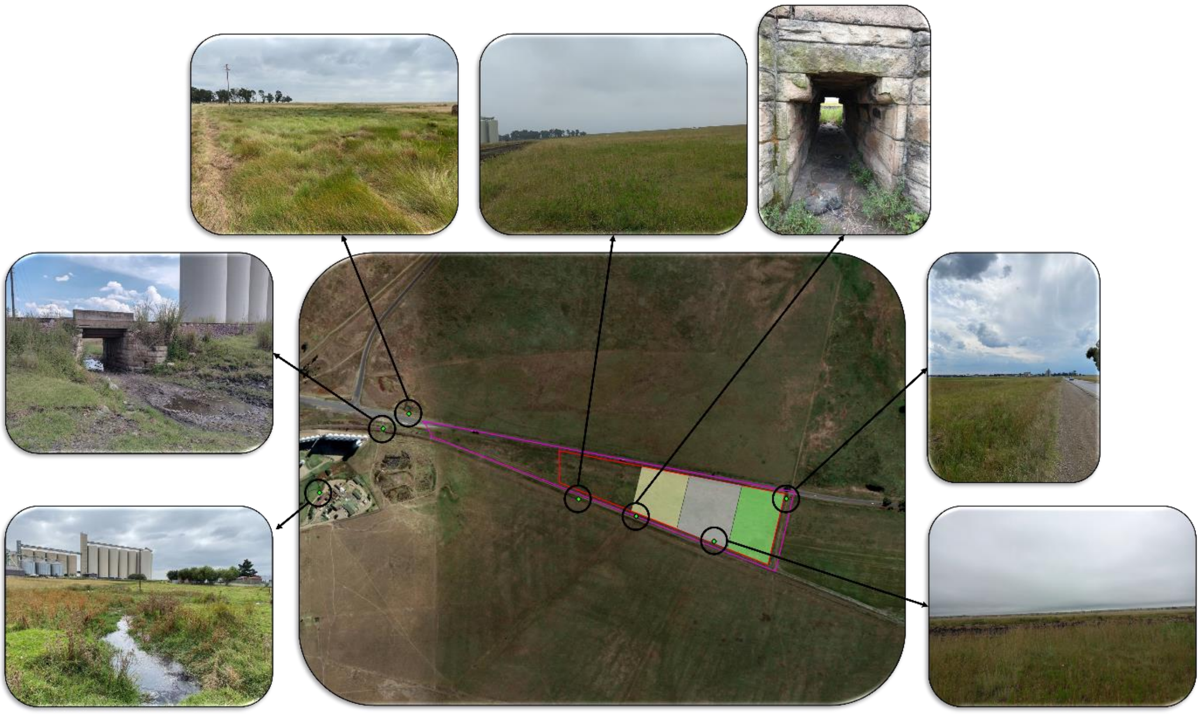

Figure 49: Photographs indicating the general environment around areas of interest within the study area

10.7.5.2 Wetlands

No wetlands were identified on the injection site, however, three wetlands were identified within a 500 m radius of the site (see Figure 50 below). A large CVB is located along the channel of the Kromdraaispruit to the north of the injection site. Two small Dep are located to the west of the injection site.

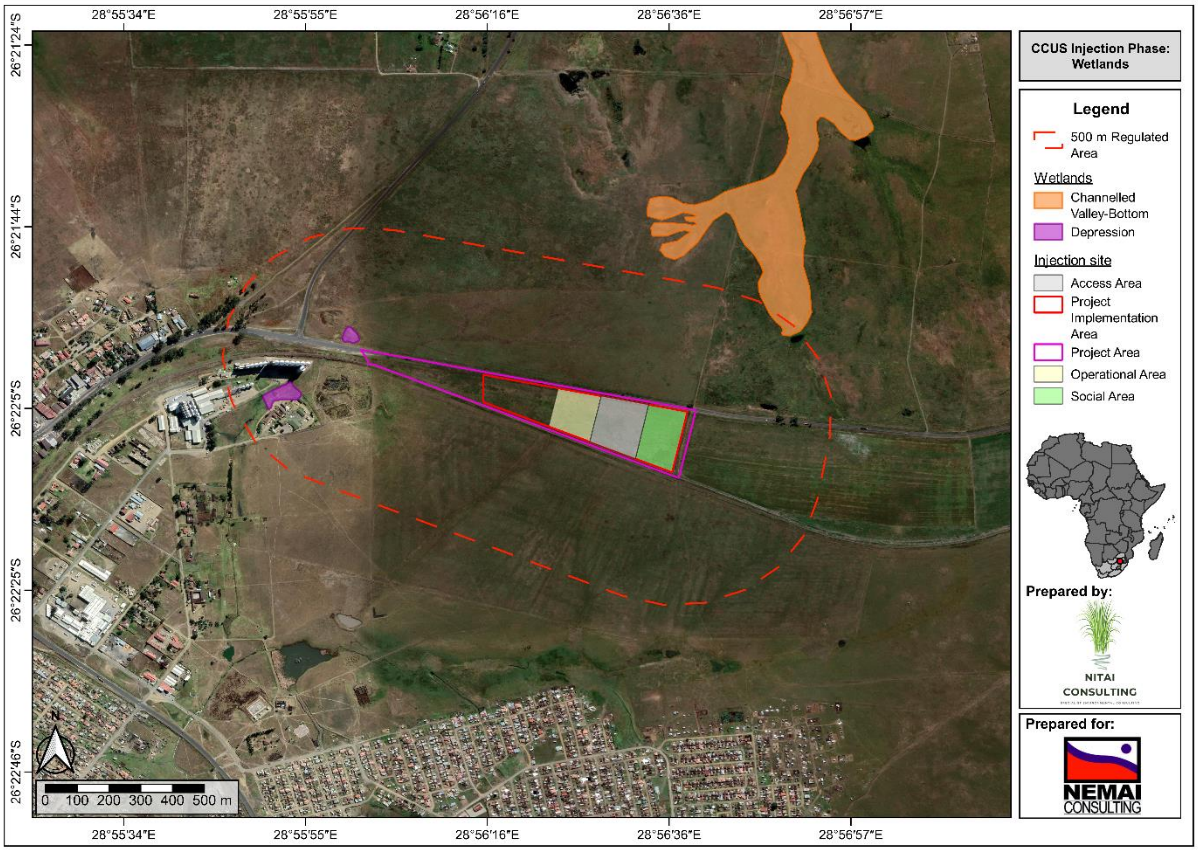

Figure 50: All identified wetlands within 500 m from the injection site

10.7.5.3 Rivers and Drainage Lines

One perennial river, the Kromdraaispruit, was found north-east of the study area and is flowing to the northerly before draining into the Wilge River (Figure 51). In addition, one drainage line is found within the study area (Figure 51). The drainage line (with a culvert underneath the railway) conveys surface runoff from the R29 away from the injection site into a small agricultural dam to the south near Lebohang.

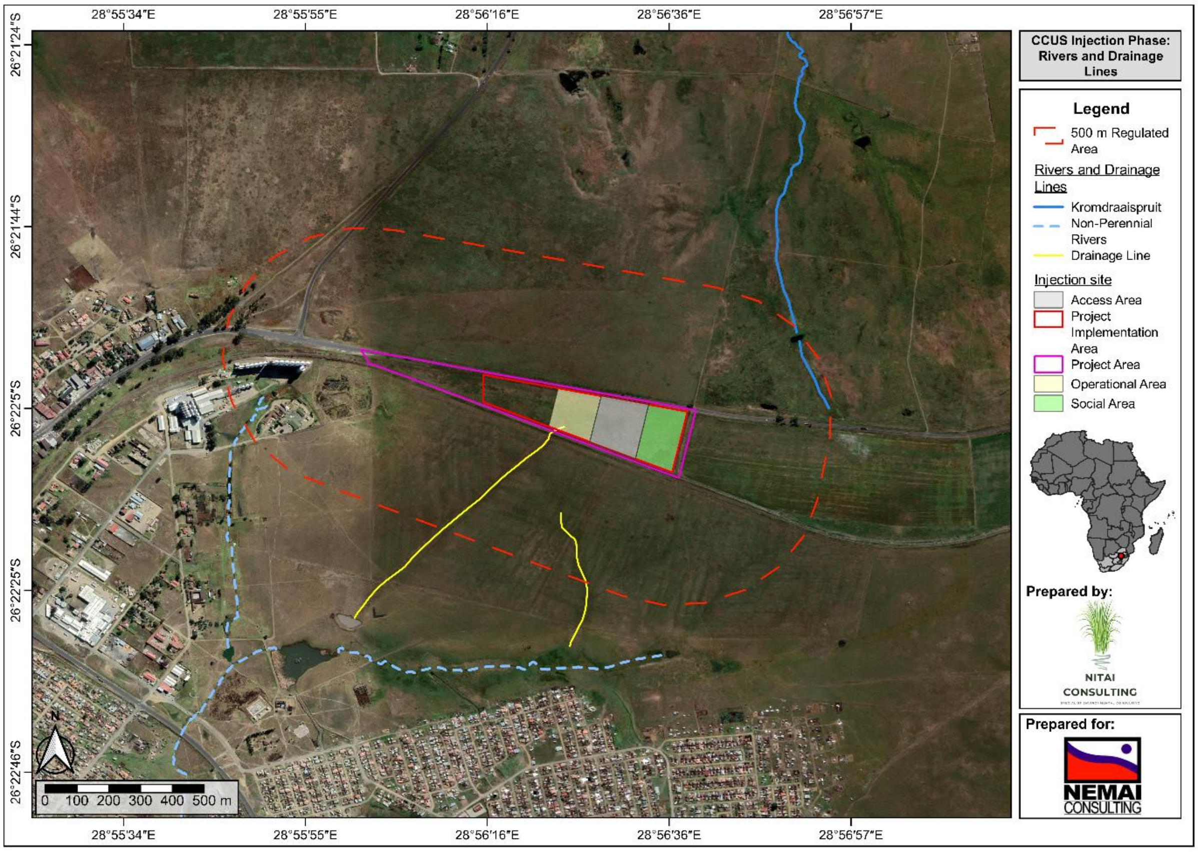

Figure 51: All identified rivers and drainage lines within the study area

10.7.5.4 Vegetation Characteristics

During the site visit, vegetation characteristics indicative of wetland habitats were observed. Typical vegetation species indicating wetness included *Typha capensis*, *Juncus punctorius*, *Cyperus fastigiatus*, *Cynodons dactylon*, *Persicaria lapathifolia*, and *Paspalum dilatatum* (Figure 52).

Figure 52: Vegetation characteristics associated with the study area. Photographs highlight the different species (a) *Persicaria lapathifolia*, *Paspalum dilatatum* and *Cynodons dactylon*, (b) *Juncus punctorius*, (c) *Typha capensis*, (d) *Cyperus fastigiatus* and (e) *Juncus punctorius* and *Typha capensis*

10.7.5.5 Present Ecological State

The Present Ecological State (PES) (Macfarlane *et al*., 2020) was determined for the wetlands verified on site during the fieldwork. The calculated PES scores for the Dep wetland were C (Moderately modified) and for the CVB the PES was also calculated as C (Moderately modified) (Table 21). Water quality was not included in the PES calculations as water quality did not form part of the overall assessment.

Table 21: PES scores calculated for CVB and Dep HGM units

HGM Unit	Hydrology	Geomorphology	Vegetation	Overall
Channelled Valley-Bottom	C (Moderately modified) Impact score: 3.1	C (Moderately modified) Impact Score: 2.8	C (Moderately modified) Impact Score: 3.0	C (Moderately modified) Impact score: 3.4
Depression	C (Moderately modified) Impact Score: 3.7	C (Moderately modified) Impact Score: 3.2	C (Moderately modified) Impact Score: 3.5	C (Moderately modified) Impact Score: 3.5

10.7.5.6 Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity (EIS) (Rountree *et al*., 2013) was determined for all the wetlands verified on site during the fieldwork. EIS categories for the Dep and CVB wetlands were calculated as Moderate (C) for both (Table 22). The majority of the wetlands identified are according to the Mpumalanga Biodiversity Sector Plan situated in Other Natural Areas (refer to Figure 47).

Table 22: EIS of the two HGM units south of the injection site

HGM Unit	Ecological Importance and Sensitivity
Channelled Valley-Bottom	Moderate (1.34)
Depressions	Moderate (1.64)

10.7.6 Wetland Ecosystems Services

The wetland ecosystem services (Kotze *et al*., 2020) for the wetlands identified during the site visit are shown in Table 23 (see Table 24 for description of impact category ratings). The wetlands were particularly Moderately-Low and Highly valuable for biodiversity maintenance. This is due to the wetlands being situated in an ESA. In addition, both wetlands are moderately valuable for cultivated foods and of low importance for livestock.

Table 23: Wetland Ecosystem Services calculated for the CVB and Dep HGM units

Ecosystem Services		Score			
		Depressions	Importance	Channelled Valley-Bottom wetland	Importance
Regulating and Supporting Services	Flood attenuation	0.0	Very Low	0.0	Very Low
	Stream flow regulation	0.0	Very Low	0.0	Very Low
	Sediment trapping	1.5	Moderately-Low	0.9	Low
	Erosion control	0.0	Very Low	0.1	Very Low
	Phosphate assimilation	1.6	Moderately-Low	0.9	Low
	Nitrate assimilation	1.3	Moderately-Low	0.6	Very Low
	Toxicant assimilation	2.1	Moderate	1.4	Moderately-Low
	Carbon storage	0.0	Very Low	0.0	Very Low
	Biodiversity maintenance	2.2	Moderate	2.7	High
Provisioning services	Water for human use	1.4	Very Low	0.0	Very Low
	Harvestable resources	0.8	Low	0.7	Very Low
	Food for livestock	0.8	Low	0.8	Low
	Cultivated foods	1.7	Moderate	2.0	Moderate
Cultural Services	Tourism and Recreation	0.0	Very Low	0.0	Very Low
	Education and Research	0.0	Very Low	0.0	Very Low
	Cultural and Spiritual	0.5	Very Low	0.5	Very Low

Table 24: Importance Category ratings

Importance Category		Description
Very Low	0-0.79	The importance of services supplied is very low relative to that supplied by other wetlands.
Low	0.8 – 1.29	The importance of services supplied is low relative to that supplied by other wetlands.
Moderately-Low	1.3 – 1.69	The importance of services supplied is moderately-low relative to that supplied by other wetlands.
Moderate	1.7 – 2.29	The importance of services supplied is moderate relative to that supplied by other wetlands.
Moderately-High	2.3 – 2.69	The importance of services supplied is moderately-high relative to that supplied by other wetlands.
High	2.7 – 3.19	The importance of services supplied is high relative to that supplied by other wetlands.
Very High	3.2 - 4.0	The importance of services supplied is very high relative to that supplied by other wetlands.

10.7.6.1 Desktop sensitivity assessment (DFFE Screening Tool)

According to the DFFE Screening Tool, the Aquatic Biodiversity Theme for the study area shows very high as well as low sensitivity (Figure 53). The very high sensitivity is due to watercourses situated within the greater area. Due to the nature of the proposed Project, the Aquatic Specialist is of the opinion that the proposed activities do not pose significant risks to aquatic features as long as the recommendations and mitigation measures are followed.

Figure 53: Aquatic Biodiversity Sensitivity Theme according to the Screening Tool

10.7.6.2 Buffer Zones

A buffer zone was determined for the drainage line that flows across the injection site. The buffer zone was calculated based on the Macfarlane and Bredin (2017) guidelines and determined as 32 m (Figure 54). No construction or operational activities can take place within the drainage line.

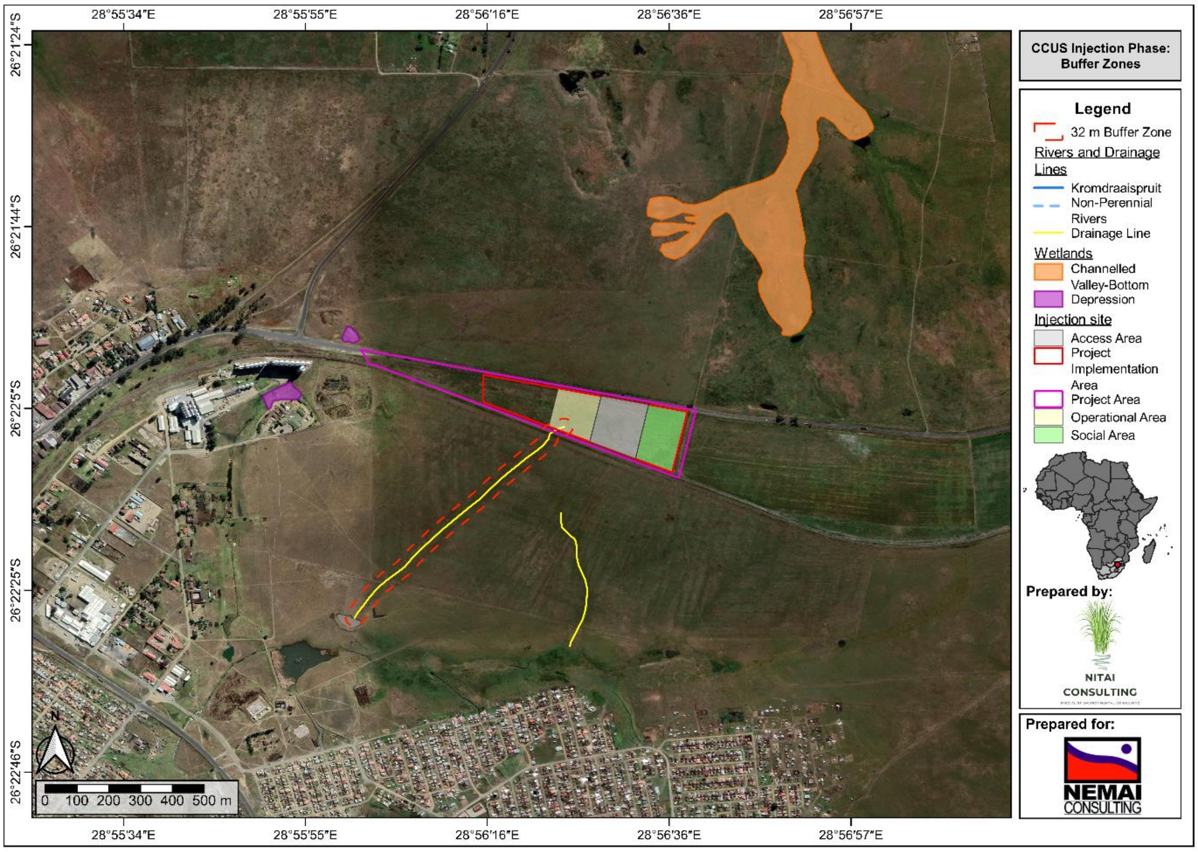

Figure 54: Buffer zone determined for the drainage line that flows across the project area

10.8 Waste management

10.8.1 Introduction

The characterization of the waste management from the Project will involve the legal framework, the identification of the types of expected waste in the construction, operation, and decommissioning phases, as well as the identification of the waste management systems that serve the area under study. This survey will serve to plan the effective management of the waste produced within the scope of the Project.

During the Project, different categories of waste will be produced, most of the waste will be generated during the construction and decommissioning phase. In the construction phase, significant quantities of construction and demolition waste and waste resulting from drilling (excavated earth material) will be produced. In the decommissioning phase, construction and demolition waste stands out.

10.8.2 Waste management system and infrastructure

10.8.2.1 Province Scope

In accordance with the State of Waste Report of South Africa (2018) (DEA, 2018), Mpumalanga had 137 licensed waste management facilities (publicly and privately owned) in 2017. According to a 2016 survey, referred to in the report, there were no unlicensed disposal facilities in Mpumalanga.

Most of the licensed facilities in 2017 were for disposal (84), followed by storage (20), recycling and recovery (12), decommissioning/closure (7), treatment (6), remediation of contaminated land (4), transfer stations and/or drop off points (3), and recycling, recover and treatment (1). The characterisation of the facility is based largely on its primary function. For example, while a landfill site may be authorised to recycle, recover, or treat waste, its primary function remains the disposal of waste (DEA, 2018).

Mpumalanga generates approximately 9.1 % of the general waste produced in SA. This represents the third highest per capita waste generation of all the country's provinces. The province is also the largest producer of hazardous waste in SA (Mpumalanga Province, 2016).

Although the Mpumalanga Province is a major producer of waste only 38 % of households had their waste collected by the local authority or a private company in 2017. Approximately 52 % of households in Mpumalanga dispose of their waste at their own or a communal dump (DEA, 2018).

In the rural areas the majority of households dispose of their waste at their own waste dump or at a community waste dump (76 %), while only 10 % of households have their waste collected. Around 13 % of the households reported leaving or dumping their waste anywhere or using some alternative solution. In contrast, in the urban areas of Mpumalanga, the majority of households have their waste collected by the local authority or a private company (82 %) (DEA, 2018).

10.8.2.2 Municipality Scope

GSDM has 26 waste management sites, 13 licensed as landfill sites, 8 licensed as transfer station and 5 sites licensed for closure (GSDM, 2021). In accordance with the Integrated Development Plan (IDP) 2021/22 of GSDM in Govan Mbeki exists three (3) landfill sites (in Leandra, Bethal and Secunda) and two facilities licensed to close (in Kinross and Evander).

On the other hand, according to the IDP 2021/22 of GMLM, the local municipality has 3 licensed operational sites to landfill (Leandra, Bethal, Secunda) and 5 closed licensed landfill sites (Evander, Lebohang, Bethal-Morgenzon, eMbalenhle and Kinross). However, as part of a feasibility study carried out on the waste management facilities, it was found that the Secunda landfill is running out of space, with a remaining useful life of between one (1) and two (2) years. Thus, the landfill of Leandra is identified as the central landfill of the municipality (GMLM, 2021). The localization of the landfill sites of Govan Mbeki that existed in 2014 are presented in Figure 55**Error! Reference source not found.**.

Based on this information, it can be seen that there are no facilities in the municipality where its main activity is dedicated to recycling and recovery or to the treatment of waste.

The Leandra landfill is the one closest to the pilot project area under study, and as such, it is the preferred landfill for the disposal of waste produced during the execution of the Project.

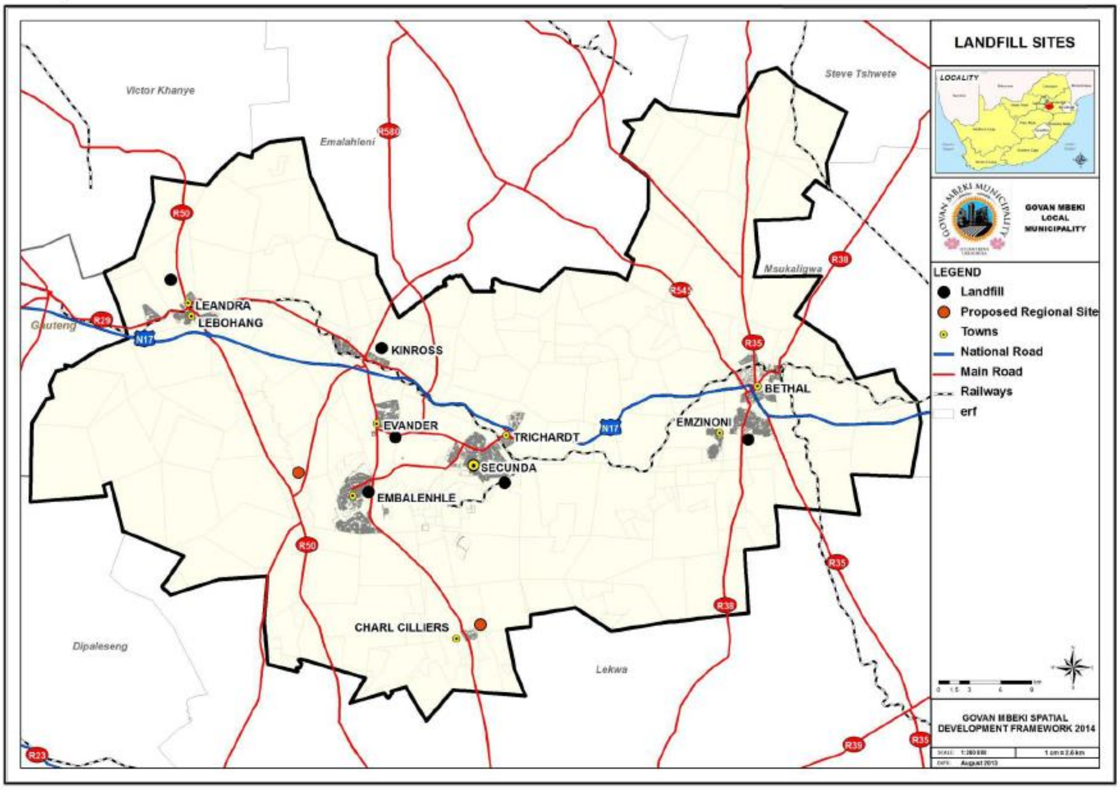

Figure 55: Landfill sites of GMLM (2014)

Although there are several landfills in GMLM, the municipal IDP 2021/2022 states that their infrastructure, as well as maintenance actions, do not meet the minimum requirements for the disposal of waste to landfill in accordance with the regulations under the Waste Act (GMLM, 2021).

From 2018 to 2021 it is found that annually more 90 % of the waste managed in GMLM goes to landfill. The quantitative values of waste managed in Govan Mbeki are presented inTable 25. From this it is possible to verify that most of the waste generated in the municipality is hazardous waste.

The general waste produced and managed in Govan Mbeki is mainly "commercial and industrial waste" (Table 26), followed by the category "Construction and Demolition Waste". As for the composition of hazardous waste (Table 27), more than 98 % corresponds to bottom ash.

Table 25: Quantity of waste managed in GMLM by type of management (SAWIS, 2022)

Management option	Waste	Year			
		2018	2019	2020	2021
Disposal of waste to land (e.g., specially engineered landfill) (mt)	General	4 883,82	71,21	60,26	51,37
	Hazardous	4 333,71	9 907,70	9 528,51	10 007,68
Disposal of waste to landfill (e.g., non-engineered landfill) (mt)	General	63,31	38,18	26,34	16,25
	Hazardous	0,00	0,00	0,00	0,00
Recycling of metals and metal compounds (mt)	General	0,00	0,00	0,00	0,00
	Hazardous	1,20	1,48	1,74	1,41
Recycling of other inorganic materials (mt)	General	*n. a*	635,10	90,00	2,47
	Hazardous	*n. a*	0,00	0,00	0,00
Biological treatment (e.g., biodegradation, composting, biogas generation) (mt)	General	0,00	0,00	0,00	0,00
	Hazardous	12,47	13,12	9,55	10,27
Thermal treatment (incineration, pyrolysis etc.) (mt)	General	0,00	0,00	0,00	0,00
	Hazardous	153,3	158,70	165,22	107,17
TOTAL (mt)	General	4 947,13	744,49	176,59	70,09
	Hazardous	4 500,61	10 081,00	9 705,01	10 126,53

Table 26: Composition of general waste generated and managed in GMLM (2021) (SAWIS, 2022)

General Waste	Source (%)	Receiving (%)
Commercial and industrial waste	75,97	73,60
Construction and demolition waste	4,95	4,77
Glass	*n. a*	0,07

General Waste	Source (%)	Receiving (%)
Metals (Ferrous and non-ferrous)	*n. a*	0,39
Municipal waste	9,14	9,02
Organic waste (garden and/or wood)	0,28	1,36
Other	9,67	9,60
Paper	*n. a*	0,38
Plastic	*n. a*	0,63
Slag (Ferrous and non-ferrous)	*n. a*	0,02
Tyres	*n. a*	0,15

Table 27: Composition of hazardous waste generated and managed in GMLM (2021) (SAWIS, 2022)

Hazardous Waste	Source (%)	Receiving (%)
Bottom ash	98,81	98,66
Liquid and sludge (organic, inorganic)	1,04	1,14
Mineral waste (foundry sand or other)	*n. a*	0,01
Miscellaneous	0,01	0,02
Organic halogenated and /or sulphur containing solvents	0,12	0,12
Solid organic waste	*n. a*	0,02
Waste oils: Waste oil	0,01	0,03

10.8.3 Potential Destinations Outside Waste Management Systems

According to the kick-off meeting and respective site visits, it was noted that the surrounding region has several industrial quarries, where the quarried material is used for construction activities, including buildings and roads.

In Leandra there is a quarry and an asphalt plant used for the manufacture of asphalt, macadam and other forms of coated roadstone. Furthermore, a new industrial quarry is being proposed at Leandra, adjacent to the existing quarry. This new facility will operate for three years and the aggregate to be removed from it will be used for the construction industry nearby. The proposed quarry will therefore contribute to the upgrading / maintenance of road infrastructure and building contracts in and around the Leandra area (Greenmined Environmental, 2021). The location of the existing quarry and the new quarry project at Leandra is shown in Figure 56.

The aforementioned quarries and asphalt plant can thus provide a destination for the bedrock removed in the drilling. Allowing the rock removed to become a resource rather than a waste.

As well as being used as a resource for building or road construction, the extracted rock can also be used in the decommissioning phase of quarries.

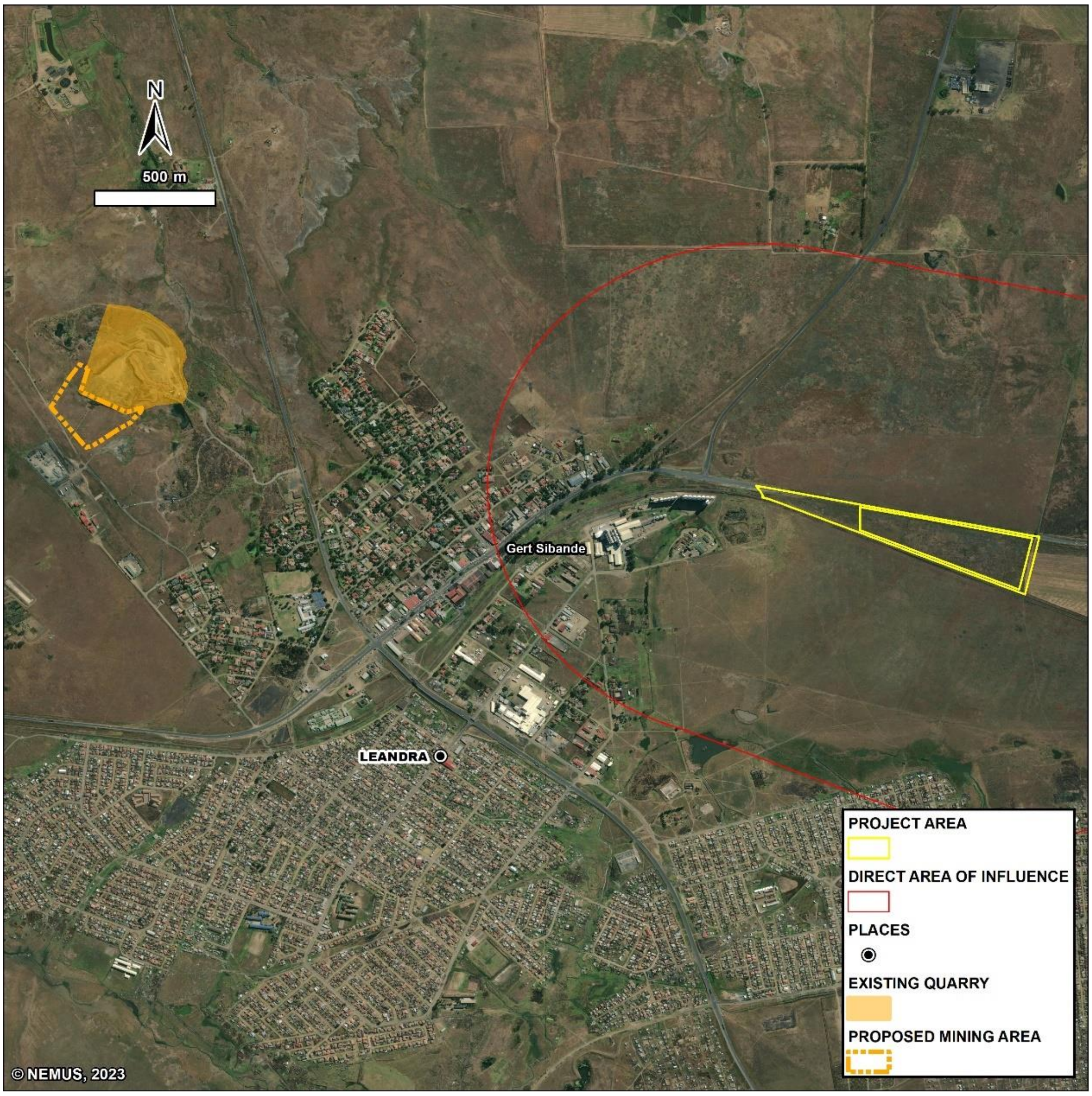

Figure 56: Location of the existing quarry and the new quarry project at Leandra

10.8.4 Summary

NEM:WA aims to ensure human health and safety and the quality of the environment, promoting the responsibility of the various actors in the process and the hierarchy of operations. In summary the legislation on waste management intends that its generator:

- Avoid and minimize the production of waste;
- Manage waste so that it does not endanger health or the environment;
- Ensures that waste is transported, treated, and disposed of properly;
- Keep accurate and up to date records of the management of the waste they generate;

- Comply with all related legislation in force, namely, when necessary, notify the responsible entities, implement management plans, request licences.

The following is noted in terms of waste collection services:

- The Municipality must provide or ensure a service for the collection and removal of domestic waste;
- The collection of industrial waste is carried out by an entity contracted by the municipality;
- The occupier of premises on which building, and demolition waste is generated must ensure that the waste is collected and transported by an accredited service provider;
- The occupier of premises must only have hazardous waste removed by a contractor approved by the competent authority.

There are no facilities in GMLM whose main activity is recycling and recovery or waste treatment. The closest landfill to the site is at Leandra, where waste from the Project can be disposed of.

The Leandra quarries and the asphalt plant are places where the rock extracted from the boreholes can be redirected, making it a resource rather than waste.

10.9 Environmental Quality

10.9.1 Light Pollution

Light pollution is the presence of excessive artificial light and is the result of urbanisation and industrialisation, mainly due to the misuse of public lighting (poorly designed outdoor lighting or the use of inappropriate luminaires).

There are five different types of light pollution:

- Over-illumination, the use of excessive amounts of light energy;
- Glare, where the light emitted is reflected off a surface creating excessive brightness that causes visual discomfort;
- Light clutter, excessive grouping of lights that causes confusion;
- Skyglow, light pollution that makes the night sky brighter; and
- Light trespass, when light shines outside of the area it´s intended to illuminate (unwanted light trespassing onto someone's property).

The World Atlas of Night Sky Brightness (www.lightpollutionmap.info), published in 2016, presents a map showing of light pollution based on a computer model that analyses satellite images. In the project implementation area, the radiance varies approximately between 1,4 and 2,5 $*10^{-9}$ W/cm^2 *sr, with an increase of about 6,2 % between 2012 and 2021, mainly influenced by light pollution from residential and industrial areas. **Error! Reference source not found.** shows the radiance (NIIRS - Visible Infrared Imaging Radiometer Suite, 2021) verified in Leandra, including in the project area.

According to available satellite imagery, there are no lighting poles on the road adjacent to the project area. However, there are **occasional sources** of light from **cars and trains** travelling on the road and railway respectively. Apart from these, the closest **source of lighting** to the project area is expected to be the adjacent **industrial/commercial units**. In Lebohang and Leslie, there will be more artificial sources of light, namely outdoor lampposts, residences and businesses.

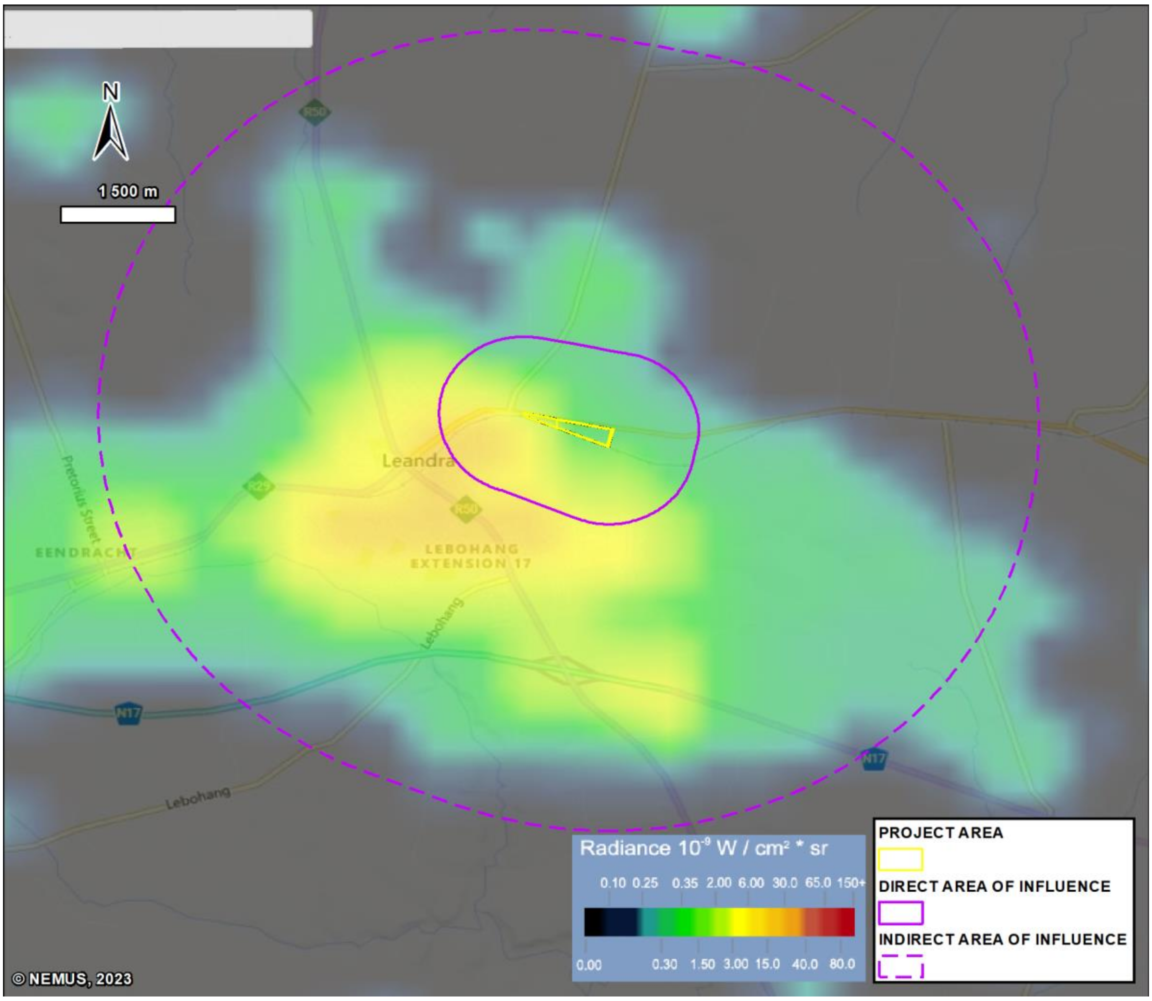

Figure 57: Light pollution in Leandra's (2021) (Microsoft Corporation; TomTom, 2023)

A report Review and Assessment of Available Information on Light Pollution in Europe (Widmer, *et al*., 2022) has developed a framework (**Error! Reference source not found.**) w hich presents ecological thresholds to assess light pollution levels in ecological zones of terrestrial and aquatic sites.

According to this review, light emissions above 2 $nW/cm^2/sr$ are likely to have at least a minor impact on ecosystems and their wildlife. The threshold of 2 $nW/cm^2/sr$ corresponds to typical light levels emitted by small villages or sparsely populated residential areas.

The lowest threshold of 0,5 $nW/cm^2/sr$ exists because light emissions around this level come from artificial light sources with a minimum luminous intensity so low that it is difficult and uncertain to distinguish from natural night light from the moon and stars.

Table 28: Thresholds to classify ecological light emissions (Widmer, *et al*., 2022)

Light emission ($nW/cm^2/sr$)	Description of light emission thresholds
< 0,5	Lowest light emission values
0,5 – 2*	Very low light emission values
2 - 10	Low light emission values
10 - 20	Medium light emission values
> 20	High light emission values

*At light emission above 2 $nW/cm^2/sr$ at least low levels of ecological impacts are expected.

From this information, it is possible to verify that the existing lighting level in the project area (1,4 to 2,5 nW/cm2 *sr) is between two thresholds (very low and low light emission values), with the lower threshold being more appropriate. In this sense, the existing lighting in the project area has little or no impact on ecosystems.

10.9.2 Noise and Vibration

10.9.2.1 Introduction

This Section develops the noise characterisation of the study area, which includes the project intervention area as well as the sensitive receptors and noise sources in its vicinity defined in the project influence area.

Noise and vibration pollution is currently one of the main factors in the deterioration of people's quality of life and well-being. This degradation can have negative effects on human health, including aggravation of hearing problems (from fatigue to trauma), psychological problems (such as stress, irritability, difficulty concentrating) and physiological problems (sleep disturbance).

The background noise of a given location can be defined as the ambient noise existing at that location before the introduction of a particular acoustic disturbance or pressure source, which may be temporary or permanent.

In this context, it is proposed to characterise the noise and vibration environment in the area of potential influence of the Project, to assess the impact of the noise and vibration descriptors for the construction, operation and decommissioning phases and, if necessary, to propose minimization measures to comply with the recommended levels.

The characterisation will include a review of local laws and regulations, identification of the main sources of noise and vibration, and identification of sensitive areas in the vicinity of the project site.

10.9.2.2 Laws, Regulations and Guidelines

Regulations and standards for noise and vibration are set out in Section 25 of the Environmental Conservation Act (Act No. 73 of 1989) (ECA).

The National Noise Control Regulations (GN R154 in Government Gazette No. 13717 dated 10 January 1992) were promulgated in terms of Section 25 of the ECA. These regulations aim to control noise, vibration and shock with a view to their prevention, reduction or elimination. This law establishes the prohibitions and restrictions and the methodology for the use of noise measuring equipment. It also provides for the identification of "controlled areas", i.e., areas close to a road or an industry, where the established noise limits are exceeded. Controlled areas are subject to specific restrictions.

According with the Noise Control Regulations a disturbing noise "*means a noise level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dBA or more*".

One of the general restrictions they impose is that "*no person shall use any power tool or power equipment for construction, earth drilling or demolition works, or allow it to be used, in a residential area before 06:00 and after 18:00 from Monday to Saturday; and at any time on any Sunday*".

In relation to restrictions on disturbing noise no person may "*operate any machinery, saw, sander, drill, grinder, lawnmower, power garden implements or similar device in a residential area, or allow it to be operated, if it may cause a noise nuisance*".

The GSDM Noise Control By-law is published in the Mpumalanga Province Gazette under Notice No. 2300 of 21 May 2014. This by-law adds to the definition of disturbing noise laid down by the Noise Control Regulations as any noise that exceeds the "*typical rating levels for ambient noise in districts, indicated in table 2 of SANS 10103 excluding residential source of disturbing noise*".

The following noise nuisance controls are set out in the GSDM Noise Control By-law:

- No person may operate any machinery, saw, sander, drill, grinder, lawnmower, power tool or similar device or allow it to be operated in a residential area during the hours set out in the corresponding act;
- No person may use any power tool or power equipment for construction work, drilling work or demolition work, or allow it to be used in or near a residential area during the hours set out in the corresponding act.

The project implementation area is not categorised under the GMLM Land Use Scheme and therefore noise and vibration restrictions for residential areas do not apply. However, it is close to residential areas.

Noise is also controlled by the Prevention and Suppression of Nuisances By-Laws in Govan Mbeki. This by-law restricts the hours of activities that have a high potential to cause noise in residential areas to certain hourly periods.

In addition to national regulations, it is important to consider the IFC Environment, Health and Safety Guidelines, particularly those relating to Noise Management. This document provides guidelines for noise levels that can be considered

Noise characterisation and impact assessment should be done based on the South African National Standards (SANS) guidelines, these published by the South African Bureau of Standards. The following standards should be considered:

- SANS 10328:2008, provides methods for environmental noise impact assessment;
- SANS 10103:2008 covers the measurement and assessment of environmental noise in terms of annoyance and speech communication. The standard specifies the acceptable noise levels in residential and non-residential areas where data on the local background noise are not available. In addition, the standard anticipates public annoyance based on the noise level being exceeded;
- SANS 10357:2004 presents the calculation of sound propagation using the Concawe method.

The **SANS 10328:2008** standard defines the following terms (Jongens, 2021);

- A-weighted sound pressure level (L_{pA}): *"the sound pressure level, in decibels, relative to a reference sound pressure, p0, and incorporating an electrical filter network (A-*

weighted) in the measuring instrument corresponding to the human ear's different sensitivity to sound at different frequencies. It is given by the following equation":

$$L_{pA} = 10 \log\left(\frac{P_A}{P_0}\right)^2 \text{dB(A)};\ p0 = 20\ \mu\text{Pa}$$

- Equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$): the term "equivalent continuous" can be understood as the "average" weighted sound level measured or calculated continuously over a period of time, T. It is often loosely referred to as "sound level" or "noise level"
- Equivalent continuous rating level ($L_{Req,T}$): *"the equivalent continuous A-weighted sound pressure level, $L_{Aeq,T}$, measured or calculated during a specified time interval T, to which is added adjustments for tonal character, impulsiveness of the sound and the time of day.*

The sound pressure level shall be determined over a period of not less than 30 minutes (Sadler & Husted, 2009). The reference time interval to which a continuous sound level refers shall be interpreted as follows, unless otherwise specified: Day-time: 06h to 22h, when $L_{Req,T}$ is denoted $L_{Req,d}$; and Night-time: 22h to 06h, when $L_{Req,T}$ is denoted $L_{Req,n}$ (Jongens, 2021)

According with SANS 10103:2008, noise annoyance to the population from a particular activity occurs when that activity causes a significant increase in the local noise level. For each interval of increase a certain level of annoyance and reaction of the population is expected. In the absence of data on noise levels, typical values for each type of district are used. Figure 58 shows typical noise levels according to district type, and Figure 59 indicates the expected responses to increasing local average noise levels.

1	2	3	4	5	6	7
Type of district	Equivalent continuous rating level ($L_{Req,T}$) for noise, dBA					
	Outdoors			Indoors, with open windows		
	Day-night $L_{R,dn}$[a]	Day-time $L_{Req,d}$[b]	Night-time $L_{Req,n}$[b]	Day-night $L_{R,dn}$[a]	Day-time $L_{Req,d}$[b]	Night-time $L_{Req,n}$[b]
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

Figure 58: Typical rating levels for noise in districts (SANS 10103:2008) (Jongens, 2021)

1	2	3
Excess $(\Delta L_{Req,T})^{a}$ dBA	**Estimated community/group response**	
	Category	**Description**
0 – 10	Little	Sporadic complaints
5 – 15	Medium	Widespread complaints
10 – 20	Strong	Threats of community/group action
>15	Very strong	Vigorous community/group action

Figure 59: Categories of community/group response (SANS 10103:2008) (Jongens, 2021)

According to the Concawe propagation method (SANS 10357:2004), the specific noise levels produced by heavy earthmoving and haulage equipment in continuous operation do not affect people at a distance of more than two kilometres (Sadler & Husted, 2009).

Based on this information, an analysis/study area with 2km buffer around the project area can be established for baseline characterisation and environmental and social impact assessment. This will include an assessment of noise and vibration sources in this area that may affect the project area, as well as an analysis of the impact of the development of the pilot project on existing sensitive areas.

10.9.2.3 Noise and Vibration Environment

The noise and vibration environment in the area surrounding the Project can be framed by the main activities and services present there that are relevant noise sources.

The project implementation area doesn't intersect with any other activity, is an unused space. However, there is a national road and a railway line (transport corridors) in the immediate vicinity, which are relevant sources of noise and vibration (high impact).

The nearest infrastructure to the project area are industrial and commercial facilities located approximately 600 m from the nearest boundary of the implementation area. These facilities are expected to generate some noise, but the noise levels generated are expected to have a low impact on the noise levels at the Project site.

In addition to these sources, within a buffer of 2 km, residential areas where other public and private service activities are developed are also contributing sources of noise. The nearest residential area is about 1 km from the project area. The contribution of these sources to the noise levels in the project area is expected to be negligible due to the low noise levels and distance.

Industrial and residential areas are not expected to cause impacts at vibration levels recorded in the project area.

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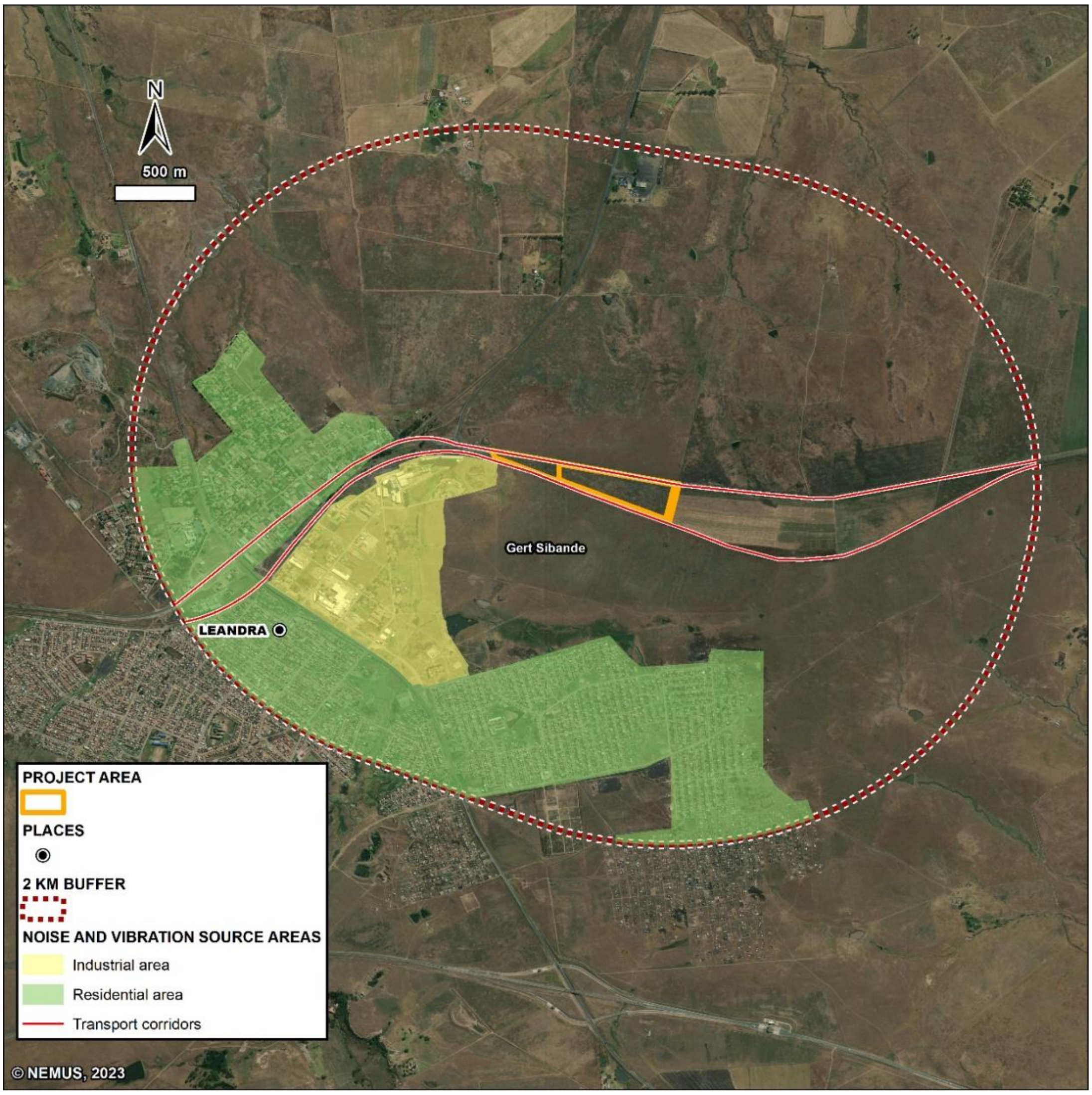

Figure 60: Potential noise and vibration sources (red: high impact; yellow: low impact; green: negligible impact)

No noise level measurements in the project area or at potential receptors have been carried out to date. Also, no previous studies or reports were found with information on noise or vibration sources and their quantification in the project area and immediate surroundings.

However, a Draft Basic Assessment Report for a proposed gravel mine at Leandra (Greenmined Environmental, 2021), about 3 km from the site, states that noise levels in the area are low and representative of a rural area, which is mainly affected by farming activities and road traffic. The project area and the gravel mine site are similar in that they are vacant areas, at some distance from residential and industrial areas, and both have a road nearby. The difference is that there is a mining operation in the vicinity of the gravel mine site and a railway line at the proposed Project site (both being high intensity point sources). As a result, it is assumed that the project area and is surroundings will also have similar noise levels to a rural area. Therefore, and taking into account noise pattern levels (SANS 10103), the noise levels experienced will be approximately 45 dB(A) during daytime and 35 dB(A) during night-time.

As for vibrations, no studies were found in Leandra, nor in the vicinity.

Within the scope of the reference characterisation, it is also important to mention that the propagation of noise and vibrations is influenced by external factors, namely (Sadler & Husted, 2009):

- Type of source (point or line);
- Distance from source;
- Atmospheric absorption;
- Wind;
- Temperature and temperature gradient;
- Obstacles such as barriers and buildings;
- Ground absorption; and
- Humidity.

10.9.2.4 Sensitive Areas

Sensitive areas are defined as specific land uses containing noise sensitive receptors that may be affected by noise from activities in the project area. The main concern is the presence of sensitive human occupations, i.e., places where people live or spend much of their time, taking into account special places such as schools, hospitals and other facilities. Sensitive areas are usually contiguous with residential areas. The sensitive areas within the area study (2 km buffer) are presented in Figure 61.

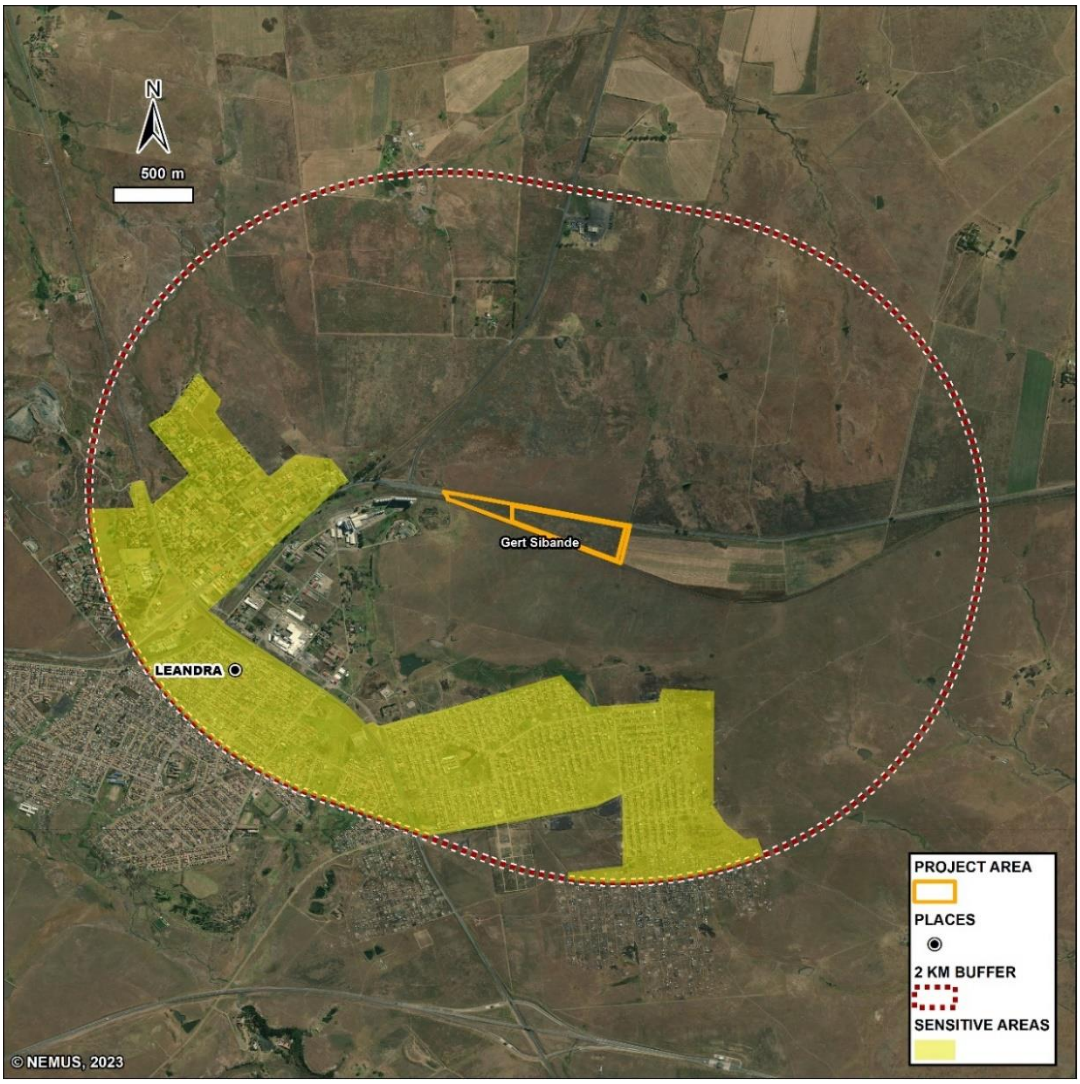

Figure 61: Sensitive zones in the study area)

10.9.2.5 Summary

Noise and vibration are regulated at national level by the National Noise Control Regulations and at municipal level by the GSDM Noise Control By-Law and the Prevention and Suppression of Nuisance By-laws. Various standards are used to assess the impact of noise, namely SANS 10328, SANS 10103 and SANS 10357.

According to SANS 10357, noise levels from heavy earthmoving and transport equipment in continuous operation do not affect people closer than two kilometres. A study area can therefore be defined with a buffer of 2 km from the project area.

Several sources of noise and vibration have been identified in the area, namely transport corridors, industrial areas and residential areas, with the transport corridors having the greatest impact on the project area.

Based on an impact assessment report for the construction of a quarry at Leandra and based on SANS 10103, the following noise levels can be predicted to occur in and around the project area: 45 dB(A) day-time and 35 dB(A) night-time. In addition, there are noise-sensitive zones in the study area, namely residential areas.

As for vibrations, no studies were found in Leandra, nor in the vicinity.

10.9.3 Air Quality

Given the relevance of air quality to the Project, a specialist study was carried out. The aim is to assess the impact on local air quality, using atmospheric dispersion modelling, and the respective Project framework in terms of Greenhouse gas emissions.

The study includes the application of the dispersion model for the construction phase (considering modelling coinciding with the most critical year of construction) and for the operational phase (considering modelling for the alternative of supercritical CO_2 injection). As a dispersion model it is considered the implementation of AERMOD, recommended by the United States Environmental Protection Agency (USEPA**Error! Bookmark not defined.**), and as a meteorological model the TAPM, of CSIRO - Marine and Atmospheric Research.

The study was undertaken in compliance with the applicable legislation, namely NEM:AQA and the World Health Organization (WHO) limit values/reference values in ambient air for the protection of human health and national/international targets for reduction of greenhouse gas emissions.

The two models proposed for developing the specialised study are presented below.

Dispersion model - AERMOD

AERMOD is an advanced dispersion model which incorporates current treatments of the planetary boundary layer, knowledge on turbulence, dispersion, and interactions with the surface. This model was formally proposed as a substitute for the ISCST3 model by the USEPA in April 2000. The last version of the model includes the plume downwash algorithms from the PRIME model. This version was evaluated by the USEPA (Documents no. EPA-454/R-03-002 and no. EPA-454/R-03-003 of June 2003) with rather positive results, being its use recommended as the authorised model. AERMOD replaces the former ISCST3 – Industrial Source Complex since November 2005 as the American regulatory model.

AERMOD is a stationary state model. In the stable boundary layer, it is assumed that the concentrations distribution is Gaussian, both horizontally and vertically. In the convective boundary layer, the horizontal distribution of the concentrations is considered to be gaussian, but the vertical distribution is described as a bi-gaussian density probability function.

AERMOD was conceived to treat ground-level and elevated sources, in simple and complex topography. Such as the ISCST3 model, AERMOD may treat multiple sources (point, area, or volume), having the following advantages over the latter:

- Takes into consideration the temperature and the wind above the emitting source, under stable conditions, and convective updrafts and downdrafts under unstable conditions;
- Regarding meteorological input data, it is able to adapt multiple levels of data to various altitudes of the emitting source and the plume, furthermore, it creates wind, temperature and turbulence vertical profiles;
- Uses a gaussian treatment for the horizontal and vertical plume dispersion under stable conditions and a non-gaussian probability density function for the vertical dispersion under unstable conditions;
- In order to formulate the mixing height, it includes a mechanical element and, by using hourly data, it gives a more realistic sequence of the boundary layer alterations throughout the day;
- AERMOD allows flexibility when selecting the study domain characteristics;
- Regarding the downwash effect of nearby structures, AERMOD benefits from the advanced technology given by the PRIME model algorithms.

AERMOD is a system of models constituted by three modules: (i) AERMOD (air dispersion model), (ii) AERMET (meteorological data pre-processor) and (iii) AERMAP (terrain pre-processor).

AERMET is AERMOD’s meteorological data pre-processing system, which aim is to compute boundary layer parameters from domain representative meteorological parameters to estimate wind, turbulence, and temperature vertical profiles. AERMET is based on a pre-processor regulated by the USEPA, MPRM (Meteorological Processor for Regulatory Models) and processes input meteorological data in three stages. In a first stage, the program performs various data quality assessment tasks.

In a second stage, the available data are grouped into 24-hour periods and stored in a single file. In a third stage, the program reads the data from the second stage and estimates the parameters needed as input for AERMOD. During this stage, two files for AERMOD are created: 1) a file for the hourly estimates of the boundary layer; 2) a file of vertical profiles for the wind speed and direction, temperature, and the horizontal and vertical standard deviations.

AERMAP is a surface pre-processor designed to simplify and standardize the AERMOD input data. Input data include receptors elevation data. The output data include, for each receptor, location, and altitude scale, used to compute the air fluxes.

This model has been used by the USEPA as a regulatory (recommended) model, being largely tested and validated.

Mesometeorological Model - TAPM

TAPM – The Air Pollution Model is a model developed by Csiro, Atmospheric Research, which includes meteorological and pollutant dispersion modules, including the formation of secondary pollutants and production of ozone. This model has the advantage to be applicable to complex topography and wind field situations, as well as long-term simulation – one year – with the advantages of comparisons between results and relevant legislation.

TAPM consists in the coupling of a meteorological prognostic model and an atmospheric pollutants concentration dispersion model. The model integrates important fluxes for the air pollution local scale, as well as sea breezes and terrain-induced fluxes taking into consideration a large-scale meteorological background supplied by synoptic analysis.

The mesoscale meteorological module uses synoptic forcing data as supplied by the GASP (Global Analyses and Prediction) of the Australian Bureau of Meteorology, topography, and land use data. The meteorological component of TAPM is a three-dimensional, non-hydrostatic, model. The model solves the quantity of movement conservation equation for the horizontal components of the wind, the incompressible fluid continuity equation for the vertical component, and scalar equations for the potential temperature and the specific humidity.

The TAPM pollutants dispersion component uses the three-dimensional Eulerian formulation developed for the physic-chemical processes simulation associated to production, transport, dispersion, and deposition of reactive and non-reactive atmospheric pollutants. The model considers reactions for various species, among which nitrogen oxides (NO and NO_2) and ozone (O_3).

The Air Quality Study is contained in Appendix D5.

10.10 Terrestrial Biodiversity

The information contained in the sub-sections to follow was extracted from the Terrestrial Biodiversity Compliance Statement (Human, 2023) (contained in Appendix D2).

10.10.1 Desktop Spatial Baseline

Table 29 below has been produced in terms of the spatial data collected and analysed (as provided by various sources such as the national and provincial environmental authorities and SANBI). It presents a summative breakdown of the ecological boundaries considered and the associated relevance that each has to the region or project area. Where a feature is regarded as relevant it is considered an ecologically important landscape feature and discussed further as part of the sub-sections that follow.

Table 29: Desktop Spatial features examined

Desktop Information considered	Relevant	Reasoning
Mpumalanga Biodiversity Sector Plan (MPTA, 2014)	Yes	Project area is “Heavily modified” and “Other Natural Area”.
Ecosystem Protection Level (SANBI & DFFE, 2021)	Yes	A very small part of the project falls within an ecosystem of “Vulnerable” rating
National Protected Areas Expansion Strategy, 2016 (DEA, 2016)	Yes	The project area does not overlap with a priority focus area
Important Bird and Biodiversity Areas (IBAs) (2015)_	No	No IBAs occur nearby
South African Protected and Conservation Areas Databases (DFFE, 2022)	Yes	No Protected areas within 10km of the study site.

10.10.2 Mpumalanga Biodiversity Sector Plan

The Mpumalanga Biodiversity Sector Plan (MBSP) strives to improve landscape level conservation and management of biodiversity and ecosystems in the province. This is achieved by providing information on biodiversity in a standardised format that can be used to inform forward planning (e.g. SDF’s) and reactive management (e.g. EIA’s) processes.

The purpose of a Biodiversity Sector Plan is to inform land use planning, environmental assessments, land and water use authorisations, as well as natural resource management, undertaken by a range of sectors whose policies and decisions impact on biodiversity. This is done by providing a map of biodiversity priority areas, referred to as Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs), with accompanying land use planning and decision-making guidelines.

The MBSP (MPTA, 2014) classifies the natural vegetation of the province according to the following categories:

- Protected Areas (sub-divided into three categories).

  - Areas that are formally protected by law and recognised in terms of the Protected Areas Act, including contract protected areas declared through the biodiversity stewardship programme.
- CBAs (sub-divided into "Irreplaceable" and "Optimal").
  - All areas required to meet biodiversity pattern and process targets; Critically Endangered ecosystems, critical linkages (corridor pinch-points) to maintain connectivity; CBAs are areas of high biodiversity value that must be maintained in a natural state.
- Other natural areas.
- ESA (sub-divided into four categories); and
- Modified (sub-divided into Heavily or Moderately modified).
  - Areas in which significant or complete loss of natural habitat and ecological function has taken place due to activities such as ploughing, hardening of surfaces, open-cast mining, cultivation and so on.
- CBAs are terrestrial and aquatic areas of the landscape that need to be maintained in a natural or near-natural state to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. In other words, if these areas are not maintained in a natural or near natural state then biodiversity targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity compatible land uses and resource uses.
- ESAs are terrestrial and aquatic areas that are not essential for meeting biodiversity representation targets (thresholds), but which nevertheless play an important role in supporting the ecological functioning of critical biodiversity areas and/or in delivering ecosystem services that support socio-economic development, such as water provision, flood mitigation or carbon sequestration. The degree or extent of restriction on land use and resource use in these areas may be lower than that recommended for CBAs.

The project area does not fall in a CBA and ESA category and is designated as "Heavily modified" and "Other Natural Area" (Figure 62).

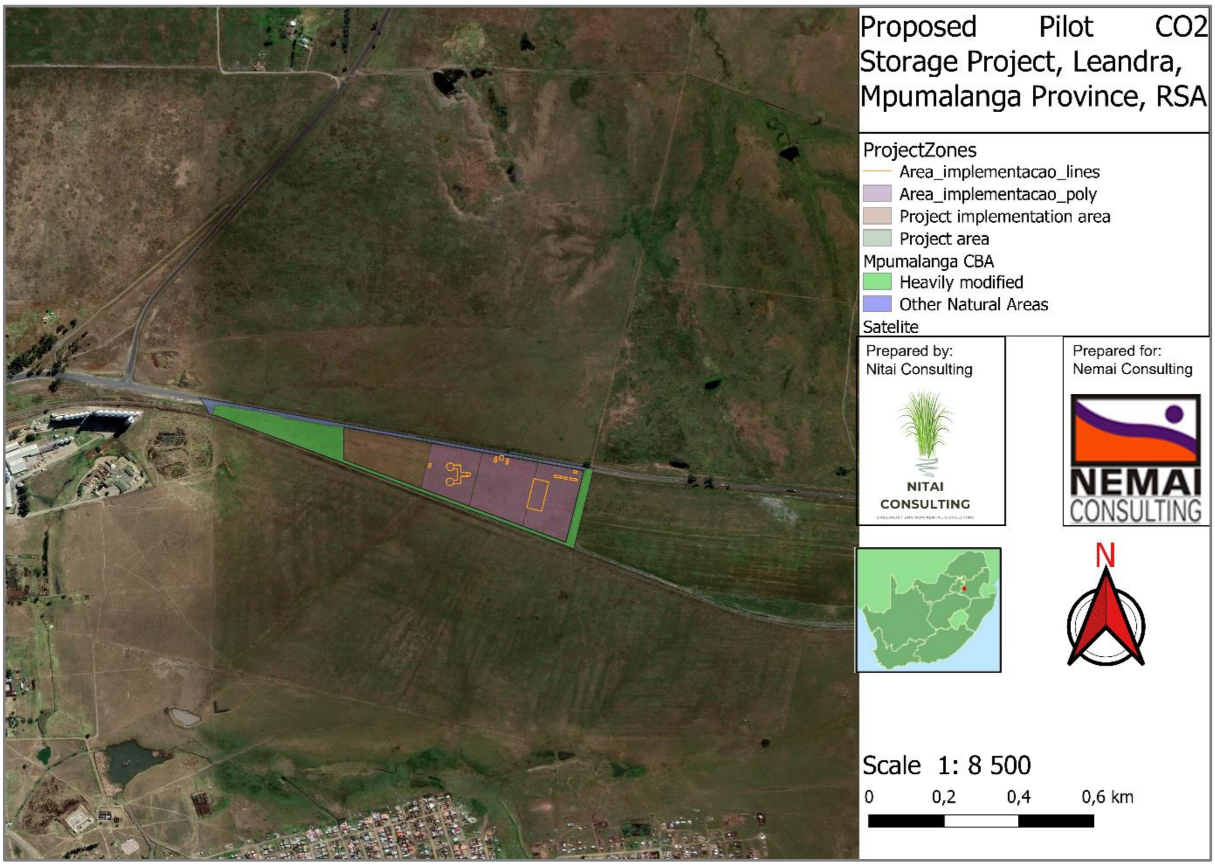

Figure 62: CBA areas for study site

10.10.3 The National Biodiversity Assessment

10.10.3.1 Ecosystem Threat status

The 2011 list focussed on terrestrial ecosystems and is referred to in Listing Notice 3 (Government Notice R985, published under NEMBA in 2014) which identifies activities that require Environmental Authorisation when undertaken in a threatened ecosystem, as identified in the list.

The 2011 list has also been used throughout SA as a decision-making support tool, especially in environmental authorisation application processes and to inform bioregional planning. The revised list, known as the 2022 Red List of Ecosystems, was developed between 2016 and 2021, incorporating the best available information on terrestrial ecosystem extent, condition, pressures, and drivers of change.

The revised list is based on assessments that followed the International Union for Conservation of Nature (IUCN) Red List of Ecosystems Framework (version 1.1) and covers all 456 terrestrial ecosystem types described in SA. The updated input data and alignment with global methods provides for a substantially improved list but also limits direct comparison between 2011 and 2022 because some ecosystem types have changed threat status category due to the change in methods, and others have changed due to land cover change or other pressures in the landscape.

Going forward, comparisons between versions of the list will be possible, facilitating trend analysis and monitoring.

The 2022 Red List of Ecosystems identifies 120 threatened terrestrial ecosystem types (55 Critically Endangered, 51 Endangered and 14 Vulnerable types).

The project area was superimposed on the Ecosystem Protection Level map to assess the protection status of the terrestrial ecosystem associated with the project area. Based on the dataset, an exceedingly small section of the ecosystem is rated as vulnerable and endemic (Figure 63 and Figure 64).

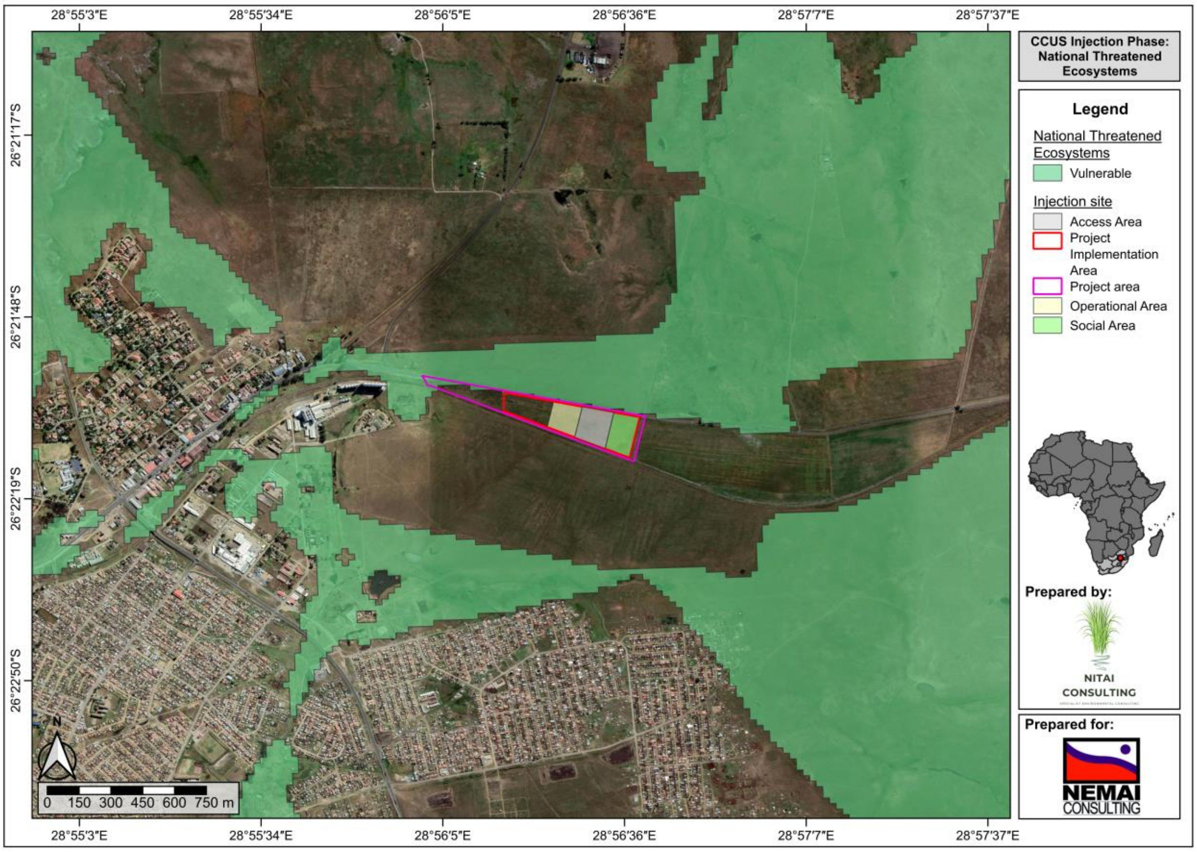

Figure 63: Red list Ecosystem status

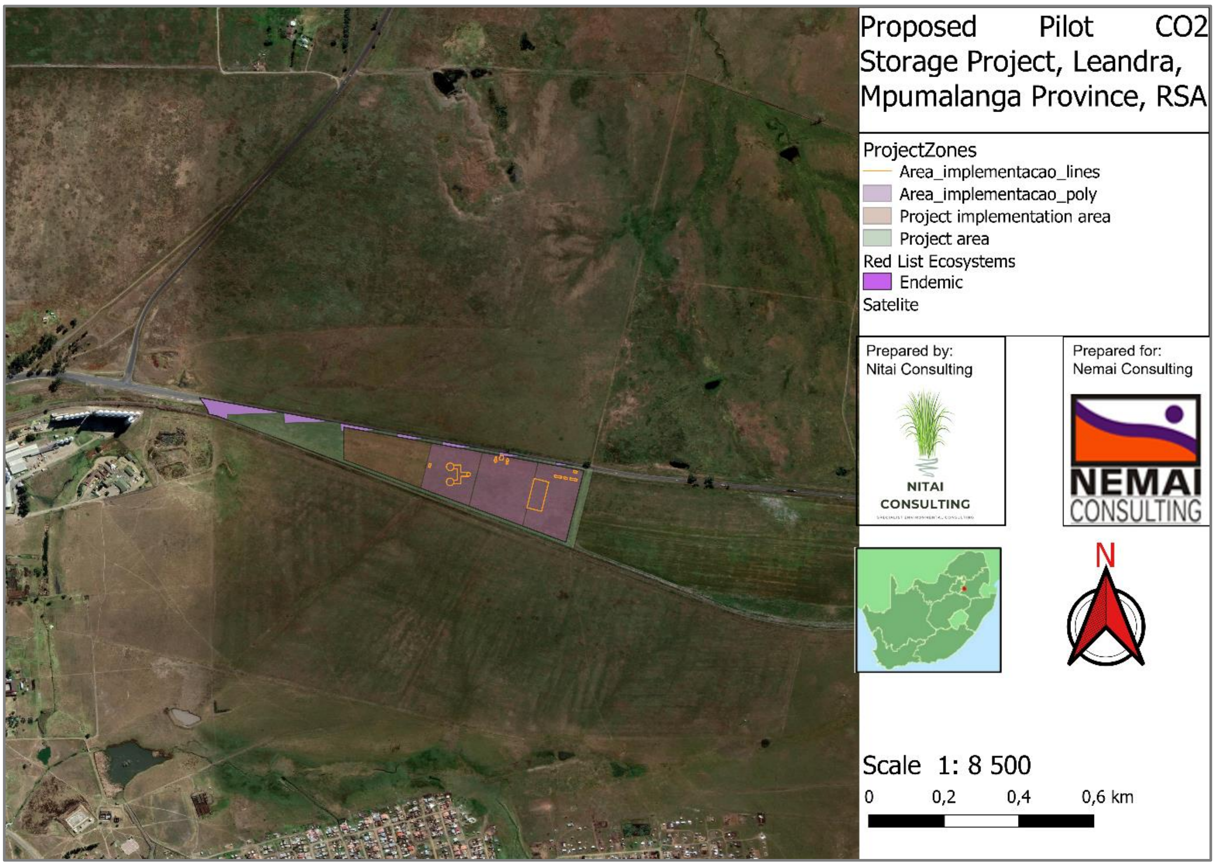

Figure 64: Ecosystem endemism status

10.10.4 South African Protected and Conservation Areas

The Department of Environmental Affairs (now DFFE) led the development of the National Protected Areas Expansion Strategy (NPAES) in consultation with the protected area agencies and other key private and public sector stakeholders. The need for the development of the NPAES was established in the National Biodiversity Framework in 2009. The NPAES is a 20-year strategy with 5-year implementation targets aligned with a 5-year revision cycle. (DEA, 2016).

SA's protected area network currently falls far short of representing all ecosystems and maintaining healthy functioning ecological processes. In this context, the goal of the NPAES is to achieve cost effective protected area expansion thus enabling better ecosystem representation, ecological sustainability, and resilience to climate change. A comprehensive set of priority areas was compiled based on the priorities identified by provincial and other agencies in their respective protected area expansion strategies. These focus areas are generally large, intact and unfragmented and are therefore of high importance for biodiversity, climate resilience and freshwater protection (DEA, 2016).

The project area does not overlap with a priority focus area for expansion according to the 2016 NPAES dataset (Figure 65).

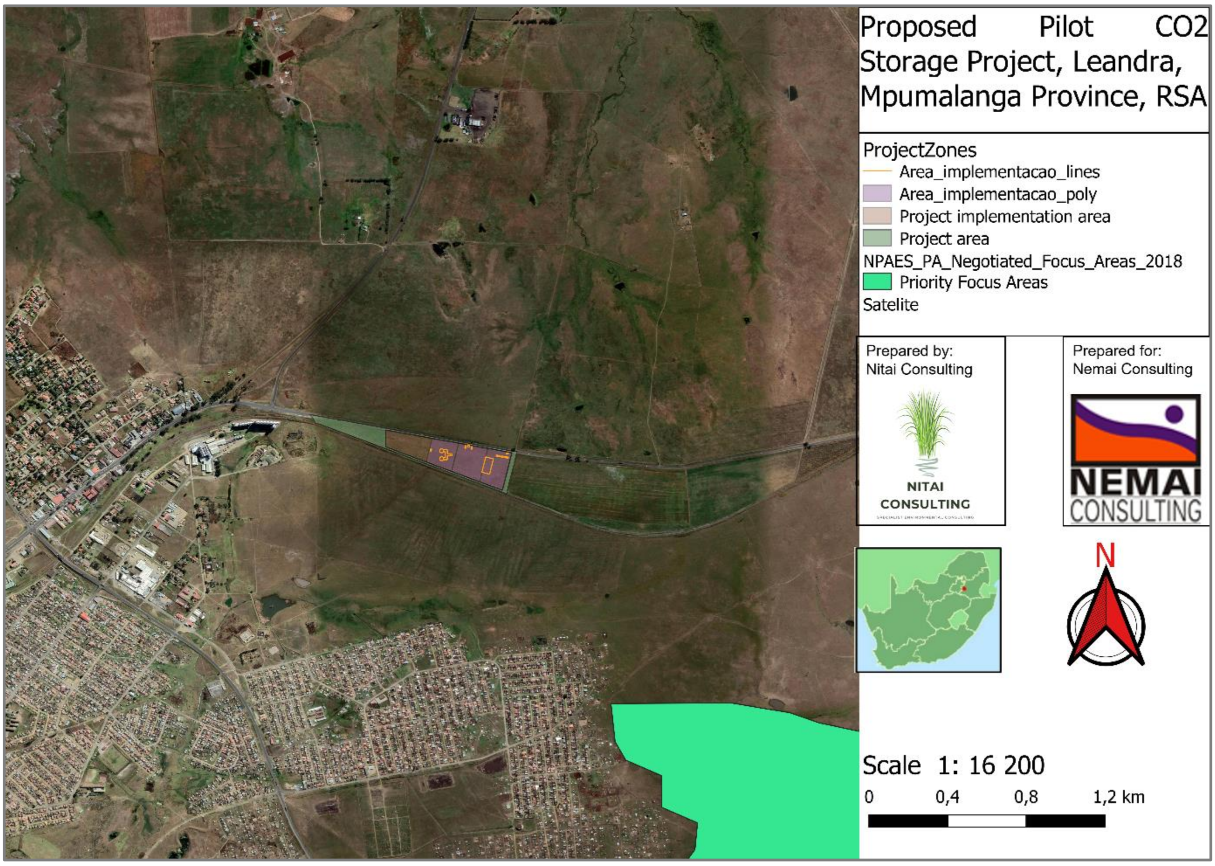

Figure 65: Protected Areas Expansion Framework for study site

10.10.5 Ecological Desktop Baseline

10.10.5.1 Vegetation Assessment

The project area is situated within the Grassland Biome. In SA, the Grassland Biome occurs mainly on the high central plateau (Highveld), the inland areas of the eastern seaboard, the mountainous areas of KwaZulu-Natal (KZN) and the central parts of the Eastern Cape (Mucina & Rutherford, 2006). However, grasslands can also be found below the Drakensberg, both in KZN and the Eastern Cape, with floristic links to the high-altitude Drakensberg grassland (Mucina & Rutherford, 2006).

The topography is mainly flat to rolling, but also includes mountainous regions and the Escarpment (Mucina & Rutherford, 2006). Altitude is mostly from about 300 to 400 m.a.s.l, but reaches up to 3 482 m on Thabana Ntlenyana, the highest mountain in southern Africa (Mucina & Rutherford, 2006). In terms of climate, the temperate grasslands of the Highveld in South Africa have cold and dry conditions, with rainfall during the summer (which can sometimes be a strong summer rainfall) and winter drought (Mucina & Rutherford, 2006).

Frost is common and there is a high risk of lightning-induced fires (Mucina & Rutherford, 2006). In terms of vegetation structural composition, grasslands are characteristically dominated by grasses of the Poaceae Family (Mucina & Rutherford, 2006). On the Lesotho Plateau and highest peaks of the Drakensberg, grassland plants xeromorphic characteristics due to the severity of the climate in these places (Mucina & Rutherford, 2006).

On a fine-scale vegetation type, the project area overlaps with Soweto Highveld Grassland (Figure 66).

Soweto Highveld Grassland

Distribution: Mpumalanga, Gauteng (and to a very small extent also in neighbouring Free State and North-West) Provinces: In a broad band roughly delimited by the N17 road between Ermelo and Johannesburg in the north, Perdekop in the southeast and the Vaal River (border with the Free State) in the south. It extends further westwards along the southern edge of the Johannesburg Dome (including part of Soweto) as far as the vicinity of Randfontein. In southern Gauteng it includes the surrounds of Vanderbijlpark and Vereeniging as well as Sasolburg in the northern Free State

Altitude: 1 420–1 760 m.

Vegetation & Landscape Features: Gently to moderately undulating landscape on the Highveld plateau supporting short to medium-high, dense, tufted grassland dominated almost entirely by *Themeda triandra* and accompanied by a variety of other grasses such as *Elionurus muticus*, *Eragrostis racemosa*, *Heteropogon contortus* and *Tristachya leucothrix*. In places not disturbed, only scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover.

Geology & Soils: Shale, sandstone, or mudstone of the Madzaringwe Formation (Karoo Supergroup) or the intrusive Karoo Suite dolerites which feature prominently in the area. In the south, the Volksrust Formation (Karoo Supergroup) is found and in the west, the rocks of the older Transvaal, Ventersdorp and Witwatersrand Supergroups are most significant. Soils are deep, reddish on flat plains and are typically Ea, Ba and Bb land types.

Climate: Summer-rainfall region (MAP 662 mm). Cool-temperate climate with thermic continentality (high extremes between maximum summer and minimum winter temperatures, frequent occurrence of frost, large thermic diurnal differences, especially in autumn and spring)

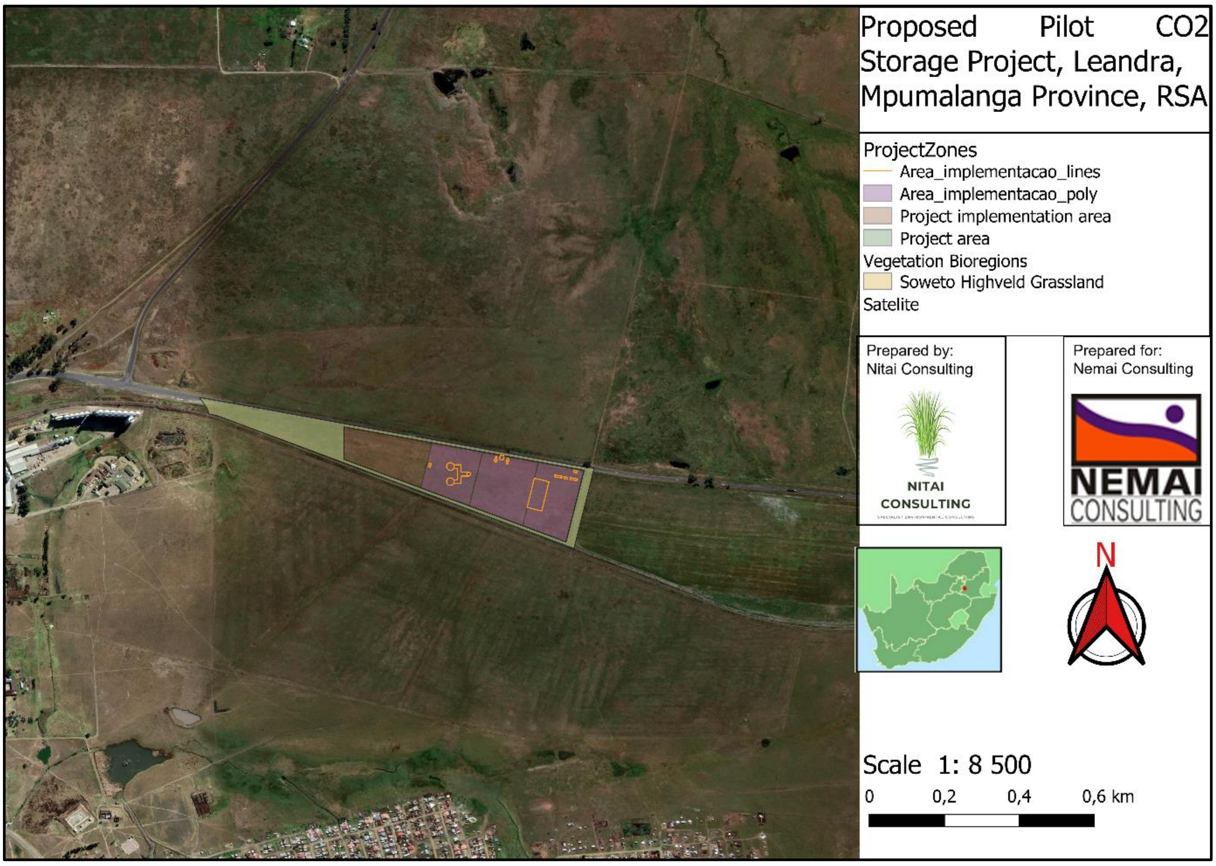

Figure 66: Vegetation region of study site

Important Taxa

Graminoids: *Andropogon appendiculatus (d), Brachiaria serrata (d), Cymbopogon pospischilii (d), Cynodon dactylon (d), Elionurus muticus (d), Eragrostis capensis (d), E. chloromelas (d), E. curvula (d), E. plana (d), E. planiculmis (d), E. racemosa (d), Heteropogon contortus (d), Hyparrhenia hirta (d), Setaria nigrirostris (d), S. sphacelata (d), Themeda triandra (d), Tristachya leucothrix (d), Andropogon schirensis, Aristida adscensionis, A. bipartita, A. congesta, A. junciformis subsp. galpinii, Cymbopogon caesius, Digitaria diagonalis, Diheteropogon amplectens, Eragrostis micrantha, E. superba, Harpochloa falx, Microchloa caffra, Paspalum dilatatum.*

Herbs: *Hermannia depressa (d), Acalypha angustata, Berkheya setifera, Dicoma anomala, Euryops gilfillanii, Geigeria aspera var. aspera, Graderia subintegra, Haplocarpha scaposa, Helichrysum miconiifolium, H. nudifolium var. nudifolium, H. rugulosum, Hibiscus pusillus, Justicia anagalloides, Lippia scaberrima, Rhynchosia effusa, Schistostephium crataegifolium, Selago densiflora, Senecio coronatus, Vernonia oligocephala, Wahlenbergia undulata.*

Geophytic herbs: *Haemanthus humilis subsp. hirsutus, H. montanus.*

Herbaceous climber: *Rhynchosia totta.*

Low Shrubs: *Anthospermum hispidulum, A. rigidum subsp. pumilum, Berkheya annectens, Felicia muricata, Ziziphus zeyheriana*.

Conservation Status: The ecosystem is rated as Vulnerable according to the 2022 Red List ecosystem data since there is 39% remaining of this ecosystem Soweto Highveld Grassland is narrowly distributed with high rates of habitat loss in the past 28 years and 0.6% is protected (DFFE, 2022).

10.10.5.2 Botanical Assessment

Based on the Plants of Southern Africa (BODATSA-POSA, 2019) database, only two species is potentially present on the study site. The screening tool identifies three potential Species of Conservation Concern (SCC) species and rated the area "Medium". Table 30 summarises the total number of plant species that have the potential to occur in or around the project area, and the corresponding IUCN rating.

Table 30: Total number of potential flora species present, and corresponding SCC

Taxon	IUCN Rating
Asclepias gibba	Least Concern
Ledebouria cooperi	Least Concern
Pachycarpus suaveolens	Vulnerable
Sensitive species 691	Vulnerable
Sensitive species 1252	Vulnerable

Of the five plant SCC, none are likely to be found resident in the project area due to a lack of suitable habitat and the associated modified nature of the project area and surrounds.

The general modified state of the area coupled with the with high levels of agricultural disturbance, results in a high level of disturbance degradation, and unsuitable environmental conditions.

10.10.6 Faunal Assessment

Largely based on the South African Bird Atlas Project Version 2 (SABAP2, 2022), IUCN Digital Distribution Maps (IUCN, 2016), and the Animal Demography Unit (ADU, 2020) databases, Table 31 summarises the total number of animal species that have the potential to occur in or around the project area, and the corresponding number of SCC.

Table 31: Total number of potential fauna species present, and corresponding SCC

Fauna type	Total potential number	Number of SCC
Avifauna	129	3
Mammals	55	5

Fauna type		Total potential number	Number of SCC
Herpetofauna	Amphibians	15	0
	Reptiles	21	0

These numbers include animals that only occur within nature reserves and private reserves. Of the 3 avifaunal SCC, none are likely to be found resident in the project area due to a lack of suitable habitat and the associated modified nature of the project area and surrounds.

Of the 55 total mammals listed, none of the mammal SCC are likely to be found resident within the project area.

The general modified state of the area coupled with the with high levels of agricultural disturbance, results in a high level of disturbance degradation, and unsuitable environmental conditions.

10.10.7 Field Survey

This section details the observations recorded during an on-site field survey conducted to ground truth the floral, faunal, and habitat features of the project area. Sampling took place from 8:00 to 15:00 on 9 February 2023 and again on 6 March 2023 from 7:00 to 14:00.

10.10.7.1 Terrestrial Flora and Fauna

During the terrestrial survey the floral and faunal communities within the project area were assessed. For ease of reading, the observations and discussions pertaining to the floral and the faunal species recorded are separated below.

Flora and Vegetation Condition

The project area was found in a heavily modified condition, mainly attributed to the agricultural practices and its associated impacts, resulting in the area being largely disturbed in some way. Grazing practices, old lands and piospheres have degraded the veld severely. These aspects further limit the functional capacity of the project area. Much of the development footprint is located within or along roads or transformed areas and their associated servitudes, and heavily modified areas which are considered as very low sensitivity. No protected trees or SCC flora species were observed.

Refer to the images below for photographs showing the habitats and the overall state of the project area.

Fauna

Mammal activity was low, due to the extent of disturbance in general and cattle grazing the area, as well as the poor habitat condition. The species present are most likely not resident due to the modified state of the area. No SCC were observed during the field survey.

Figure 67: General condition of the study site

10.10.7.2 Habitat Survey and Site Ecological Importance

The main habitat types identified across the project area were initially identified and pre-delineated largely based on aerial satellite imagery. These habitat types were then refined based on the field coverage and data collected during the survey.

The degraded habitat has been modified from its natural state, and it represents habitat that has been historically impacted, and has not recovered. This habitat is largely limited to areas that have been impacted through effects from agricultural grazing practices and associated impacts, roads, and land use, as well as mismanagement and inadequate rehabilitation procedures. These habitats are not entirely transformed, but exist in a constant degraded state, as they cannot recover to a more natural state, due to the ongoing disturbances and impacts received.

Transformed habitat was present in the form of the existing railway line, existing infrastructure, or any other areas devoid of vegetation, artificially. Due to the transformed nature of this habitat, it is regarded as having a very low sensitivity.

The two delineated habitat types have each been allocated a Site Ecological importance (SEI) category, and this breakdown is presented in Table 32 below. To identify and spatially present sensitive features in terms of the relevant specialist discipline, the sensitivities of each of the habitat types delineated within the project area are mapped in (Figure 68).

It is important to note that this map does not replace any local, provincial, or national government legislation relating to these areas or the land use capabilities or sensitivities of these environments.

Table 32: SEI assessment summary of the habitat types delineated within the project area

Habitat Type	Conservation Importance	Functional Integrity	Biodiversity importance	Receptor resilience	Site Ecological Importance
Degraded Grassland	Low	Medium	Low	Medium	Low
Transformed	Low	Medium	Low	Medium	Low

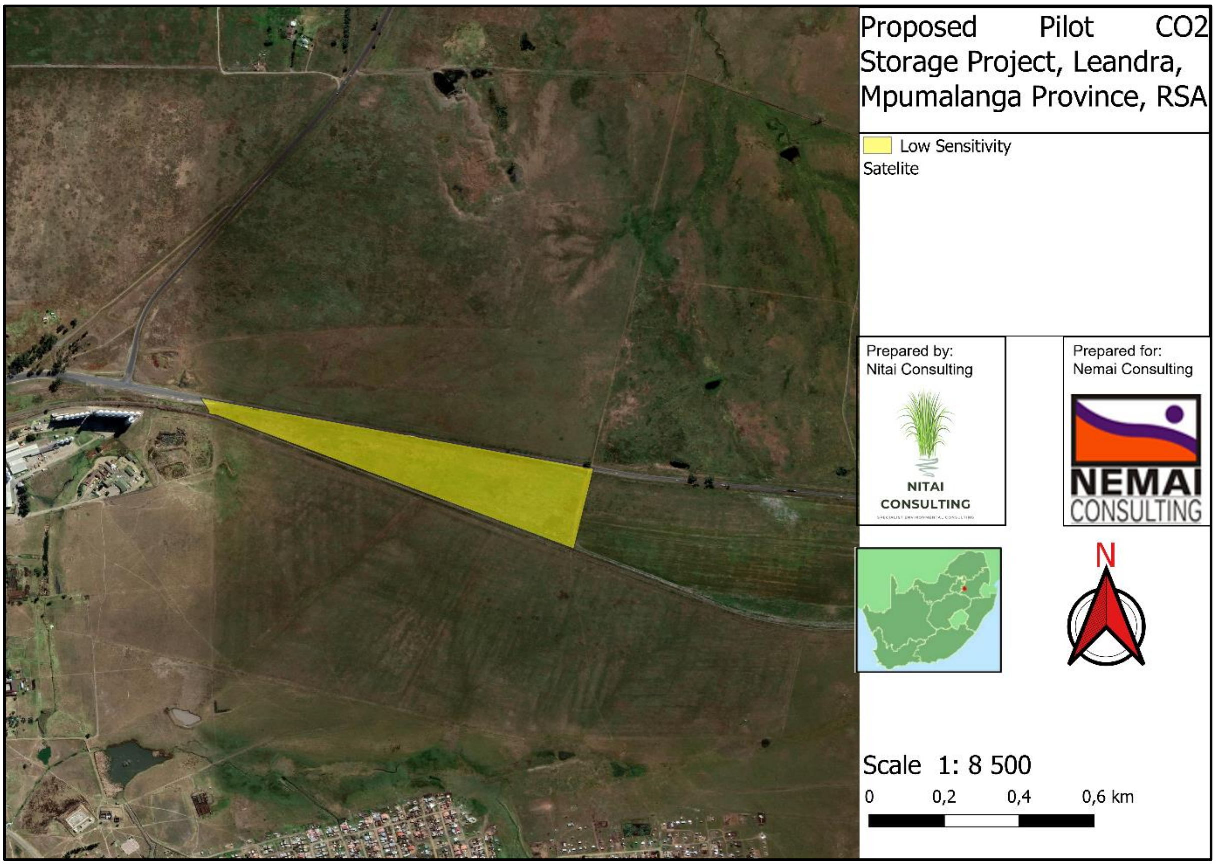

Figure 68: Terrestrial biodiversity SEI delineation relevant to the project area

The terrestrial biodiversity theme sensitivity as indicated in the screening report (compiled by the Screening Tool) was derived to be 'Very High' (Figure 69).

The completion of the terrestrial desktop and field studies disputes the 'Very High' sensitivity presented by the screening report. As discussed above, the project area is largely modified and as such is assigned a sensitivity rating of 'Low'.

The screening report classified both the animal and plant theme sensitivity as 'medium'. Following the field survey findings, both the animal and plant species themes may be re-classified as having 'Low' sensitivities. This is since there is limited suitable habitat available to support the regular occurrence of any flora or faunal SCC within the project area.

Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
X			

Sensitivity Features:

Sensitivity	Feature(s)
Very High	Vulnerable ecosystem_Soweto Highveld Grassland

Figure 69: Biodiversity Sensitivity of the project area according to the Screening Report.

10.11 Land Use and Spatial Planning

10.11.1 Introduction

This section focuses on the Spatial Planning and Land Use Management Act (Act No. 16 of 2013) (SPLUMA), which aims to provide a framework for spatial planning and land use management in SA. The GMLM Spatial Planning and Land Use Management By-Law and Land Use Scheme were established in terms of Section 6(1)(a) and (b) of the SPLUMA.

To support the characterisation, the SDF's (national, provincial, and municipal), the regional development strategic plans, as well as other relevant notices published were considered. The information provided by the DFFE Screening Tool was also considered.

In order to characterise land use and applicable constraints, emphasis was placed on the study of the Project's implementation area. However, where relevant, the area of direct and indirect influence was also considered, to allow an integrated approach to the local territory and its interactions.

10.11.2 Development Models - Programmes and Strategic Plans

Development in SA is broadly guided and directed by a wide range of legislation. Some legislation is sector specific (e.g., housing, environment) while others are more generic in nature, focusing on planning processes and proposals. In addition to existing legislation, a range of national, provincial, and local development policies and plans exist to further guide and direct development (GSDM, 2022).

These development models, although they may not be strictly associated with the spatial planning theme, represent the strategic planning and development structure on which it is based. As such, these documents frame the development priorities and objectives to be pursued through the strict area-specific management instruments. The programmes and plans of greatest relevance in the thematic and geographic context of the Project are:

<u>International development models</u>

- **Nationally Appropriate Mitigation Actions (NAMAs)**: NAMAs are a set of policies and actions that developing countries undertake as part of a commitment to reduce greenhouse gas emissions. The instruments can be directed at transformational change within an economic sector, or actions across sectors for a broader national focus. The term recognises that different countries may take different nationally appropriate measures based on their capacities (UNFCCCC, 2018). The carbon dioxide capture and storage are one of the possible actions to reduce Greenhouse Gas (GHG) emissions, and its application has been reported by Botswana. The pilot project under study is an important step towards the development and application of CCS in SA, helping to reduce greenhouse gas emissions.

Africa Union development models

- **Agenda 2063**: This agenda aims for the Union of Africa to achieve seven development visions, each with its own set of goals, by 2063. One of the visions is "*a prosperous Africa based on inclusive growth and sustainable development*". This vision includes the goal of achieving environmental sustainability and a climate resilient economy and community (African Union, 2022a);
- **Climate Change and Resilient Development Strategy and Action Plan (2022-2032)**: In February 2022, the African Union heads of state adopted the first continental climate strategy, built on the Green Recovery Action Plan (2021-2027). The strategy and action plan aims, among other objectives, to reduce the GHG emissions trajectory and unlock major economic opportunities and create new markets and jobs. (African Union, 2022b);

National development models

- **National Development Plan 2030 (NDP)**: The NDP sets out the vision for SA to 2030, addressing the needs identified by the National Planning Commission in the Commission's Diagnostic Report, released in June 2011. This plan has the aim of eradicating poverty and inequality between people in SA through the promotion of development. To achieve the improvements the plan identifies the role that different sectors of society need to play. The NDP recognises that one of its critical actions is to institute interventions to ensure environmental sustainability and the creation of employment. One of SA's challenges linked to environmental sustainability is the reduction of greenhouse gas emissions. The NDP sets the goal of achieving the peak, plateau and decline trajectory for greenhouse gas emissions, with the peak being reached around 2025 (Republic of South Africa, 2022a).
- **Medium-Term Strategic Framework (MTSF) 2019-2024:** This strategy sets out priorities for action over the next 5 years to implement the NDP. The priorities include the need to create jobs and promote environmental sustainability (Republic of South Africa, 2019a);.
- **National Framework for Sustainable Development (NFSD) 2008**: The country's sustainable development vision is outlined in the NFSD as "*South Africa aspires to be a sustainable, economically prosperous and self-reliant nation state […] managing its limited ecological resources responsibly for current and future generations*." To achieve sustainable development of South Africa this framework highlights the importance of reducing high emissions per capita (Republic of South Africa, 2008).
- **National Strategy for Sustainable Development and Action Plan (NSSD) 2011 – 2014**: This strategy was built on the 2008 NFSD and several other private and public

initiatives and regards sustainable development as a long- term commitment. NSSD describes the pathway to sustainable human settlements, development by presenting an action plan and monitoring indicators. One of NSSD's strategic objectives is to respond effectively to climate change by contributing to the effort to stabilise GHG concentrations in the atmosphere (Republic of South Africa, 2011).

- **New Growth Path (NGP):** This framework, launched in 2010, reflects government's commitment to prioritising employment creation in all economic policies (Republic of South Africa, 2022b). The jobs drivers identified in the NGP include:
  - Substantial public investment in infrastructure both to create employment directly, in construction, operation and maintenance as well as the production of inputs, and indirectly by improving efficiency across the economy;
  - Taking advantage of new opportunities in the knowledge and green economies.

  The Green Economy is identified as key investment. Green jobs include work in research and development and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; decarbonise the economy and minimize or altogether avoid generation of all forms of waste and pollution.
- **National Climate Change Response Strategy White Paper (2014):** This paper presents the South African Government's vision for an effective climate change response by making transition to a climate-resilient, equitable and internationally competitive lower-carbon economy and society. One of the two objectives is "*make a fair contribution to the global effort to stabilise GHG concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system*" (Republic of South Africa, 2014).
- **Science, Technology and Innovation White Paper (2019)**: Sets the long-term policy direction for the South African government to ensure a growing role for Science, Technology and Innovation in a more prosperous and inclusive society. One of the intentions of this Paper is to explore new sources of economic growth taking into account the opportunity of a transition to a low-carbon economy and accelerating eco-innovation driven by the current economic crisis and the focus on climate change (Republic of South Africa, 2019b).

Provincial and municipal development models

- **Mpumalanga Vision (2013-2030):** The Mpumalanga Vision 2030 was established as a direct implementation response to the 2030 NDP vision. The framework describes the province's approach to realizing the objectives of the NDP in the provincial context and seeks to achieve the strategic objectives established by the Provincial Government. The objective of the implementation of the Mpumalanga Framework is to overcome a disjointed approach to planning in the province. In addition to this it is also intended to provide a strategic and integrated vision of development in order to ensure correct planning decisions. The framework aims to achieve socio-economic outcomes (Mpumalanga Province, 2019): employment & economic growth; improving education, training and innovation; health care for all; and social protection. In order to achieve these results, the vision intends to put in place key mechanisms, namely: economic infrastructure; transforming human settlements; environmental sustainability and resilience; inclusive rural economy. The Mpumalanga Vision 2030 is based on nine key drivers. Key drivers 1 to 6 is focused towards promoting economic development, key drivers 7 and 8 are focused on human settlement and key driver 9 is focused on the conservation and sustainable management of the natural environment.

- **Strategic Plan of Mpumalanga Province (2020–2025)**: This strategic plan focuses on the economic and social development of the province which is fostered by various mechanisms in which environmental sustainability and resilience. The growth of new potential economies is considered in the plan, namely the green economy that aims to respond to environmental challenges. One of the challenges identified is the province's high carbon footprint as a result of coal-based power generation (Mpumalanga Province, 2020).
- **GSDM Integrated Development Plan (IDP) 2022-2027:** Every municipality in SA is required to produce an IDP. This plan should present the short, medium and long-term development strategy. It includes land use planning and economic development issues, among others. The PESTEL model presented in the IDP GSDM highlights that climate change is an opportunity for development, but also a threat to the community. The strategic objectives include reducing the rate of environmental degradation, including air quality (GSDM, 2022). In order to improve air quality, the plan considers the green economy as a key intervention, declaring support to local municipalities and stakeholders in the development of this type of projects and programmes. The district aims to mobilize all key stakeholders to form partnership towards transition to low carbon emission, reduction of greenhouse emissions and support for just transition and development for a reduction of carbon footprint. According to the IDP GSDM the district municipality will:
  - Mobilize resources to support projects and programs aimed at environmental sustainability, rehabilitation, and conservation;
  - Coordinate and mobilize key stakeholders, community to implement environmentally sustainable projects and programs; and
  - Promote, support programs, projects aimed at avoiding destruction, alteration, disturbance of environmental assets as a priority on any proposed development.
- **GMLM IDP 2022-2027:** Govan Mbeki's fifth version of IDP was built on the basis on the 2030 NDP, Mpumalanga Provincial Developmental Plan and District Development Modelling with a view to ensure strategic alignment, translation and matching of the developmental goals into the local environment of Municipality (GMLM, 2022). The strategic objectives are:

- Revenue enhancement and securing financial sustain ability;
- Provision of sustainable services, optimising operations and improving customer care;
- Facilitation and creation of an enabling environment for diversified local economic development, social cohesion, and job creation;
- Enhancing the capacity of human capital and deliver institutional transformation;
- Development of spatial integrated, safe communities and a protected environment;
- To promote good corporate governance and effective stakeholder engagement.

Within the scope of the Project, the following areas of action stand out: job creation, air quality management and climate change;

Based on the motivation for the Pilot Carbon Dioxide Storage Project, it is concluded that it is a strategic project, and the implementation thereof is supported by various development models. The stimulus for job creation and environmental sustainability, with the reduction of the carbon footprint, are emphasised.

10.11.3 Regional Management Instruments

The regional management instruments in force in the study area are presented in this section. These instruments represent a differentiated approach to the region. The plans discussed cover national, provincial, or municipal scope, according to the geographical and thematic relevance considering the Project under assessment.

10.11.3.1 Spatial Planning and Land Use Management Act, 2013

SPLUMA provides the guiding framework for spatial planning and land use management in SA. SPLUMA aims, among others:

- To provide a framework for spatial planning and land use management;
- To specify the relationship between the spatial planning and the land use management;
- To provide a framework for policies, principles, norms and standards for spatial development planning and land use management; and
- To address past spatial and regulatory imbalances.

In accordance with SPLUMA, the term "land use management system" means the system of regulating and managing land use and conferring land use rights through the use of schemes and land development procedures. The spatial planning system in SA consists of the following components (SPLUMA, Section 4):

- SDF to be prepared and adopted by national, provincial, and municipal spheres of government;

- Development principles, norms and standards that must guide spatial planning, land use management and land development;
- The management and facilitation of land use through the mechanism of Land Use Schemes (LUS); and
- Procedures and processes for the preparation, submission and consideration of land development applications and related processes.

SPLUMA establishes that municipal planning is composed of the following elements:

- Compilation, approval, and review of IDP's;
- Compilation, approval, and review of the components of an IDP prescribed by legislation and falling within the competence of a municipality, including a SDF and a LUS; and
- Control and regulation of the use of land within the municipal area where the nature, scale and intensity of the land use do not affect the provincial planning mandate of provincial government or the national interest.

It should be noted that the provincial and national planning elements include the provincial and the national SDF.

The term land development "*means the erection of buildings or structures on land, or the change of use land, including township establishment, the subdivision or consolidation of land or any deviation from the land use or use permitted in terms of an applicable land use scheme*".

SPLUMA establish the following principles to spatial planning, land development and land use management: spatial justice; spatial sustainability; efficiency; spatial resilience; and good administration. These general principles apply to all organs of state and other authorities responsible for the implementation of legislation regulating the use and development land.

10.11.3.2 National Spatial Development Framework

The National Spatial Development Framework (NSDF) is a strategic long-term spatial plan towards 2050. The NSDF is legally mandated by SPLUMA and must be aligned with the 2030 NDP. This framework provides the following:

- A visual representation of the desired national spatial development pattern for the country;
- A set of national spatial directives for all forms of infrastructure investment and development spending in the country; and
- A series of national strategic spatial areas for targeted investment by government and the private sector.

The NSDF vision is "*All Our People Living in Shared and Transformed Places in an Integrated, Inclusive, Sustainable and Competitive National Space Economy*".

The NSDF identifies a set of national development priorities which include targets for economic growth and employment, equality and prosperity. It identifies the need to achieve a sustainable natural resource base in which it intends to decrease the carbon footprint and shirk the risks and vulnerability of communities to climate change (South African Government, 2019).

10.11.3.3 Mpumalanga Spatial Development Framework 2050 – Draft (2019)

The spatial objectives of the Mpumalanga SDF are (Mpumalanga Province, 2019):

- Connectivity and corridor functionality;
- Sustainable Concentration and Agglomeration;
- Conservation and Resource utilisation;
- Liveability and Sense of place;
- Rural Diversity and transformation.

The Sustainable Concentration and Agglomeration objective refers to the creation of an agglomeration economy that will encourage people and economic activities to locate near one another in urban centres and industrial clusters.

The Conservation and Resource Utilisation aims to, among others:

- Allow for the maintenance of healthy natural environments, ecosystems and biophysical processes which support life, and which must be allowed to continue without significant change;
- Ensure that stresses that affect environmental integrity are avoided, or at the very least limited and mitigated;
- Focus on maximising the use of scarce natural resources through recycling, the transformation of existing consumption patterns, the use of zero-emission transportation systems and the reduction of waste;
- Protect high-potential agricultural land to ensure future food security; and
- Manage and mitigate the environmental impacts of mining - water, air pollution and agricultural land.

The strategic objectives of the Conservation and Resource Utilisation are:

- Protection of biodiversity and resource utilisation;
- Ensure conservation of all water resources and catchment areas;
- Promote a sustainable agriculture;
- Promote a climate resilient and low carbon economy;
- Climate Change Adaptation; and

- Optimally utilise the mining potential without compromising the long-term sustainability of the natural environment.

The Mpumalanga SDF groups together the most relevant objectives and key priorities of the SDF's of the districts that compose the Mpumalanga Province. The following priorities are highlighted in terms of environmental management and conservation in GSDM:

- Protection and enhancement of conservation areas and agricultural land with a focus on food security;
- Limiting the effects of mining on high potential agricultural land;
- Protect sensitive areas and agriculture land in surrounding region; and
- Conservation and sustainable use of natural environmental resources.

10.11.3.4 GMLM Spatial Planning and Land Use Management By-Law

The GMLM Spatial Planning and Land Use Management By-Law was established in the Provincial Notice 10 of 2016 in the Mpumalanga Provincial Gazette No. 2650. This by-law directs, among others, the publication of a Municipal SDF and a LUS.

One of the elements of LUS is to include specific conditions, limitations, provisions or prohibitions relating to the exercising of any land use rights or zoning approved on a property in terms of the approved scheme. According to this by-law "*no person may commence with, carry on or cause the commencement with or carrying on of land development which is not permitted in the land use scheme*".

However, a municipality may amend its LUS by rezoning any land considered necessary by the municipality to achieve the development goals and objectives of the Municipal SDF (SPLUMA, 27 Section). The Municipality may suspend or remove, either permanently or for a period of time, and either unconditionally or subject to any specific condition, any restrictive condition.

When an applicant or owner exercises a use right granted, he or she must comply with the conditions of the approval and the applicable provisions of the LUS.

10.11.3.5 GMLM Spatial Development Framework 2014-2034

The spatial development strategies of GMLM are in line with the NDP, Mpumalanga Vision Implementation Framework and Plan and the principles set in the SPLUMA. The following strategic objectives were identified in the GMLM SDF (GM-SDF) (GMLM, 2014):

- Protect biodiversity, water, and agricultural resources;
- Promoting education, training, and innovation;
- Accommodating urbanisation and transforming human settlements.

- Promote the development of the rural areas within Govan Mbeki that can support sustainable economic, social, and engineering infrastructure; and
- Infrastructure Investment.

The project area is located in Leandra Development Node (Leslie, Lebohang and Eendracht), which is situated on the western edge of the municipal area. This secondary node is characterised as a dormitory zone and is territorially fragmented. Leandra has a slow rate of development; expected to be able to accommodate commercial and industrial growth for many years.

The town of Leandra, which consists of Leslie (north), Lebohang (south) and Eendracht (west), was established to fulfil a service centre role for either the mining and or agricultural sectors in the district. The town is fragmented, with Lebohang being separated from Leslie by the R29 and a railway line. The Local Spatial Framework is shown in **Error! Reference source not found.**. The implementation area falls within a zone in the "Future Development" land use category. In accordance with the Integrated Housing Strategy the project implementation area is located in a housing development area in the period 2019 to 2034 (Figure 71).

The property earmarked for the CO_2 injection belongs to the GMLM, who has entered into a lease agreement with the CGS in 2021 as a research site for the investigation into the viability of CCUS. According to this agreement, the site is located on Portion 2 of the Farm Goedehoop 308 (21-digit Surveyor General No.: T0IR00000000030800002) (see Figure 5 above).

The project implementation area is situated roughly north-east of the settlement of Lebohang and east of the town of Leslie, in an area with grassland biome (Figure 72). From the field visit and satellite images it was determined that the project implementation area is vacant and unused.

Some key features of Leandra, based on the Municipal SDF, include the following (GMLM, 2014):

- Leslie is characterised by large stands, many vacant serviced stands and proclaimed undeveloped residential areas;
- Lebohang, which has smaller stands, was identified as a service upgrading priority area as it has a low level of infrastructure and social services;
- A mixed use development corridor is proposed along Provincial Routes R29 and R50, wherein high and medium density residential, business and light industrial/commercial development is promoted;
- The central business district (CBD) has an elongated shape, stretching along the R29 through the town of Leandra; and
- The open space system is based on the various watercourses that traverse Leandra.

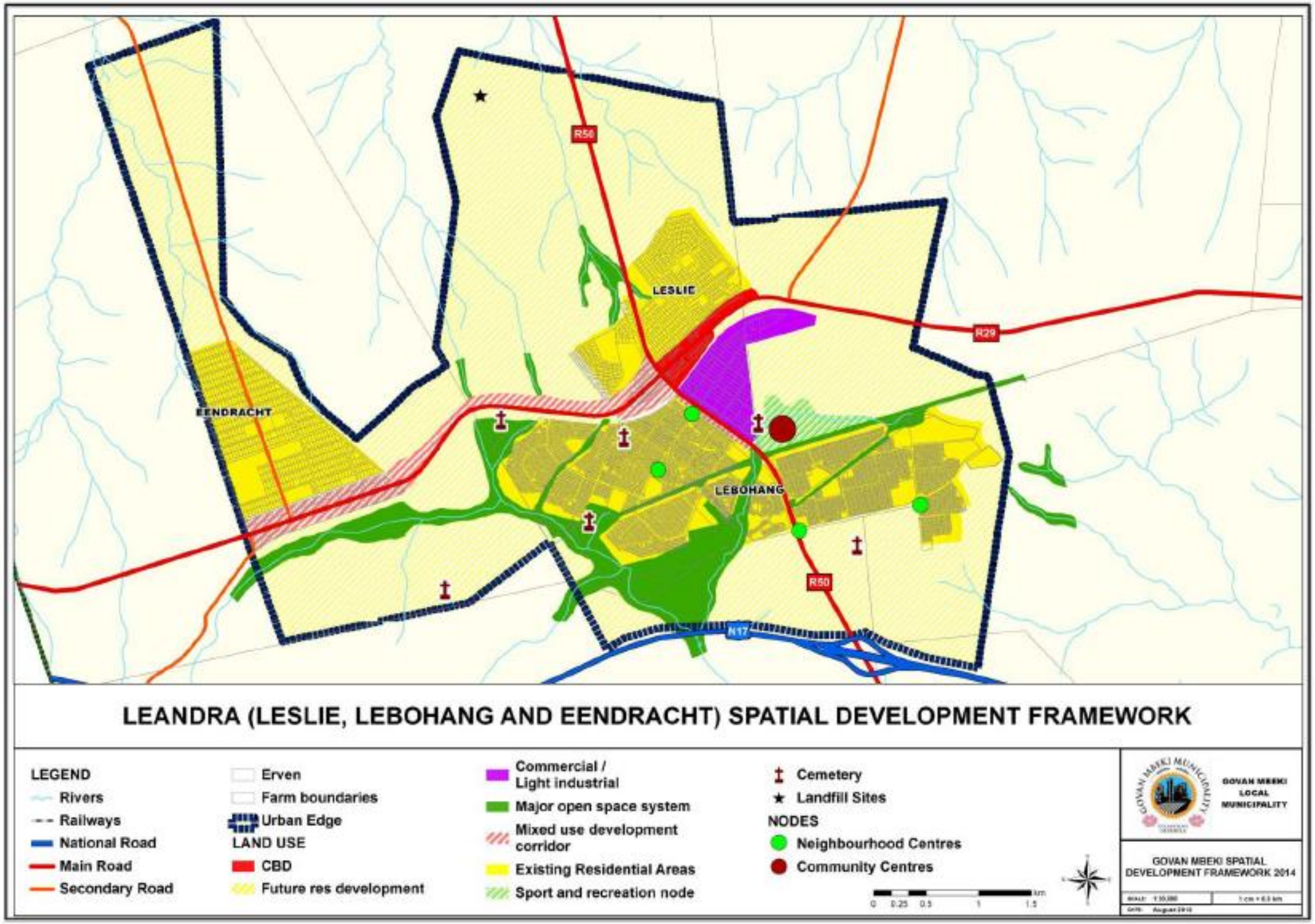

Figure 70: SDF of Leandra (2014-2019) (GMLM, 2014)

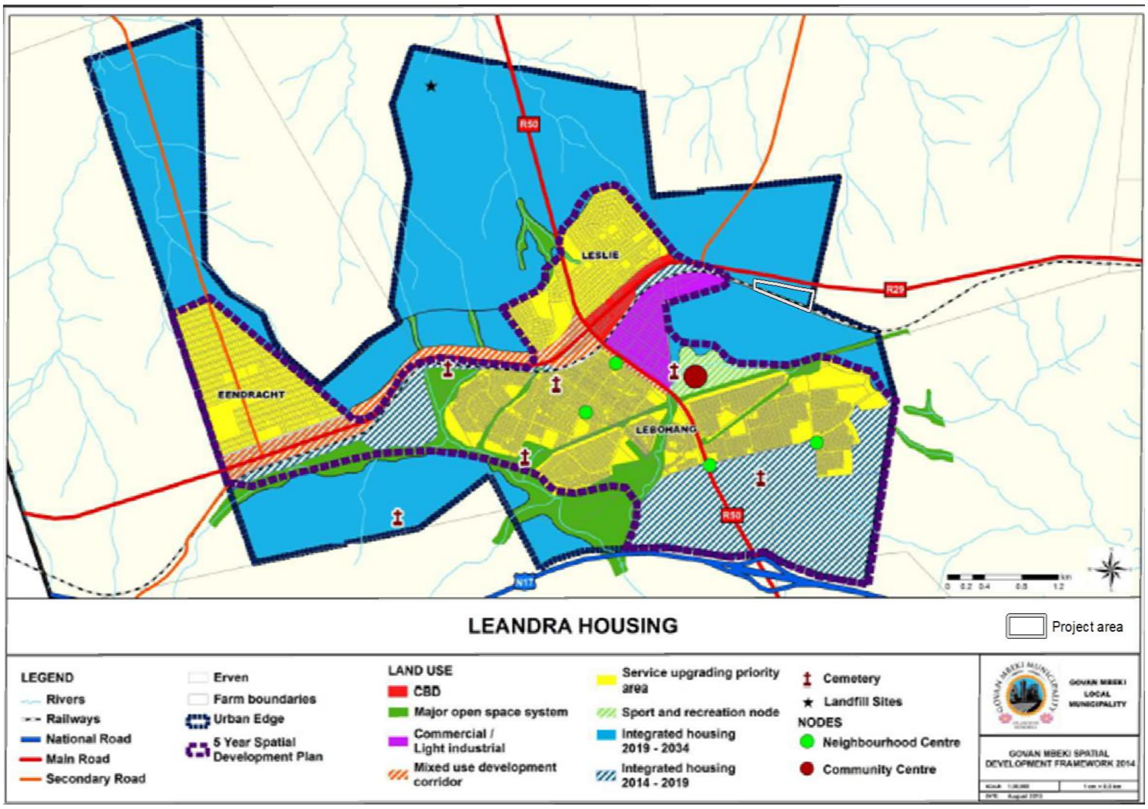

Figure 71: Integrated Housing – Leandra (2014) (GMLM, 2014)

Figure 72: View of injection site

The urban edge includes the following (GMLM, 2014):

- On the northern side the proposed urban edge follows the northern boundaries of Eendracht and Leandra and encloses some vacant land north of Provincial Road R29 between these two areas;

- On the eastern side the proposed urban edge encloses some vacant land east of Leslie industrial area and Lebohang which can be used for future extensions to Lebohang; and
- On the southern side the proposed urban edge roughly follows the southern and western boundaries of Lebohang and the railway line.

The project implementation area falls within the urban edge.

The area under study is surrounded by the following roads (Figure 73):

- National Road N17 (runs from Johannesburg to Oshoek);
- Sub-regional road R29 (joins Johannesburg with Leandra and Kinross); and
- Sub-regional road R50 (linking Standerton with Delmas).

In addition, the Richards Bay Coal railway line runs along the southern boundary of the site in an east-west direction. The presence of roads, railway lines and airfields in Govan Mbeki is presented in Figure 73. The project implementation zone intersects with the regional investment strategy areas of the N17 road as well as the railway line.

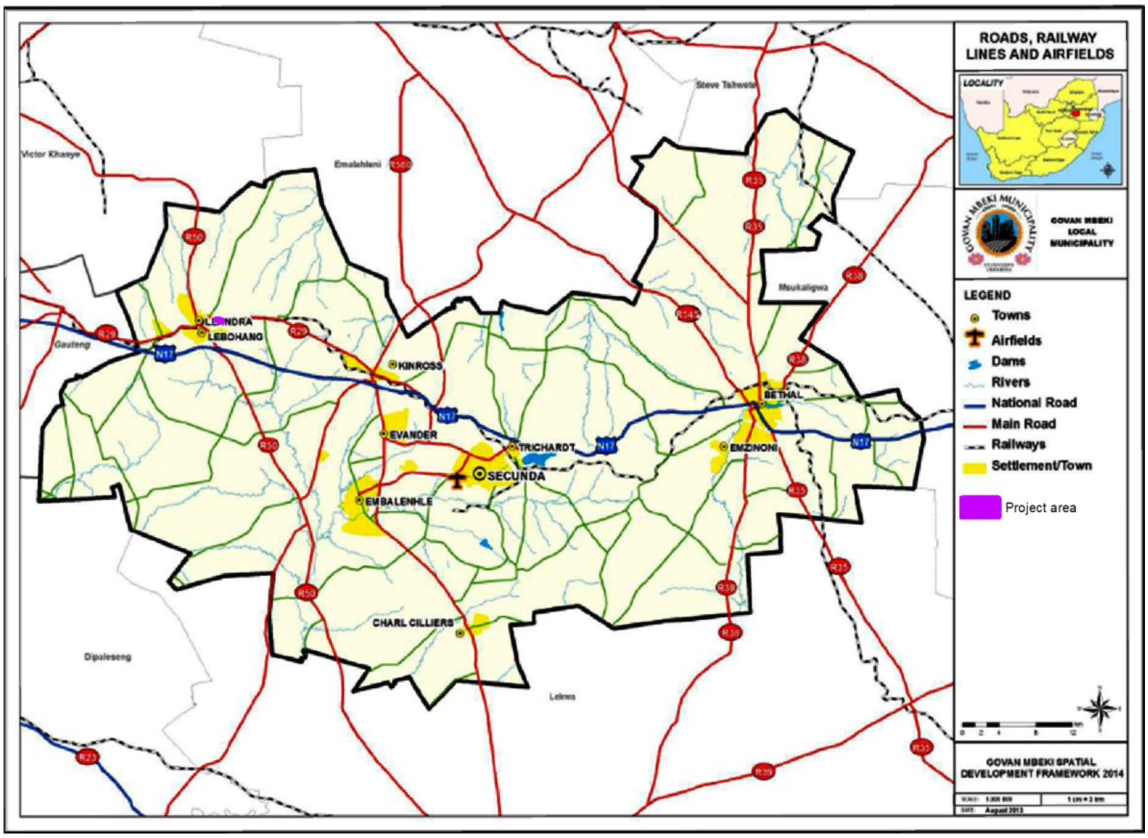

Figure 73: Roads, railway lines and airfields in Govan Mbeki (2014) (GMLM, 2014)

The GM-SDF indicates spatial development issues that have an influence on the spatial development in the area of the municipality. These observations are made by local stakeholders of the municipal wards. The project implementation area is located in Ward 6 (**Error! Reference source not found.**). The Direct Influence Area of the Project also intersects w ith Ward 1 and Ward 2 and the Indirect Area of Influence with Ward 3.

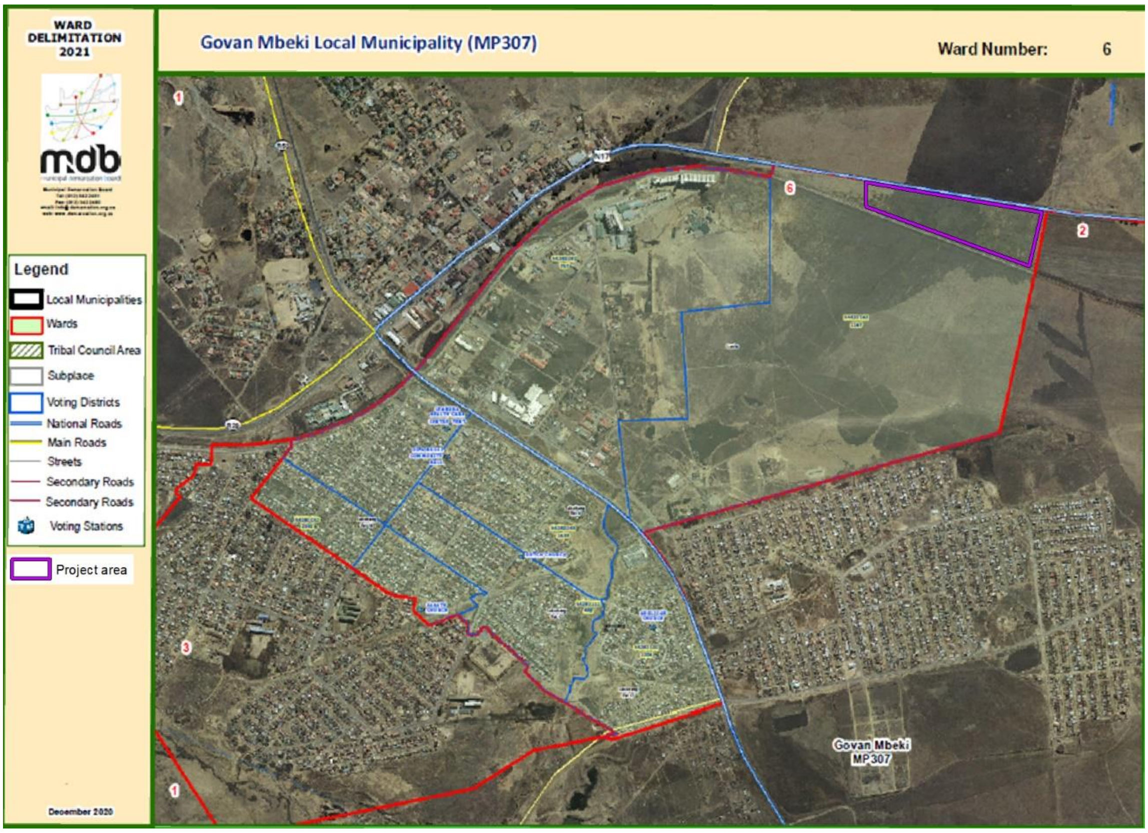

Figure 74: Ward 6, Govan Mbeki Local Municipality (2020)

Of the issues mentioned in the GM-SDF in Ward 6, the following are the most relevant, on the basis of the Project under evaluation:

- Road provision, the main access road to the Ward 6 and residential roads have all a gravel surface type and is in a bad condition;
- Limited employment opportunities; and
- No environmental problems were identified.

10.11.3.6 GMLM Land Use Scheme

Section 24 of SPLUMA specifies that every municipality must adopt and approve a LUS for its entire area of jurisdiction. These schemes are tools used by municipalities to guide and manage development according to the vision, strategies, and policies of the IDP and the SDF (DRDLR, 2017).

In accordance with the GMLM LUS the purpose of the LUS is "*the co-ordinated and harmonious development of the area to which it relates in such a way as will most effectively tend to promote the health, safety, good order, amenity, convenience and general welfare of such area as well as efficiency and economy in the process of such development […]*".

The Municipal Land Use Scheme provides a detailed, property-bound guideline to assist investment decisions by the private sector and planning application decisions by the Municipality. It works by developing zones that contain detailed regulations regarding compatible land uses, i.e., confers restrictions on use in the demarcated areas (GMLM, 2010).

Of the components portrayed by LUS, the following are highlighted:

- **Land Use Categories**, indicating the orientation of the land uses. The categories shall be used to spatially indicate the existing land use rights on a map;
- **Land Use Zones,** that indicate the type of development that is regarded as desirable (pertaining to the potential use and development) within a specific, demarcated area. The zones were developed from the Govan Mbeki IDP and SDF and reflect the development objectives and strategies of the Municipality; and
- **Management Zones**, that impose management guidelines and/or regulations with regards to specific issues of concern or importance in the Municipal area.

The Land Use Zones include the following (GMLM, 2010):

- **Free Land Uses,** meaning land uses that may be exercised without an application or approval procedure;
- **Permitted Land Uses,** meaning land uses that are considered to be compatible and desirable in the zone and which may be obtained by way of application in terms of the Scheme;
- **Discretionary Land Uses,** meaning land uses that may be compatible and desirable within the zone subject to certain conditions and which may be obtained by way of application in terms of the Scheme, and
- **Prohibited Land Uses**, meaning land uses that are prohibited in that zone.

GMLM's SDF 2014-2034 presents the urban land uses of the municipality, including of Leandra (Leslie, Lebohang and Eendracht). This use is governed by the Municipal LUS, which sets out the land use rights, as well as the future land uses that will be permitted. The local spatial framework of Leslie and Lebohang, including the land use zonings in terms of the LUS, is presented in Figure 75.

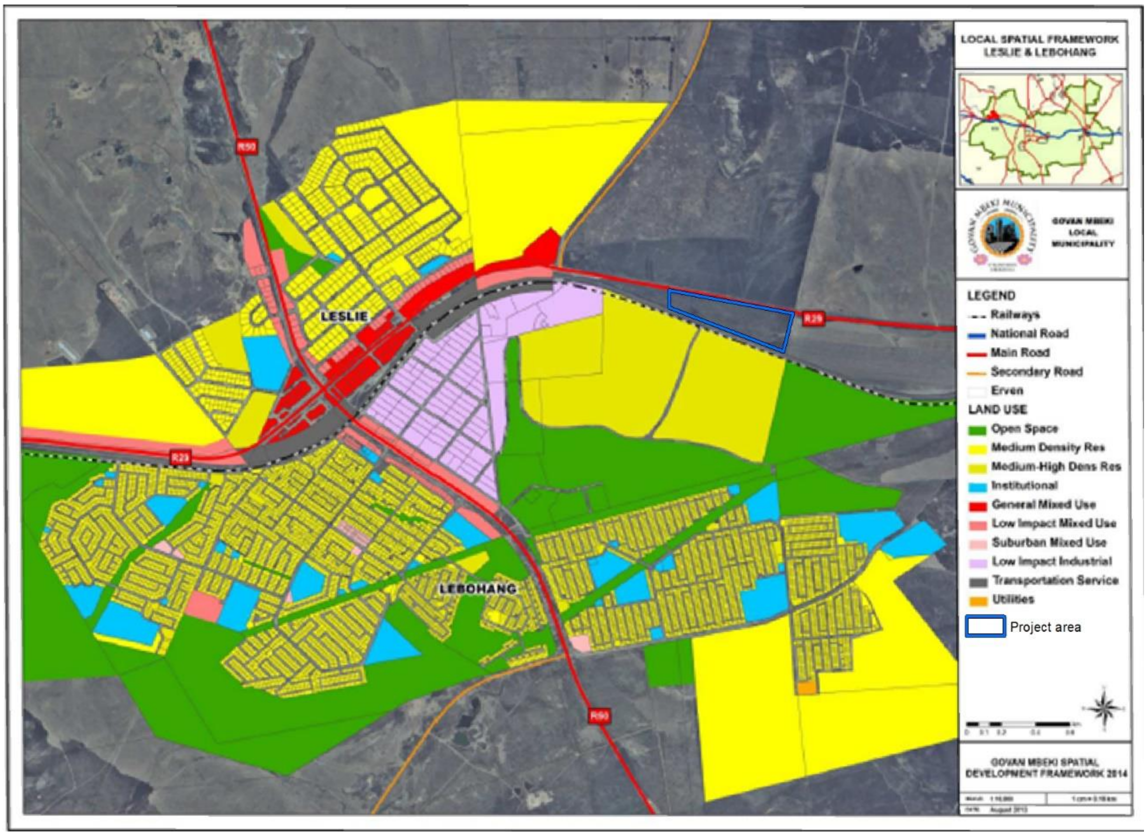

Figure 75: Local Spatial Framework: Leslie & Lebohang (GMLM, 2014)

As can be seen in Figure 75 above, the project implementation area is not categorised in the GMLM LUS, and as such, it is assumed that it does not present restrictions on its use, in terms of land use planning.

10.11.3.7 Site Sensitivity

As mentioned, a sensitivity analysis was conducted of the project area by using the DFFE Screening Tool.

The project area is included in the Olifants Environmental Management Framework (EMF) and intersects with the Air Quality - Highveld Priority Area and with the Strategic Gas Pipeline Corridors-Phase 8: Rompco Pipeline Corridor. These zones may contain development incentives, restrictions, exclusions, or prohibitions that apply to the proposed development footprint.

Furthermore, in the context of spatial planning, the project area, and the project's indirect area of influence, falls within the areas of environmental sensitivity of civil aviation (high sensitivity - within 8 km of other civil aviation aerodrome) and defence (low sensitivity).

In accordance with the Protected Areas Register (Department of Forestry, Fisheries and the Environment, 2022) there is no intersection of the project area with Protected Areas, Conversion Areas, or Biosphere Reserve Zones.

A. <u>Olifants Environmental Management Framework</u>

Within this EMF, the project implementation area is at the edge of zone A - Highveld/Energy Hub Area (Environomics, 2009) (Figure 76).

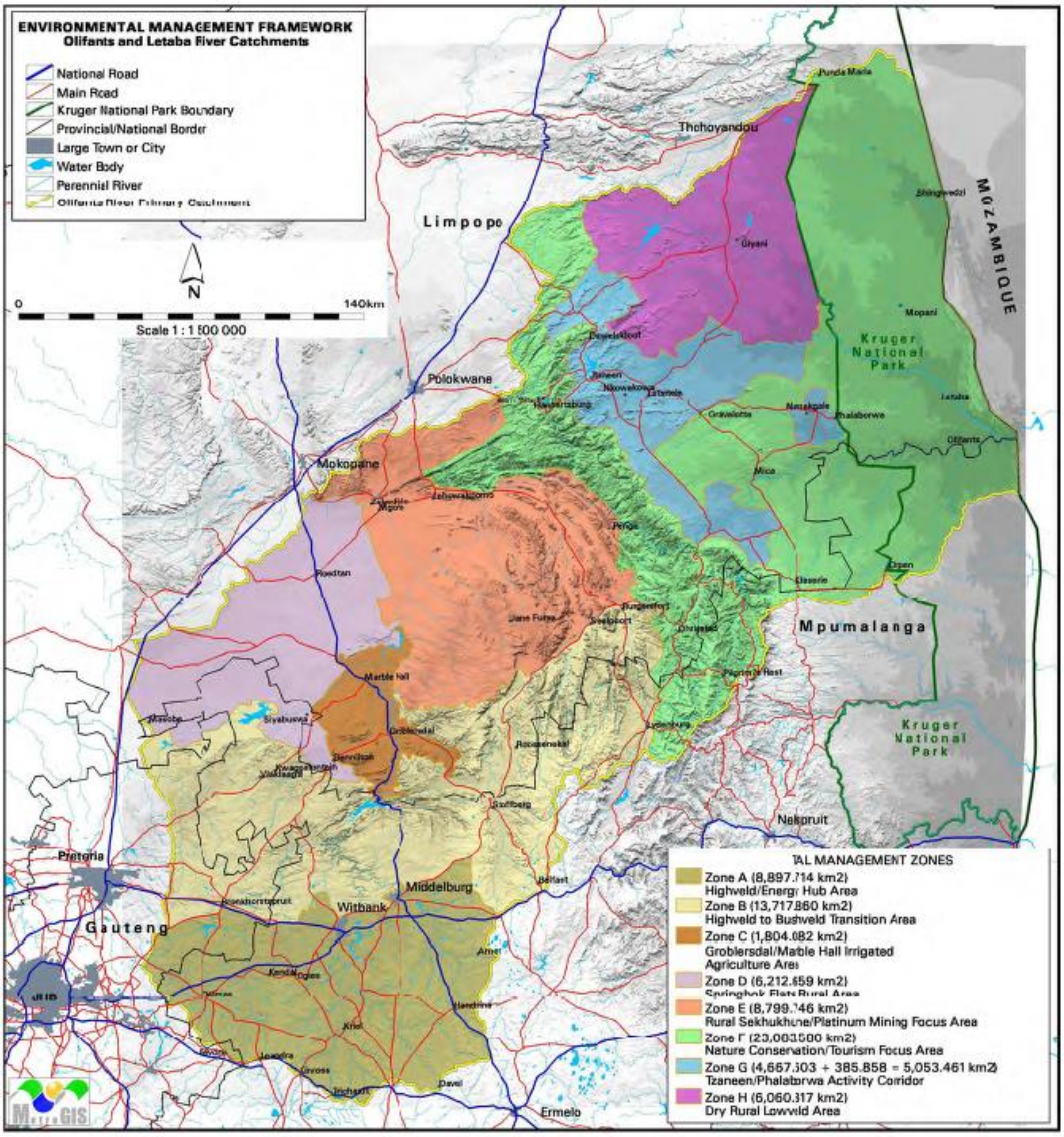

Figure 76: Environmental Management Zones of the Olifants EMF (Environomics, 2009)

In this zone the major constraints are over-allocation of water, limited scenic value, and very little remaining natural habitat. The mining activities, industrial activities and power stations have a large negative impact on the natural environment, especially air and water quality. The remaining pans and wetlands are important refuges for natural life and should be protected if possible.

The water resource in this zone is already over-allocated. There is no additional water available for industrial and mining development. Additional allocations to these sectors must come from savings and reallocation of existing sources.

Mining and the transportation of mined materials is a major cause of air pollution in the zone that forms part of the Highveld Priority Area national air pollution hotspot. The emission of pollutants into the air is expected to continue for the foreseeable future.

The major opportunities include the strong income base from coal mining and associated activities and high agricultural potential, with an obvious potential conflict between the opportunities that are provided by mining and agriculture, respectively.

The following management guidelines are prescribed for Zone A:

- Water allocation: There is no additional water available for industrial and mining development in the zone. Additional water allocations for the agricultural, mining, and industrial sectors must come from savings from existing allocations that are reallocated;
- Water quality: Water users must ensure that water that is released back into the system from their activities must comply with the relevant quality standards. It is their responsibility to find out what standards are applicable to them;
- Conservation: All natural wetlands, riparian areas and river systems that occur in the zone as depicted on Spot 5 satellite images dated on or before 30 November 2009 must be maintained in at least the area and condition as of 30 November 2009.

B. Air Quality - Highveld Priority Area

The HPA AQMP was published on the GN 144 in the GG 35072 of 2 March 2012. The HPA is associated with poor air quality, and elevated concentrations of criteria pollutants (including NO_2; O_3; PM_{10}; NO_x; and SO_2) occur due to the concentration of industrial and non-industrial sources. The primary motivation of the HPA AQMP is to achieve and maintain compliance with the ambient air quality standards. Figure 77 shows the locality of the HPA, showing the three district municipalities, their constituent local municipalities (including GMLM), and the single metropolitan municipality (DEA, 2011).

There is no national or internationally recognised ambient air quality standard for Carbon Dioxide. As part of global agreements to address global warming and climate change impacts, targets have been set for countries to reduce CO_2 emissions significantly (DEA, 2011).

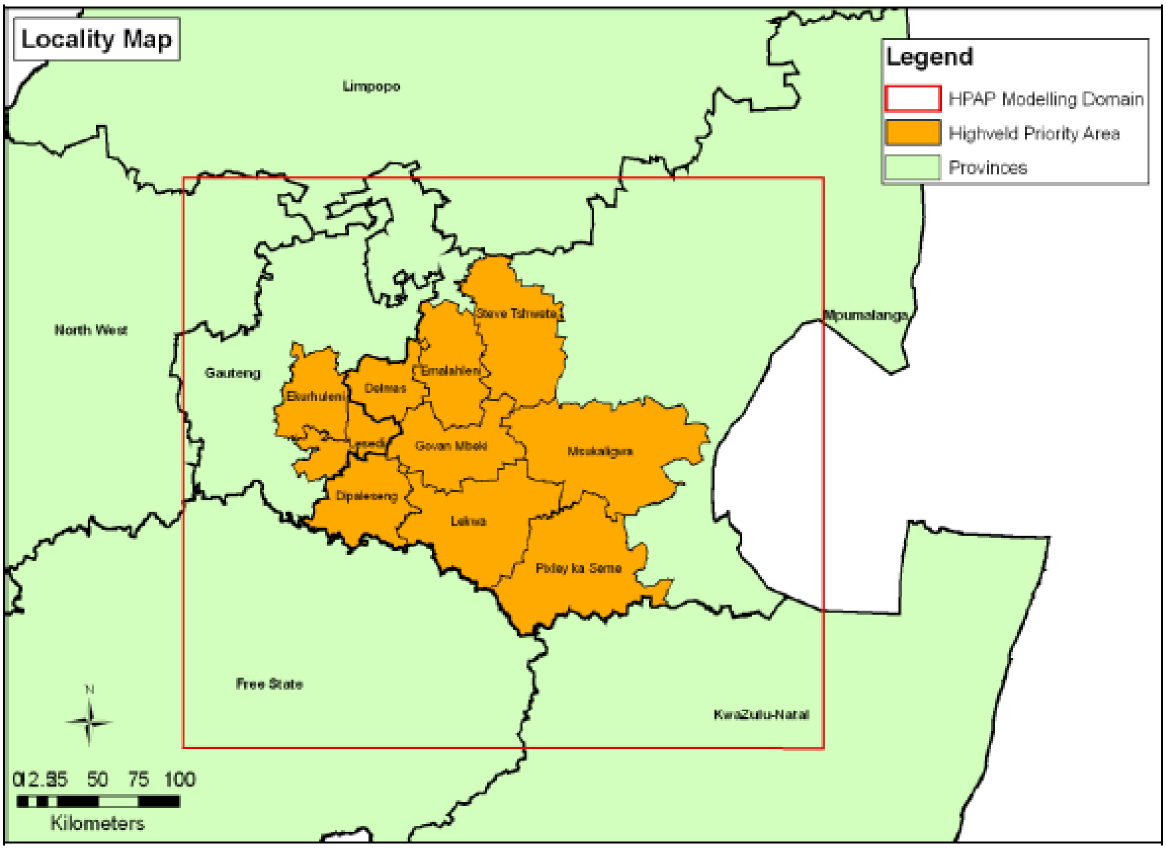

Figure 77: Locality map depicting the HPA (DEA, 2011)

C. Strategic Gas Pipeline Corridors-Phase 8: Rompco Pipeline Corridor

The strategic corridors are part of the Operation Phakisa, launched by the South African National Government in July 2014, with the aim of implementing priority economic and social programmes (DEFF, 2019).

The Strategic Environmental Assessment (SEA) for the Development of a Phased Gas Pipeline Network in SA (DEFF, 2019) identified 9 Strategic Gas Pipeline Corridors related to the phased development of a gas pipeline. These strategic gas pipeline corridors were published under GN 143 in GG 4419 of 26 February 2021 (Figure 78). One of these, the phase 8 – Rompco pipeline corridor intersects with the project area.

In addition to the SEA, there is published a generic Environmental Management Programme (EMPr) for Gas Transmission Pipeline Infrastructure (DEFF, 2020). This EMPr applies to the development, expansion, and related operation of gas transmission pipeline infrastructure outside an industrial complex, using pipelines, exceeding 1,000 m in length, with a throughput capacity of more than 700 tons or 50 m^3 per day (Department of Environment, Forestry and Fisheries, 2020). The pipelines will be below ground at a depth of approximately 1 m, with pigging stations above ground (DEFF, 2019).

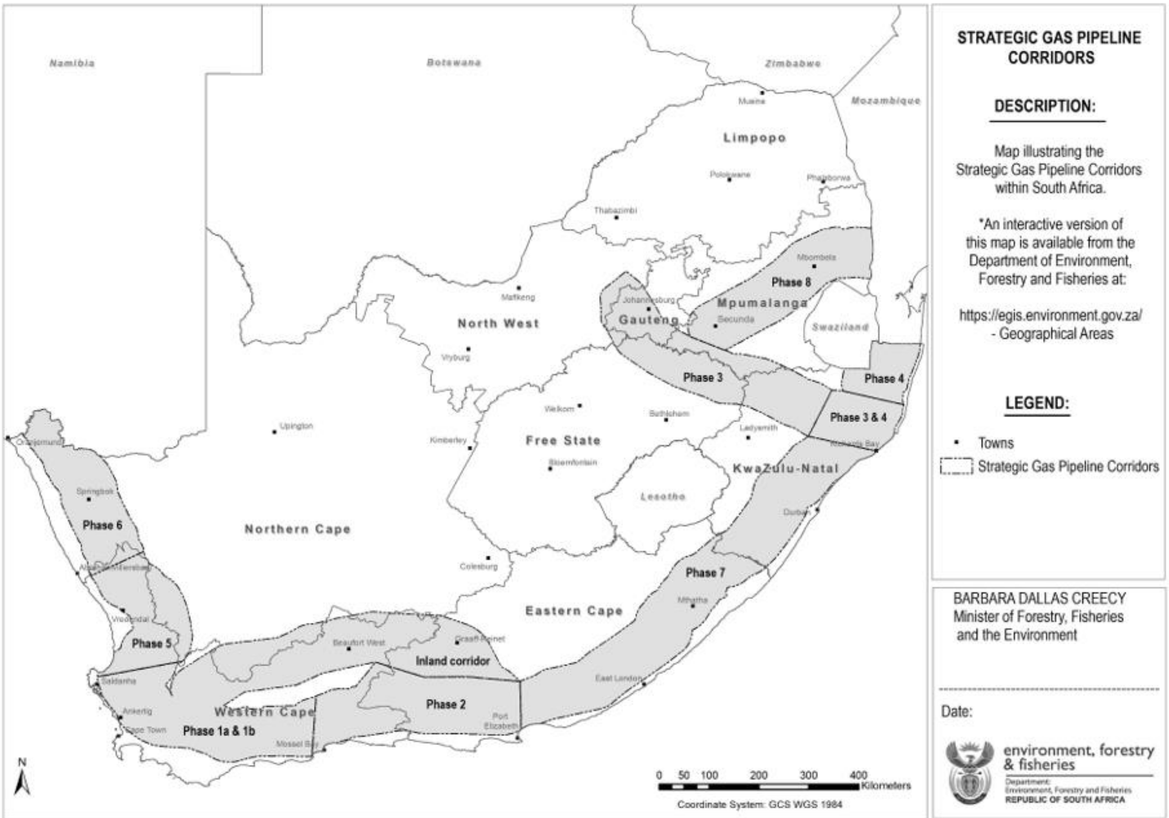

Figure 78: Map image of Strategic Gas Pipeline Corridors (DFFE, 2022)

The SEA does not necessarily guarantee construction of any phase of the assessed corridors, as it is not a specific project. The construction of the corridors depends on there being a viable business case for each of the phases, i.e., there being a source of gas at one end and a guaranteed customer. However, there is an estimated timeframe of five years, including negotiation with the landowner in terms of easement requirements (DEFF, 2019; DEFF, 2020).

If the phases of the Project coincide with the construction of these pipeline corridors (spatial and time) there may be cumulative impacts.

D. <u>Environmental Sensitivity - Civil Aviation</u>

According to the Screening Tool, the project area has a high sensitivity in terms of civil aviation (Figure 79).

Civil aviation is governed by the Civil Aviation Act (Act No. 13 of 2009), which aims to repeal, consolidate and amend the aviation laws giving effect to certain International Aviation Conventions and to provide for the control and regulation of aviation within SA, among others.

The South African Civil Aviation Authority (SACAA, 2021) is mandated with controlling, promoting, regulating, supporting, developing, enforcing, and continuously improving levels of safety and security throughout the civil aviation industry.

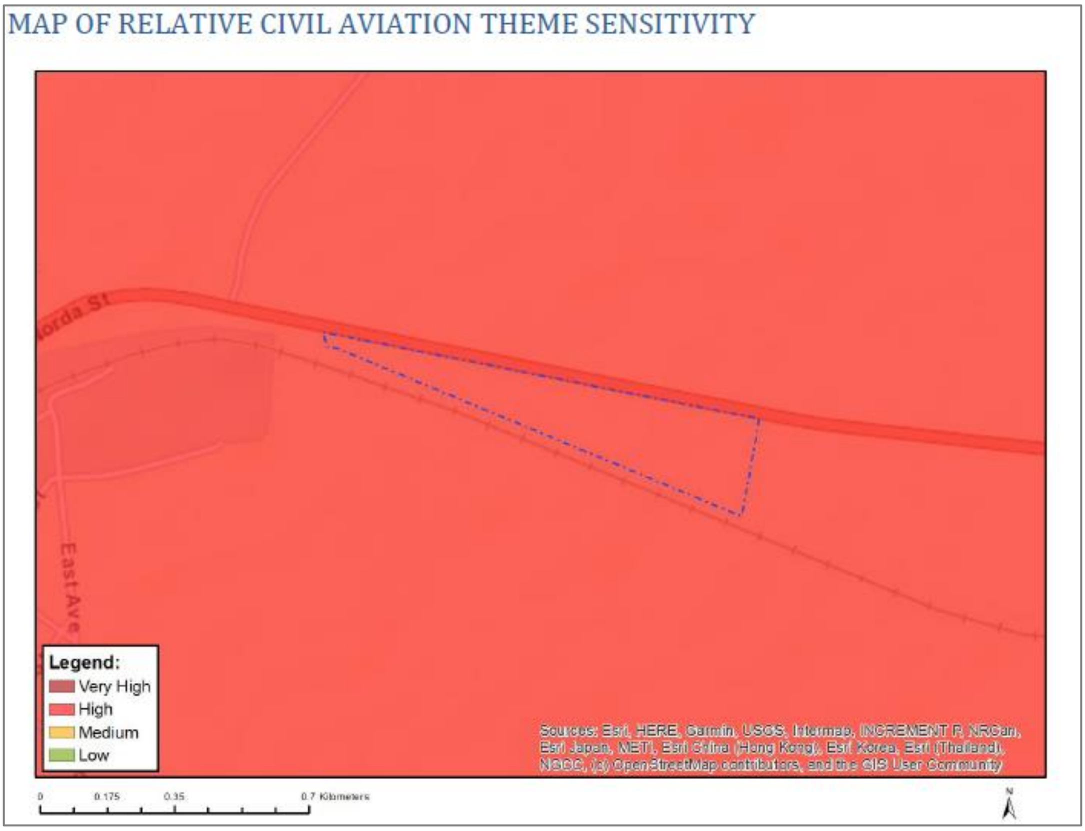

Figure 79: Map of relative civil aviation theme sensitivity (DFFE Screening Tool, 2023)

All proposed activities that have the potential to affect civil aviation in SA should be assessed by the SACAA in terms of the South African Civil Aviation Regulations and South African Civil Aviation Technical Standards in order to ensure aviation safety (Department of Environment, Forestry and Fisheries, 2019).

The Obstacle Evaluation Committee (OEC), which is composed by members of the SACAA and the South African Air Force, is responsible for evaluating and approving the development of proposed activities that may affect civil aviation, military aviation, or areas of military interest (DEFF, 2019).

According to DEFF (2019), the following is noted:

- "…the *Regulation 19.01.30 (3) of the Civil Aviation Regulations (2011) states that "buildings or other objects which will constitute an obstruction or potential hazard to aircraft moving in the navigable air space in the vicinity of an aerodrome, or navigation aid, or which will adversely affect the performance of the radio navigation or instrument landing systems, must not be erected or allowed to come into existence without the prior approval of the Director" of the SACAA*". It is therefore necessary to submit an application for approval to the SACAA for any development that includes obstacles that may constitute a hazard to aviation.

- "…i*n South Africa, all structures taller than 15 metres above ground level must be assessed and registered as potential obstacles to aviation in the Electronic Terrain and Obstacle Database (eTOD)".*

As such, the impact of the Project on civil aviation tends to be limited because carbon storage will be below-ground, with the exception of the construction and support infrastructure and equipment. The largest structure is expected to be the drilling equipment which may vary depending on the equipment and techniques used; however, it is not expected to exceed 15 m, following the example of the HYDX-6 Full Hydraulic Core Drilling Rig, a full hydraulic core drill rig, from GEODRILL EQUIPMENT Co. Ltd, which have a drilling capacity of between 1,000 and 2,000 m (GEODRILL RIG, 2016).

E. <u>Environmental Sensitivity – Defence</u>

The Screening Tool shows low sensitivity in terms of defence (Figure 80). Hence, no adverse impacts on defence structures are expected from the Project activities in the project implementation area. No further assessment or mitigation measures are required.

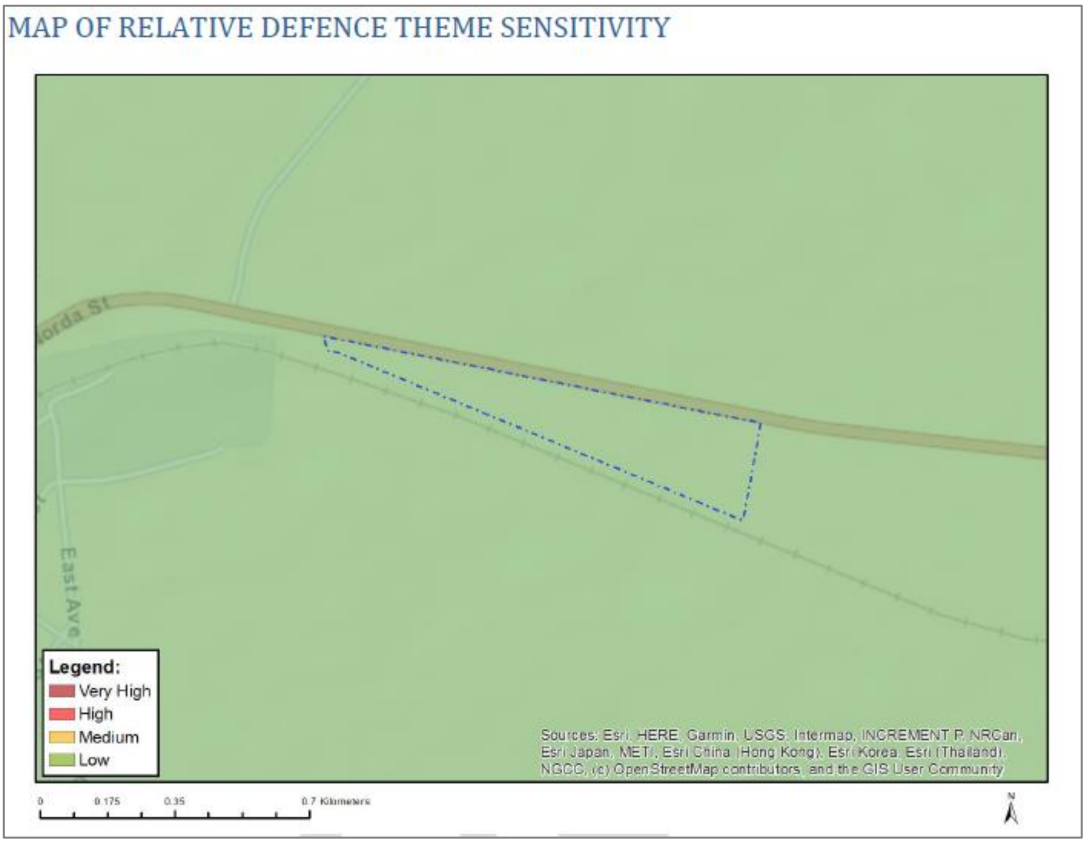

Figure 80: Map of relative defence theme sensitivity (DFFE Screening Tool, 2023)

10.11.4 Land Cover

The dominant land uses in the region include mining and agriculture, with scattered towns (see Figure 81 below).

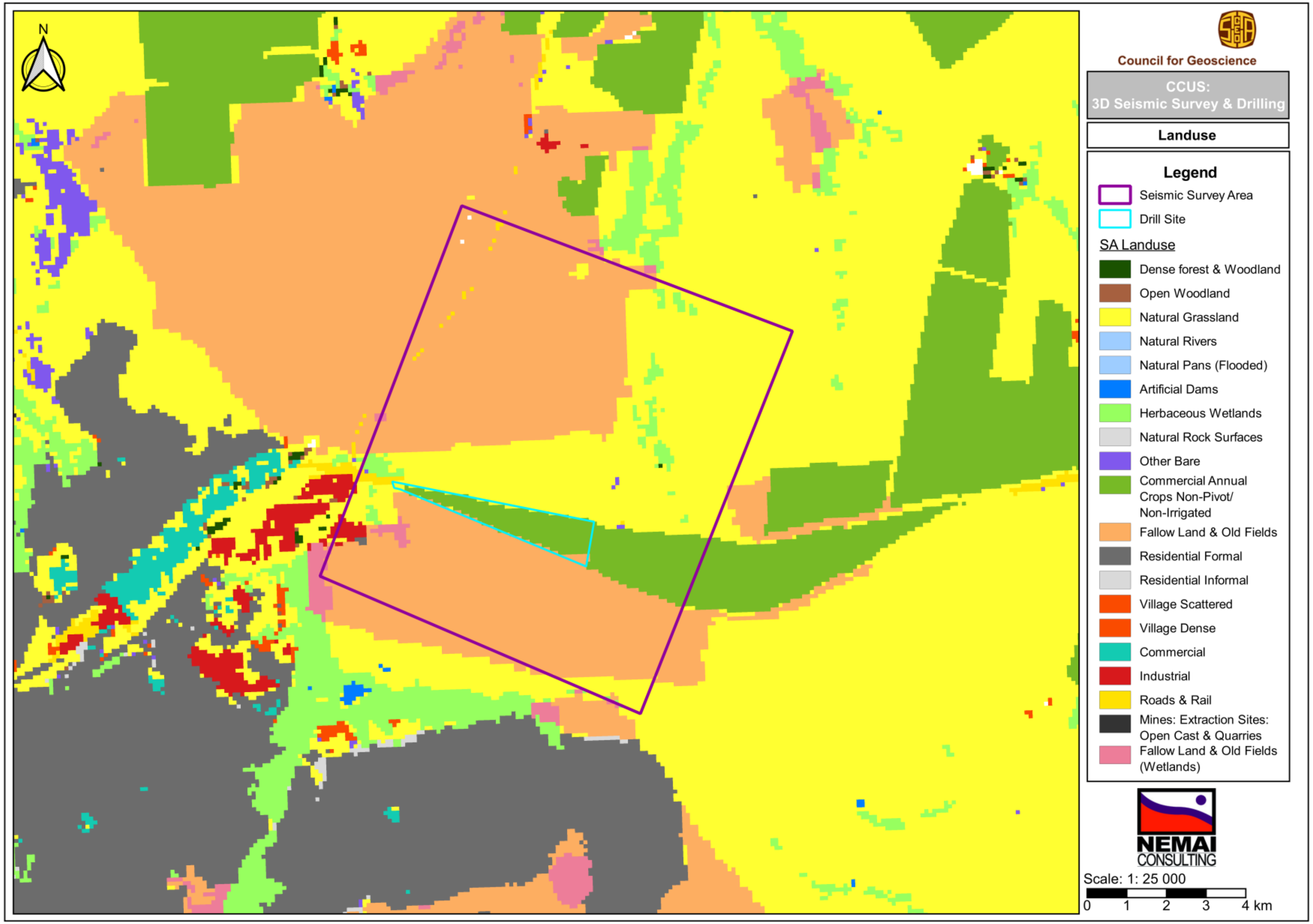

Figure 81: Land cover in project area

The project implementation area is vacant (see Figure 82 below). Although the land cover in Figure 81 below shows the site to consist of commercial croplands, from historical aerial imagery it appears that the site has not been cultivated in at least the last 20 years. The site will be fenced for safety and security purposes.

Figure 82: View of drill site looking westwards towards the town of Leandra

10.11.5 Summary

The characterisation of land use and constraints in the context of the Pilot CO_2 Storage Project was based on the framework of the development models advocated in the operational programmes and strategic plans, the regional management instruments and the constraints of public utility applicable to the study area.

The following development models/programs were considered, with a general focus on the creation of jobs, the reduction of greenhouse gas emissions and improving the resilience and environmental sustainability:

- International development models -
  - Nationally Appropriate Mitigation Actions.
- Africa Union development models -
  - Agenda 2063;
  - Climate Change and Resilient Development Strategy and Action Plan.
- National development models -

- National Development Plan 2030;
- Medium-Term Strategic Framework 2019-2024;
- National Framework for Sustainable Development;
- National Strategy for Sustainable Development and Action Plan;
- New Growth Path;
- National Climate Change Response Strategy White Paper;
- Science, Technology and Innovation White Paper.

❑ Provincial and municipal development models -

- Mpumalanga Vision;
- Strategic Plan of Mpumalanga Province;
- IDP of Gert Sibande District Municipality;
- IDP of Govan Mbeki Local Municipality.

Although a pilot Project is proposed, and as such it will have a low impact in contributing to spatial planning development models, its implementation will contribute to technological, scientific, and industrial development, with the aim of implementing similar larger-scale projects.

In the area under study the following land management instruments stand out:

❑ National SDF;
❑ GSDM SDF;
❑ GMLM SDF; and
❑ GMLM LUS.

Of the objectives outlined by these, and in the context of the Project, the objective of protect biodiversity, water and agricultural resources and investment in infrastructure stand out.

The earmarked property is owned by the GMLM, but which is being leased to CGS to conduct the pilot Project. In terms of the GMLM SDF, the proposed injection site is located within an area designated for future residential development. It is currently an open field with no activity. It has in close proximity the N17 National Road and the Richards Bay Coal Railway. According to the Municipal LUS there are no restrictions on use in this area.

The project implementation area intersects with the following sensitivities:

❑ Olifants EMF;
❑ Air Quality - HPA;
❑ Strategic Gas Pipeline Corridors-Phase 8: Rompco Pipeline Corridor;
❑ Area of environmental sensitivity of civil aviation (high sensitivity); and
❑ Area of environmental sensitivity of defence (low sensitivity).

The following points regarding sensitivities are highlighted:

- The water resource in the zone is already over-allocated. There is no additional water available for industrial and mining development. Additional allocations to these sectors must come from savings and reallocation of existing sources;
- Water users must ensure that water that is released back into the system from their activities must comply with the relevant quality standards;
- Possible cumulative impacts, if the construction of a gas pipeline is near the vicinity of the project area and during the same period; and
- If structures or equipment used in the development of the Project exceed 15 m in height it must be assessed and registered as potential obstacles to aviation.

10.12 Socio-Economic Environment and Public Health

10.12.1 Introduction

This section presents the socio-economic context for the Project, focusing on population dynamics, education, employment and economic activities, health, safety, poverty, and the SA's energy sector.

The proposed CO_2 Storage Project is administratively located in the GSDM region of the Mpumalanga Province, SA. The site will be developed within the GMLM, near the town of Leandra, which is a semi-urban municipal area consisting of farms and urban settlements.

The data presented by Statistics of South Africa from the Census 2011 considers Leandra and Lebohang to be distinct towns. As it is represented inFigure 83, the data of Leandra comprises the data of Leslie and Eendracht neighbourhoods while Lebohang is considered to be a separate town (Figure 84). Therefore, in this Section, the data relative to Leandra will comprise data of Leslie and Eendracht neighbourhoods, while the data for Lebohang will be presented separately.

The data at the local municipality and district level is more recent as it is from the Community Survey undertaken in 2016.

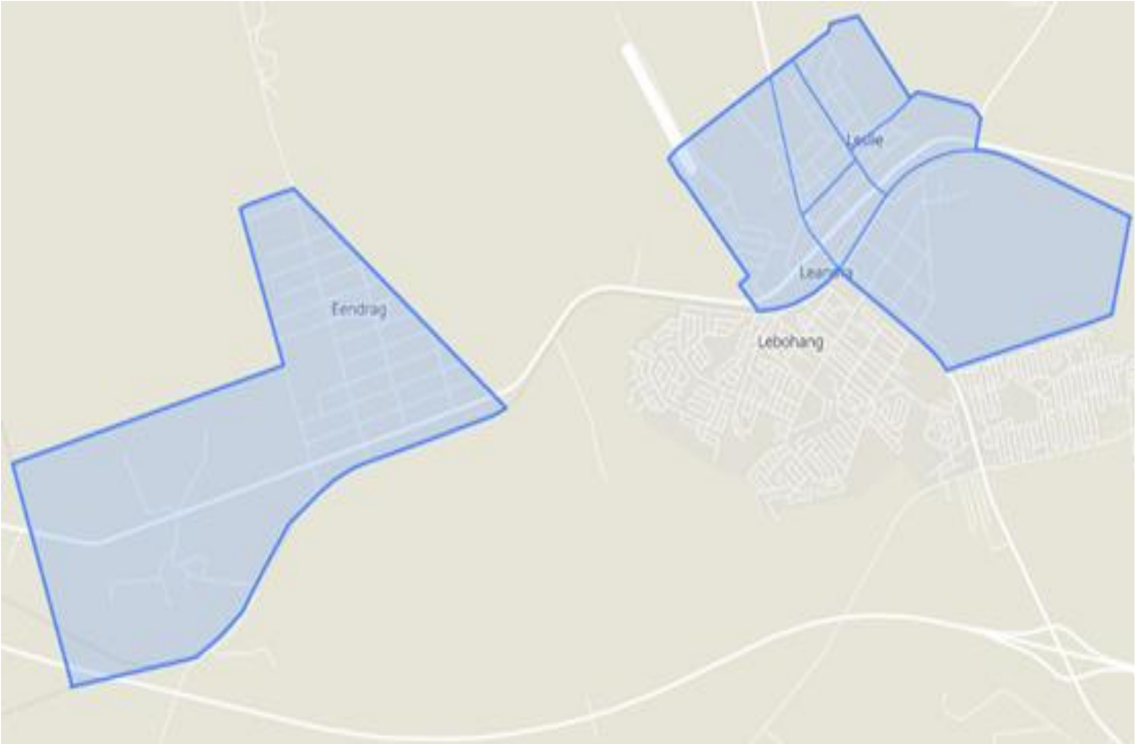

Figure 83: Map of Leandra Town from Census 2011 (Frith, 2011)

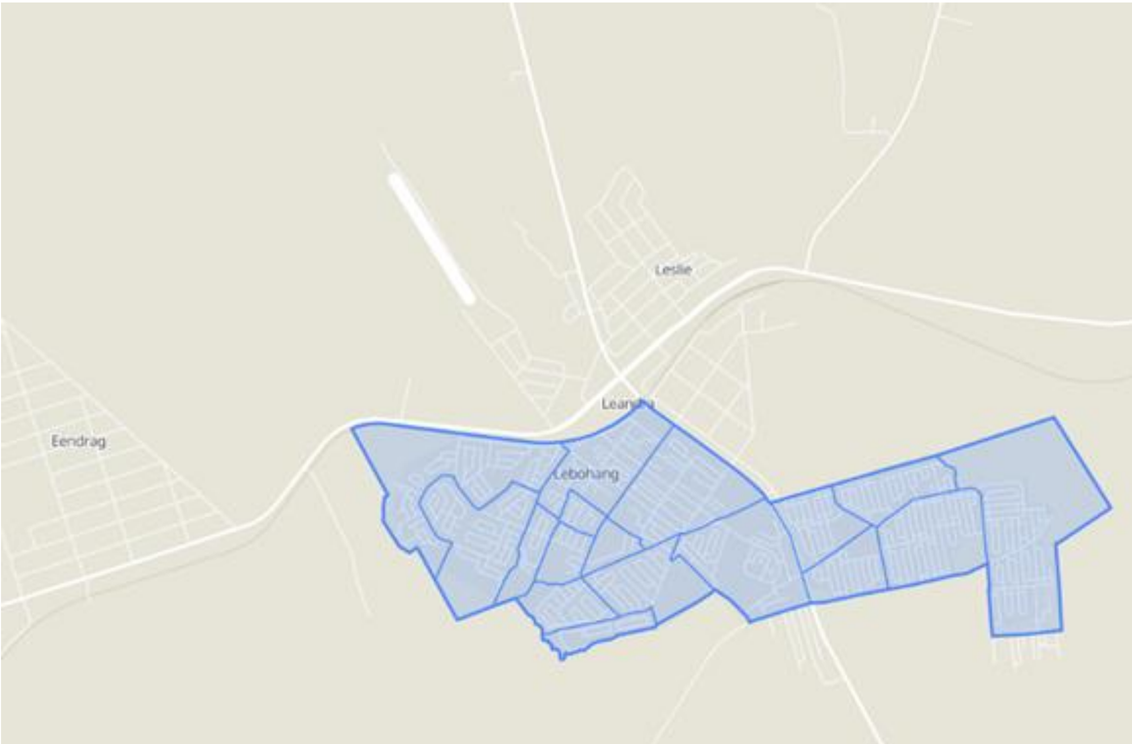

Figure 84: Map of Lebohang Town from Census 2011 (Frith, 2011)

10.12.2 Land Use

The GMLM is mostly rural, with three urban areas situated within it, namely Leandra on the western edge, the Greater Secunda in the central part and Bethal/Emzinoni on its eastern edge.

The most prevalent land use in the rural areas of GMLM is commercial agriculture, particularly dry land crop cultivation, such as maize, sunflowers and beans. Almost the whole municipal area in covered by vast coal reserves.

Leandra developed first as an agricultural support centre and grew as a result of the gold and coal mining and Sasol activities in the region. In addition, it is strategically located on the N17 thereby tapping into the Gauteng-Richards Bay Road and rail freight route (GMLM, 2014).

Industrial and commercial uses are mostly located in the southern part of Leslie, south of the railway line and east of Provincial Road R50, as seen in **Error! Reference source not found.** (represented in purple).

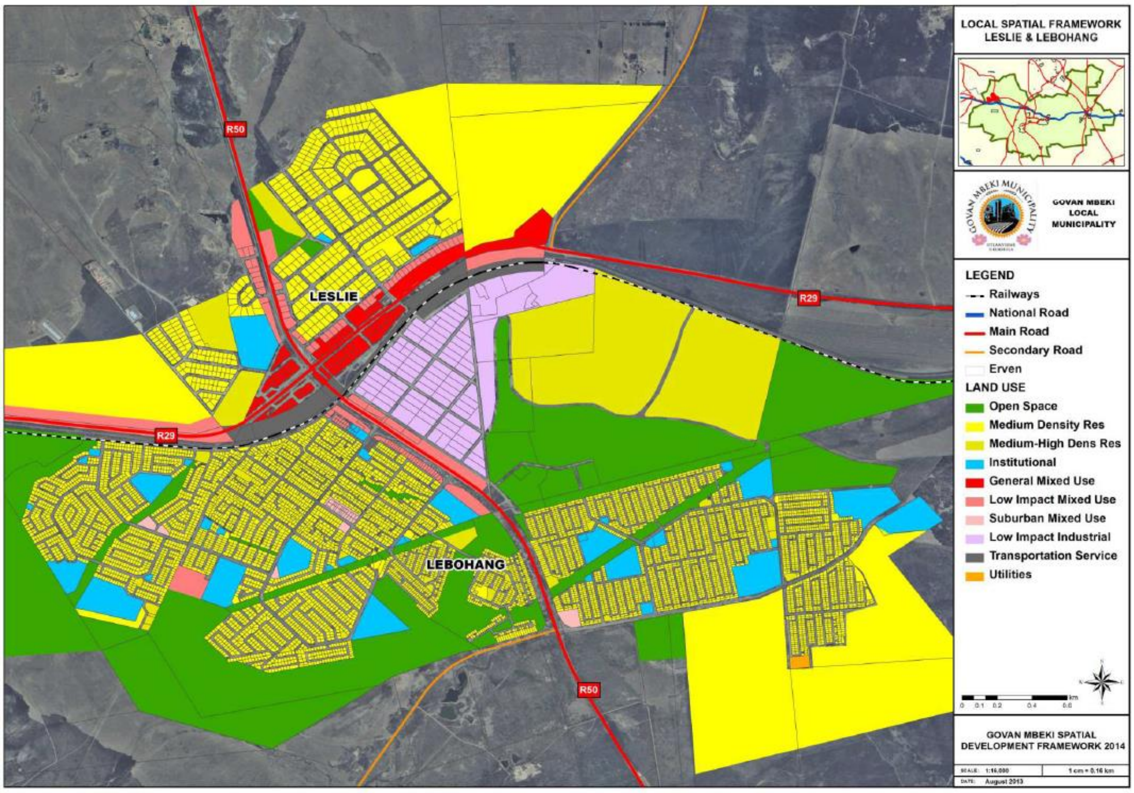

Figure 85: Local Spatial Framework: Leslie and Lebohang (GMLM, 2014)

Lebohang is a typical apartheid–style dormitory township housing people working in Leandra, Secunda and as far as Springs and Nigel in Gauteng. The town is a mono-functional residential area with almost no employment areas. Therefore, the town is mostly residential and there are no industrial and commercial formal activities and very few formal businesses (GMLM, 2014).

10.12.3 Population

Leandra and Lebohang (IAI) comprise 11.4% of the population of GMLM. In 2011, the population of Leandra was 2,023 and the population of Lebohang was 31,553. Leandra had more male population and Lebohang had more female population. The population density was more than 30 times higher in Lebohang compared to Leandra.

Since 2011, it is likely that the population has increased (positive population growth) as it has been the case for GSDM and GMLM.

Table 33: Population Dynamics (Stats SA, 2022)

Population Dynamics	GSDM (2016)	GMLM (2016)	Leandra Town (2011)	Lebohang (2011)
Population	1,135,409	340,091	2,023	31,553
Sex Ratio (Males per 100 females)	98.6	108.5	110.3	97.5
Population density (population per km²)	35.7	115.1	210.0	6,519.0
Population growth 2011-2016 (per annum)	1.93%	3.27%	-	-

The age structure of the population reveals a young demographic, with most of the population in the working age category.

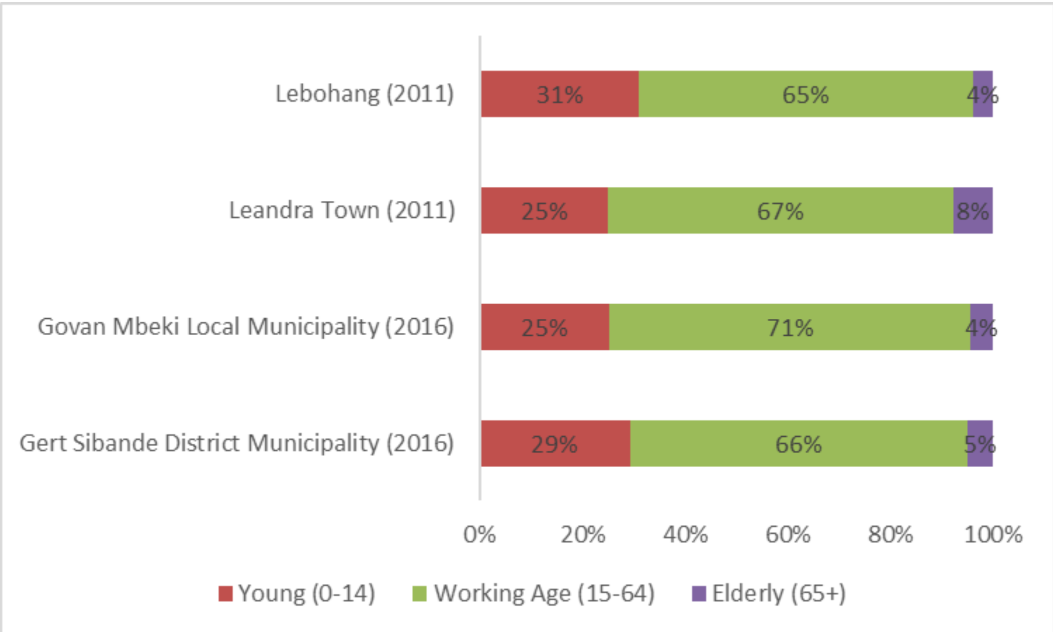

Figure 86: - Age Structure (Stats SA, 2022)

In terms of ethnic groups, in Lebohang almost the total population is black African (99%). In Leandra, the proportion of white population (42%) is similar to the black African proportion (44%).

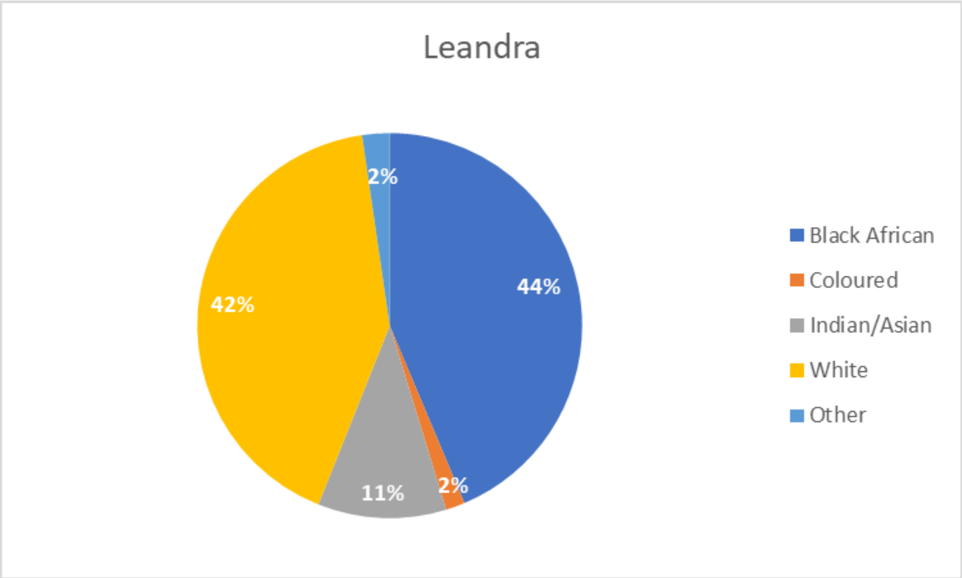

Figure 87: Percentage distribution of ethnic groups in Leandra, 2011 (Stats SA, 2022)

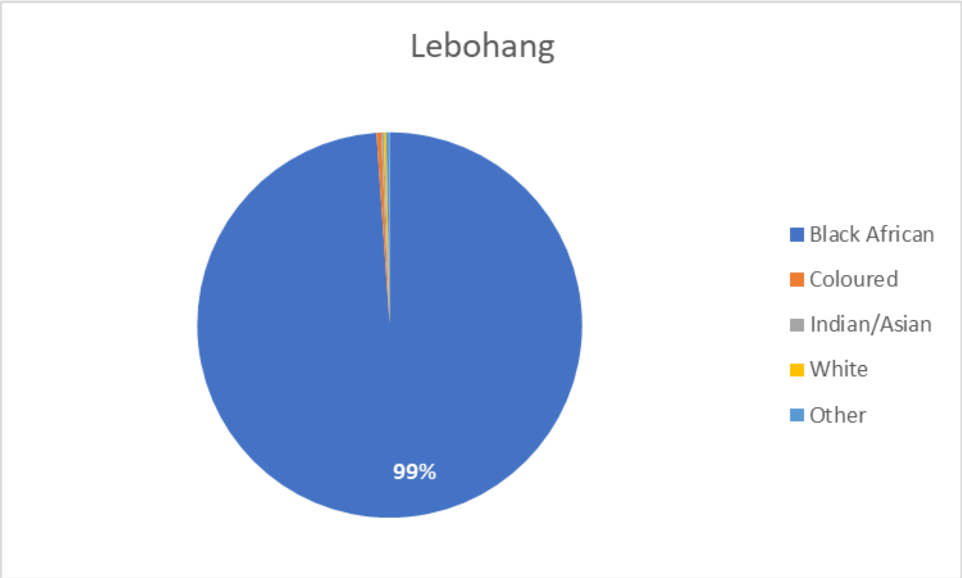

Figure 88: Percentage distribution of ethnic groups in Lebohang, 2011 (Stats SA, 2022)

10.12.4 Education

Comparing the two areas in the IAI, the level of education is considerably higher in Leandra compared to Lebohang. In Leandra, 18% of the population has higher education and only 3%

has no level of formal education. In contrast, 13% of the population of Lebohang has no education.

Compared to the education levels in GMLM and GSDM, Leandra has higher education levels and Lebohang has lower education levels.

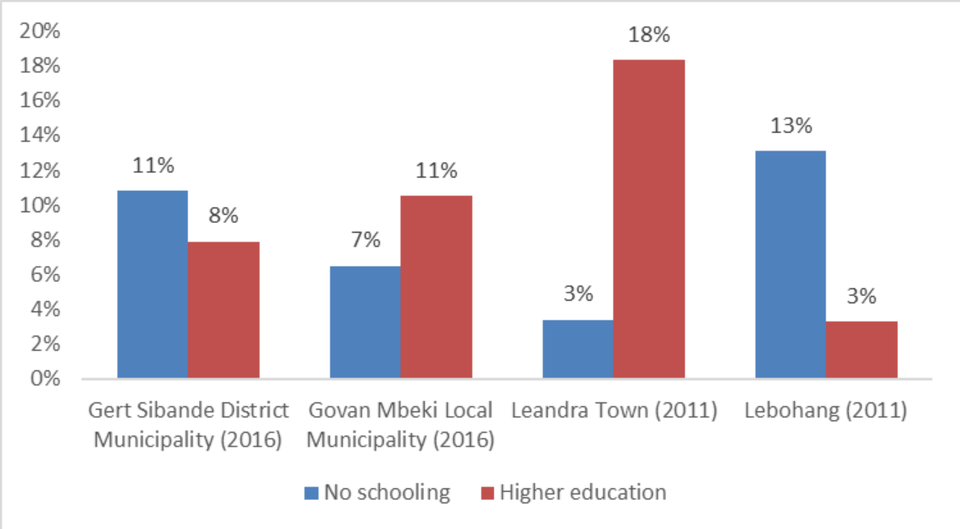

Figure 89: Education (Stats SA, 2022)

10.12.5 Households and Basic Infrastructure

Table 34 reveals the Household Dynamics. Lebohang has a relatively high share of female headed households compared to the other area, even though most of the households are still headed by males. The high percentage of households headed by women in Lebohang reflects the likelihood that the men have left the area in search of employment opportunities.

The areas under analysis are mostly composed by formal dwellings. Around 77% of the houses are formal in Lebohang and almost all the dwellings in Lebohang are formal residencies (99%). Additionally, most of the houses are either owned or in the process of being paid off.

Table 34: Household Dynamics (Stats SA, 2022)

Household Dynamics	GSDM (2016)	GMLM (2016)	Leandra (2011)	Lebohang (2011)
Households	333,815	108,894	508	8,908
Female Headed Households (%)	39.1	30.8	26.4	40.2
Formal dwellings (%)	78.0	76.3	98.6	76.5
Housing owned/paying off (%)	59.5	56.5	57.7	56.0

Leandra and Lebohang have superior municipal services coverage than the local and district municipalities (Table 35). The vast majority of dwellings use electricity for lighting, have weekly refuse removal, have piped water and a flush toilet connected to sewerage.

Table 35: Municipal Services (Stats SA, 2022)

Municipal Services	GSDM (2016)	GMLM (2016)	Leandra (2011)	Lebohang (2011)
Electricity for lighting (%)	88.5	93.7	96.9	96.5
Piped water inside dwelling (%)	34.3	44.8	89.2	73.0
Weekly refuse removal (%)	54.3	70.3	90.7	97.9
Flush toilet connected to sewerage (%)	67.1	91.1	90.4	96.5

10.12.6 Economy

10.12.6.1 Employment and Economic Activities

The main economic activities in the Mpumalanga Province consist of mining and petrochemical institutions and, thus, it is the province with the most prevalent CO_2 emissions in the country.

Figure 90 shows the employment and GDP by industry for the GMLM. Even though trading (including tourism) and community services are the largest employers in GMLM, mining and manufacturing contribute the most to the local and provincial GDP. The key economic cluster of GMLM are petrochemicals.

The mining sector employs 7% of the population and contributes 31% to the GDP of GMLM. The manufacturing sector employs 13% of the population and generates 30% of the product of GDP. Therefore, mining and manufacturing are high value-added activities.

Agriculture is the smallest contributing sector in GMLM, contributing only 1.6% to the municipal economy.

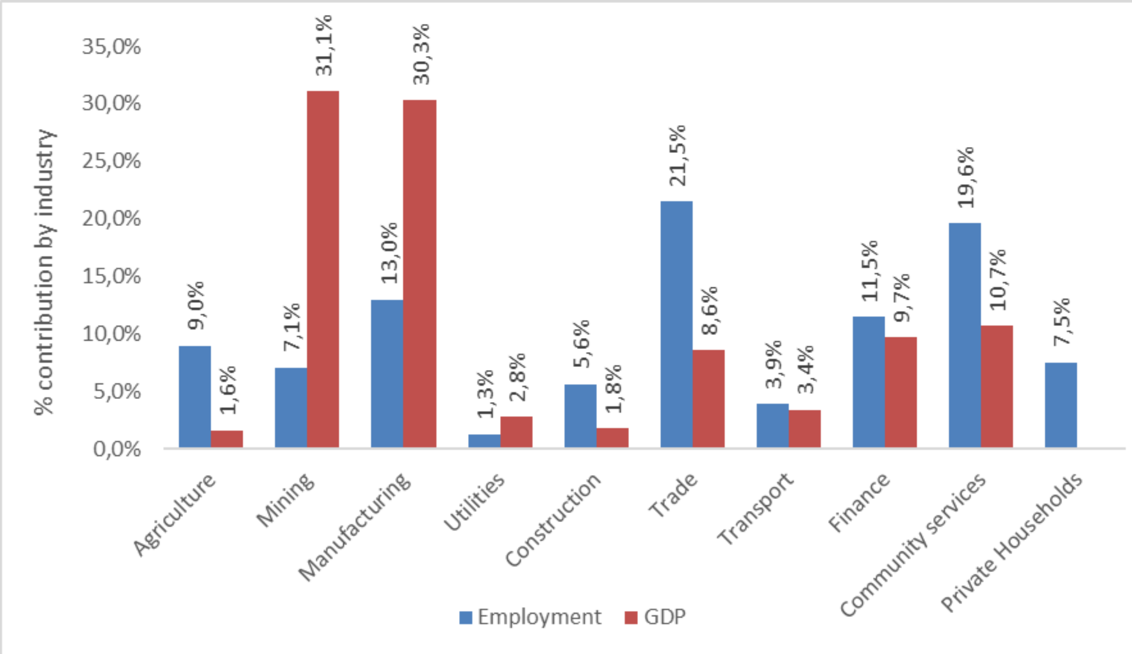

Figure 90: GMLM Employment and GDP by Industry (GMLM, 2020)

In 2020, GMLM contributed 11.1% to Mpumalanga's economy and 41% to GSDM's economy.

From 2015 to 2020, there was a negative average annual economic growth of -2.3% (Table 36). Since 1996, the economy shrank instead of growing.

Table 36: Economic growth of GMLM (GMLM, 2020)

GMLM	
% Contribution to Mpumalanga economy 2020	11%
% Contribution to Gert Sibande economy 2020	41%
Average annual economic growth 1996-2020	-0.2%
Average annual economic growth 2015-2020	-2.3%

10.12.6.2 Distribution of Income

The annual average household income is higher in Leandra in comparison with Lebohang. While 55% of households in Leandra have an annual average household income of R76,400 or more, only 5% of the households in Lebohang have this level of income.

While the average household income is larger in Leandra in comparison with GMLM, Lebohang's average household income is smaller than GMLM, which signals for inequalities among the IAI of the Project.

It is relevant to mention that 18% of the population of Lebohang and 11% of the population of Leandra have no formal income, which is considerably high as people with no formal income are more vulnerable to poverty.

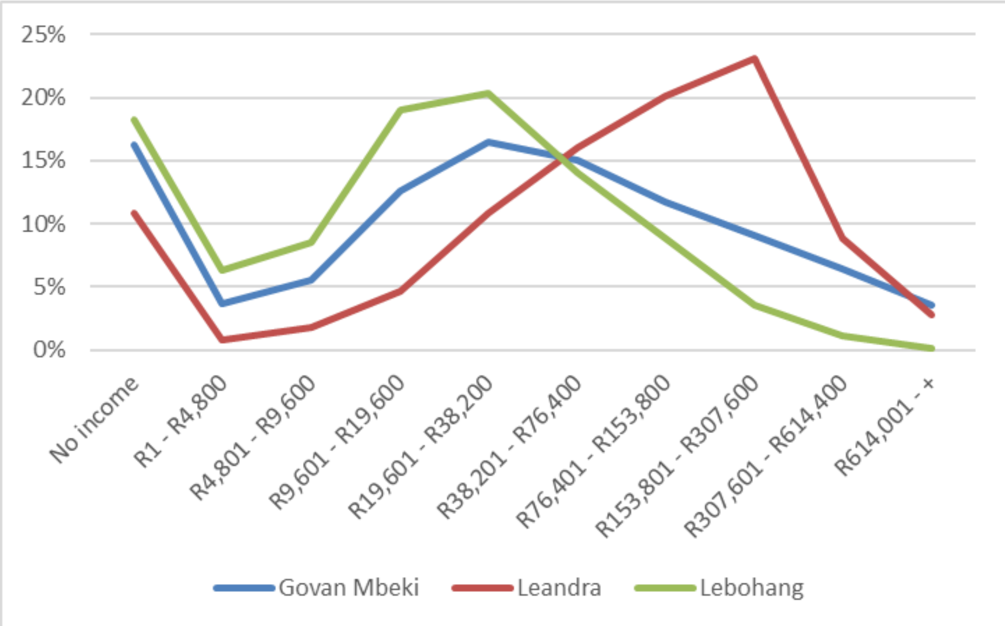

Figure 91: Share of population per annual Average Household Income, 2011 (Stats SA, 2022)

It is also worth noting the gender gap in median earnings. In Mpumalanga Province, in 2020, the median female earnings were only 76.2% of the median male earnings (Stats SA, 2022).

10.12.6.3 Unemployment

The unemployment rate in GMLM increased from 31% in 2016 to 33% in 2020. The average annual employment growth is quite low in comparison with the population growth, meaning that the growth in employment opportunities does not grow at the same pace as the population, further increasing unemployment. Even though the unemployment rate is considerably high, it is still one of the lowest in the province.

The unemployment rate is higher among females than males. The youth unemployment is significantly high, affecting 45% of all youth of Govan Mbeki in 2020. This means there is a lack of employment opportunities.

Additionally, according to the information gathered in the public consultations, unemployment is even higher in Leandra and Lebohang. It was indicated that about 70% to 80% of the population is unemployed although the accuracy of this data cannot be verified due to the lack of area-level unemployment data from official sources.

The lack of employment means there is a lack of opportunities for generating product and wealth in the economy, reflecting into an increase of poverty and a negative economic growth.

Table 37: Unemployment in GMLM (GMLM, 2020)

Govan Mbeki	2016	2020
Unemployment rate	31%	33%
Female Unemployment	38%	39%
Youth unemployment (15-34 years)	42%	45%
Average annual employment growth 2016-20	0,2%	

10.12.7 South Africa's Energy Sector

SA is the largest CO_2 emitter on the African continent as a result of the country's heavy reliance on coal as a source of energy and a pillar in its economic growth. Most of the coal-fired stations in SA are located in Mpumalanga Province, and, thus, this province is a major polluter and responsible for high levels of CO_2 emissions.

As represented in Figure 92, SA's energy supply is dominated by coal, which made up 65% of the primary energy supply in 2018. Conversely, renewables only made up 11% of the energy mix. The country's dependency on coal-based energy is unlikely to change significantly in the next two decades, according to the Mineral Resources & Energy Department (2021).

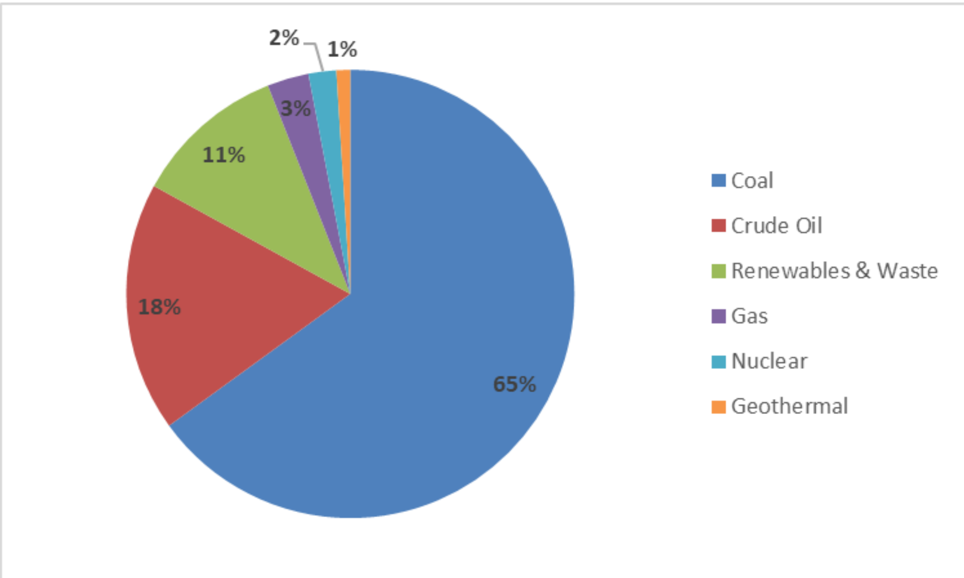

Figure 92: Primary energy supply, 2018 (Mineral Resources & Energy Department, 2021)

Figure 93 represents the energy demand by sector in 2018. The industrial sector is the sector that consumes more energy, with a consumption of 51% of all the energy. Chemical and petrochemical activities consume more energy within the industrial sector, followed by iron and steel activities and mining and quarrying.

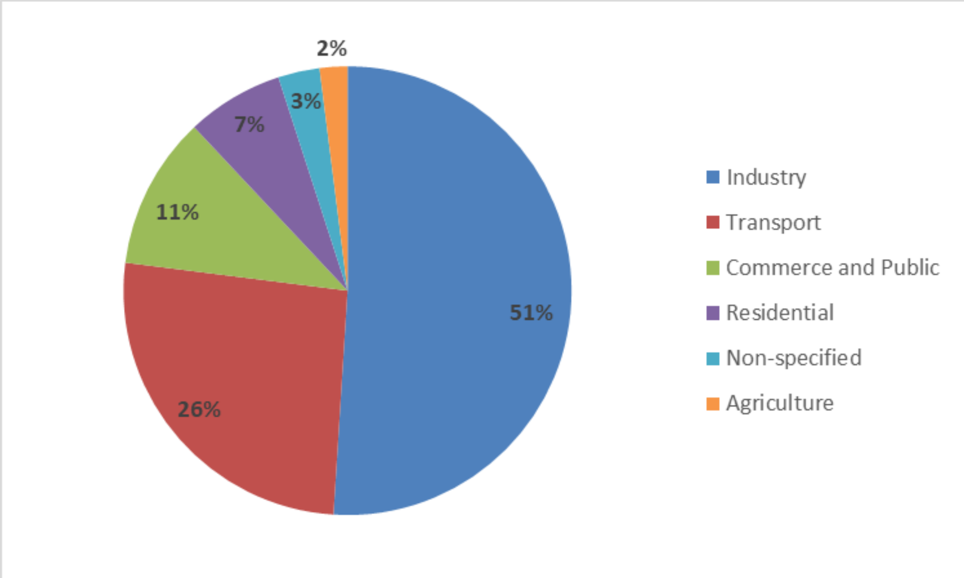

Figure 93: Energy demand by sector, 2018 (DMRE, 2021)

In addition to its significant domestic consumption, SA exported 24% of its coal in 2018. In 2021, SA was the fifth country worldwide with the highest monetary value of coal exports, exporting 6.08 billion USD of coal (Workman, 2022). The main advantages of coal are its abundance in SA, affordability, easy transportation, storage, and use. However, it is highly polluting and means around 80% of CO_2 emissions in the country come from energy supply, with negative consequences for the air quality and health of the population (Timperley & McSweeney, 2018).

In 2011, SA hosted the 17th formal meeting of the UNFCCC (United Nations Framework Convention on Climate Change) in Durban. Here, countries agreed to establish a new universal and legally binding climate treaty in 2015 for the post-2020 period. This, ultimately, led to the 2015 Paris Agreement.

However, according to the Climate Action Tracker (CAT), an independent scientific analysis, reached the conclusion that SA's climate action is insufficient to meet the goals established in the Paris Agreement (CAT, 2022).

10.12.8 Tourism and Recreation

Since there are no accommodation options, hotels or tourist attractions close to the Project, there are no major tourist receptors in the study area. This is related to the landscape's disturbed setting and the area's generally featureless landscape.

10.12.9 Safety

In 2016, 7% (7,803 people) of the population of GMLM reported to have experienced a crime in the past 12 months.

The perception of safety is relatively low in GMLM. Around 33% of the population reported feeling unsafe when walking alone during the day and 79% when its dark.

GMLM has the highest perception of not feeling safe during the night and the second highest perception of not feeling safe during the day in Mpumalanga. Therefore, safety is a large concern of the population of GMLM (STATS SA, 2018).

There is a concern regarding security in the project area as there is a history of civil unrest and potential for volatility and security threats.

According to the public consultations, the large unemployment rate and the high incidence of drug abuse in the area are related to the low perception of safety. There is a high incidence of housebreakings, damage to vehicles and private properties as well as theft in general. Moreover, riots and malicious damage are also common.

The security of the equipment of independent contractors is the responsibility of the contractor. The security of the CGS personnel and equipment are responsibility of the Council. As the Project is of national interest, the CGS will have access to the state security agency and, thus, security measures will be coordinated with the South African Police Services.

10.12.10 Public Health

It is also necessary to study the effect of environmental factors on human health, namely air quality and noise.

Air pollution represents a risk to public health and affects individuals with lower defences, such as children, the elderly, and those suffering from respiratory diseases. The effects of the degradation of air quality can be manifested through the increased incidence of respiratory and cardiovascular diseases, symptoms such as fatigue, headaches and anxiety, irritation in the eyes, nose and throat, damage to the nervous system, lung cancer, among others.

Noise pollution, besides causing a decrease in the acoustic comfort of the population, also poses threats to human health, such as the potential onset of hearing problems (from fatigue to trauma), psychological (stress and irritability), physiological (sleep disturbance) or negative effects on work (affecting the ability to concentrate).

Figure 94 shows the leading causes of death in GSDM for the period between 2009 and 2014.

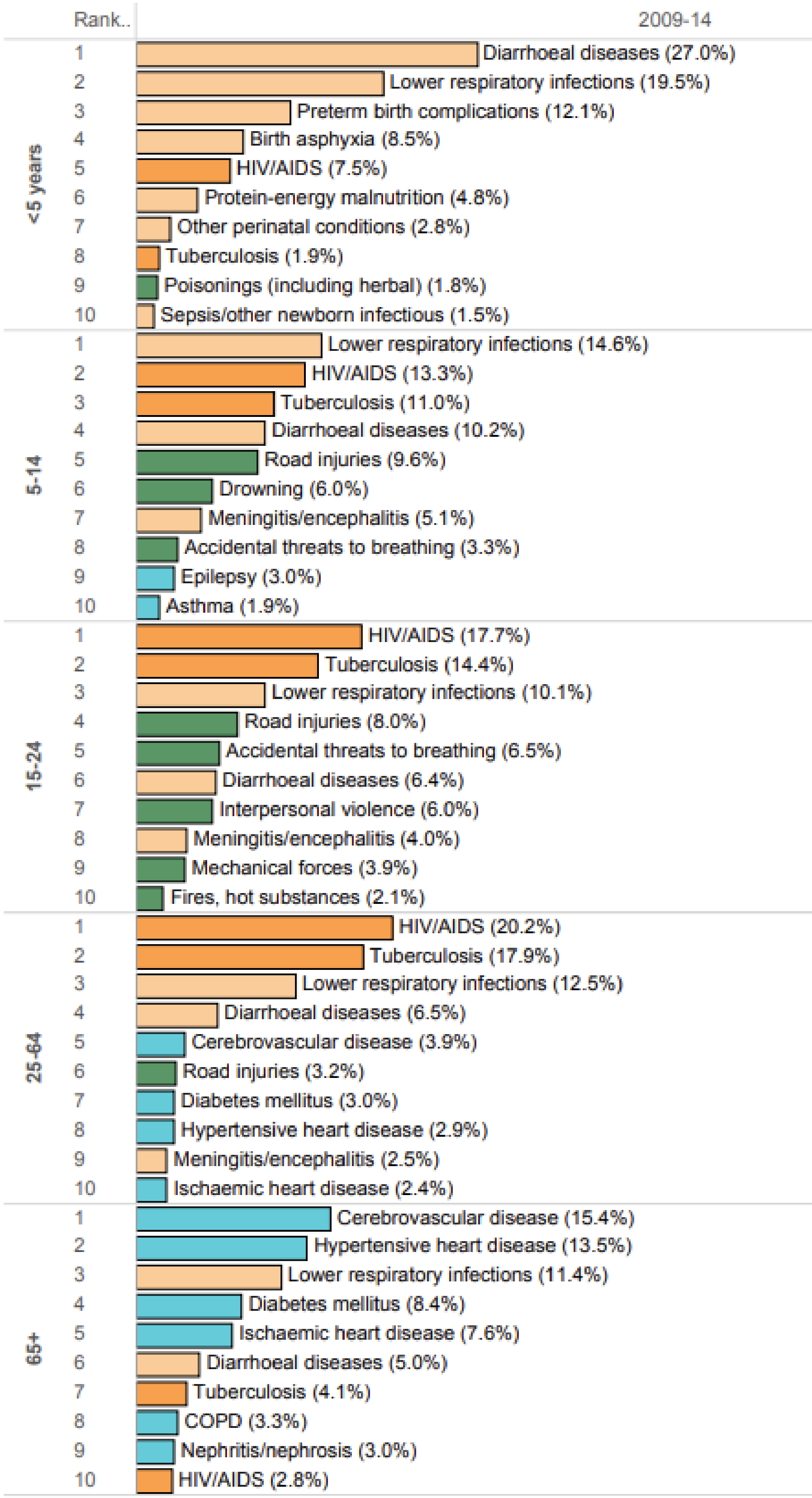

Figure 94: Percentage of deaths by leading causes in Gert Sibande District Municipality, 2009-2014 (Statistics South Africa, 2016)

As shown in Figure 94 above, for children under 5 years of age, the two main causes of death were diarrhoeal diseases and lower respiratory infections. For individuals aged 5 to 14 years, the main causes of death were lower respiratory infections and HIV/AIDS. For people aged between 15 and 64 years, the two main causes of death were HIV/AIDS and Tuberculosis. Lastly, for the elderly (65+), the main causes of death were cerebrovascular disease and hypertensive heart disease.

Overall, the diseases that caused more deaths were lower respiratory infections, HIV/AIDS and Tuberculosis. Getting HIV/AIDS is mostly related to a behavioural risk, while respiratory infections and tuberculosis are transmitted from person to person through the air.

Mpumalanga is the province with the highest HIV rate among pregnant women (46% in 2013). In 2011, in Govan Mbeki 45,8% of pregnant women were HIV positive and the overall prevalence rate (excluding pregnant women) was around 33% (GMLM, 2021).

Regarding health infrastructure in the project area, in 2016, in Govan Mbeki there were 18 health infrastructure, namely 11 clinics, 3 community health centres (CHC), 2 district hospitals and 2 other hospitals.

10.12.11 Poverty and Inequality

The number of people below the poverty line increased from 2016 to 2020. While in 2016, 33.3% of the population was considered poor in GMLM, this share rose to 39% in 2020. However, in comparison with other municipalities of Mpumalanga, the share of poverty in GMLM was the fourth lowest.

In 2020, Govan Mbeki's poorest 40% of households shared 6.5% of total income, which was lower/worse than the 6.7% share recorded in 2016. As a result, inequality is increasing as the share of people in poverty is rising.

The Human Development Index (HDI) improved from 0.63 in 2016 to 0.67 in 2020, despite the increase in poverty and the fall in economic growth.

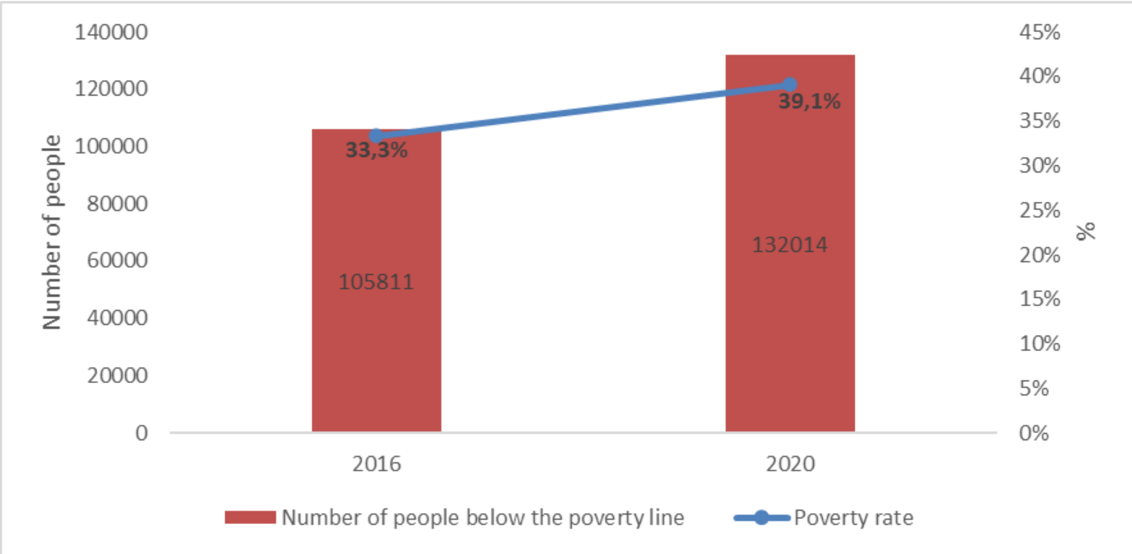

Figure 95: Poverty in GMLM, 2020 Poverty in Govan Mbeki, 2020

10.12.12 Vulnerable Groups

Vulnerability is related to the ability of individuals and groups to adapt to socio-economic or biophysical change. Social vulnerability refers to potential harm to people. It involves a combination of factors that determine the degree to which someone's life and livelihood are put at risk by a discrete and identifiable event in nature or in society. Social vulnerability refers to the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recovery from the impact of a natural hazard (Wisner, Gaillard, & Kelman).

Vulnerable individuals and groups are therefore more susceptible to negative impacts and/or have a limited ability to take advantage of positive impacts. Vulnerability is a pre-existing status that is independent of the project and may be reflected by the existing low level of access to key socio-economic or environmental resources or a lack of access to information and decision making.

Socially vulnerable groups can encompass the following dimensions: poverty, ethnicity, religion, gender, age (children or elderly), disability, health, literacy or education, households' characteristics, such as single parents, among others.

In the study area, vulnerability has been identified and linked to the following factors:

- Female headed households - These families are particularly vulnerable as females have, on average, lower earnings and face higher unemployment.
- Poor Households - Households with particularly low incomes or no formal income at all.

- Disable persons - Those who lack physical mobility or who have mental health issues may be vulnerable to changes and have more difficulties adapting to new contexts.
- Orphans and vulnerable children – Those between 0 and 17 years old who are either orphaned or more vulnerable to HIV/AIDS. The children can be marginalized, stigmatized, or discriminated against.

10.12.13 Summary

The main challenge in the study area is the high population growth and shrinking economy, which leads to an increase in unemployment and poverty rates.

The population of Lebohang is more than 15 times higher than the population of Leandra, with a much higher population density. There are clear inequalities amongst these two towns of the IAI, as Lebohang presents lower education levels, more informal dwellings, and lower levels of income.

Even though most of the population in the IAI is in the working age category, there are almost no employment opportunities in Lebohang. However, Leandra presents some employment opportunities in the industrial and commercial sector.

Inequality in GMLM is increasing and there are high levels of poverty (39% in 2020). The perception of safety is one of the lowest in the province. Additionally, there is a gender gap in median earnings and unemployment is larger amongst females.

Trading and community services are the largest employers in GMLM, yet mining and manufacturing are the ones that contribute the most to the local and provincial GDP due to the high prevalence of petrochemical and mining companies.

SA's energy supply is dominated by coal and the country's dependence on coal is not likely to change significantly in the next two decades, as the economic growth of SA is linked with the exploration of coal..

Regarding public health, the diseases that caused more deaths were lower respiratory infections, HIV/AIDS and Tuberculosis. Getting HIV/AIDS is mostly related to a behavioural risk, while respiratory infections and tuberculosis are transmitted from person to person through the air.

10.13 Cultural Heritage & Palaeontological Features

10.13.1 Cultural Heritage

The information contained in the sub-sections to follow was extracted from the Heritage Impact Assessment (Kitto, 2023) (contained in Appendix D3).

10.13.1.1 Screening Tool

According to the Screening Tool, the Archaeological and Cultural sensitivity of the project area is low (Figure 96).

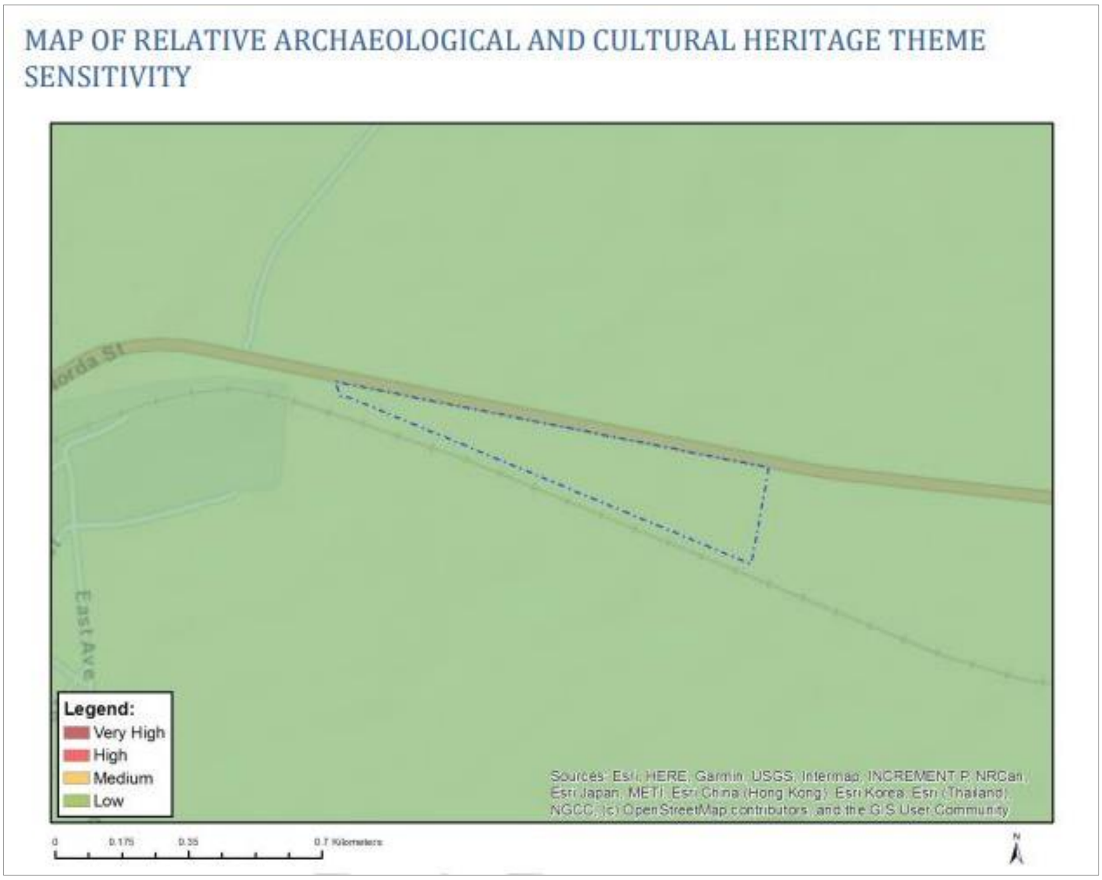

Figure 96: Map of relative archaeological and cultural heritage theme sensitivity (DFFE Screening Tool, 2023)

10.13.1.2 Desktop Review

A literature review / historical desktop study was undertaken which showed that various archaeological and historical resources could be expected to occur in the project area. The examination of the earliest edition (1965) of the 1:50 000 topographical maps produced by overlying the maps with satellite Imagery (Google Earth) showed that a few heritage features are depicted within the CO_2 Injection Site (Figure 97).

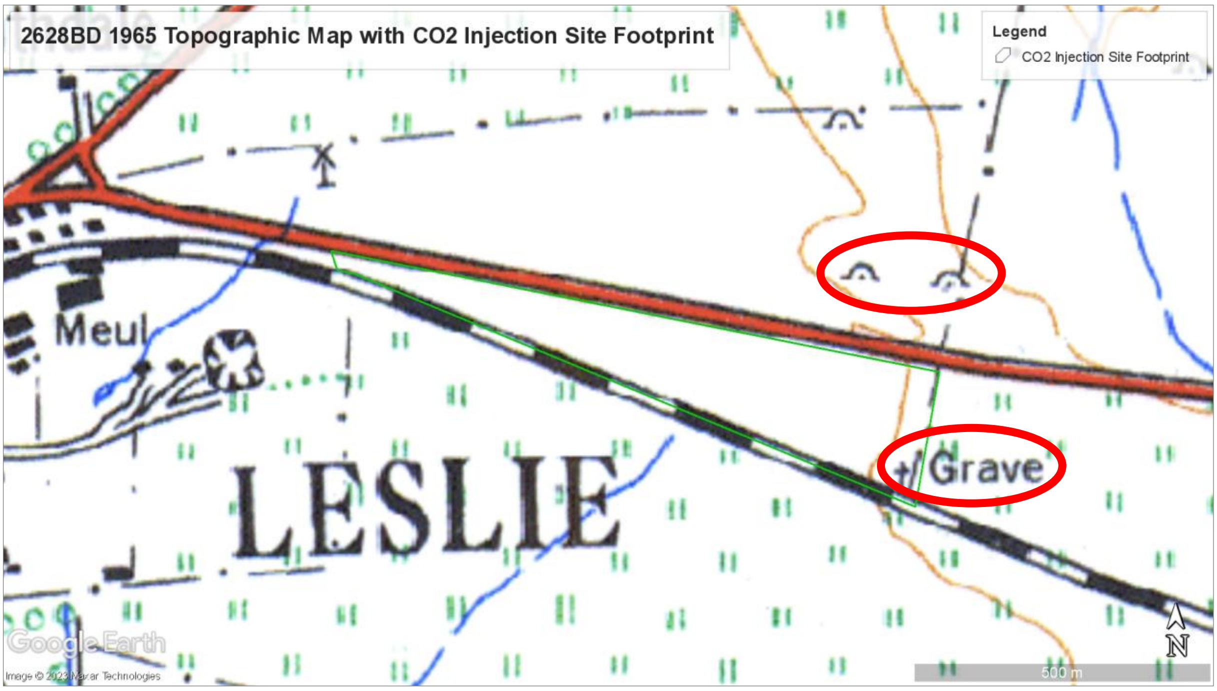

Figure 97: Enlarged view of topographic map 2628BD Ed 1 1965, depicting one heritage features within the CO2 Injection Site footprint (green polygon). Several homestead clusters or single homesteads are depicted in the area immediately north of the R29 (Kitto, 2023)

10.13.1.3 Field Survey Results

The subsequent fieldwork confirmed the findings of the desktop study and identified the following five heritage resources within and adjacent to the CO_2 Injection Site (Figure 98 and Figure 99):

- CO-01 (possible homestead; low significance);
- CO-02 (grave depicted on 1965 map just north of the railway line; high significance);
- CO-03 (stone culvert under railway line; high significance);
- CO-04 (possible remains of structure; low significance); and
- CO-05 (stone culvert under railway line; high significance).

Figure 98: Enlarged satellite view of the proposed CO2 Injection Site showing the five Identified Heritage Sites (Kitto, 2023)

Figure 99: Photographs of heritage resources identified in the project area (Kitto, 2023)
(top left = CO-01: possible homestead; top centre = CO-02: possible grave; top right = CO-03: stone culvert; bottom left = CO-4: possible remains of structure; bottom right = CO-05: stone culvert)

10.13.2 Palaeontological Features

10.13.2.1 Screening Tool

According to the Screening Tool, the palaeontological sensitivity of the project area is medium for the presence of fossils (Figure 100).

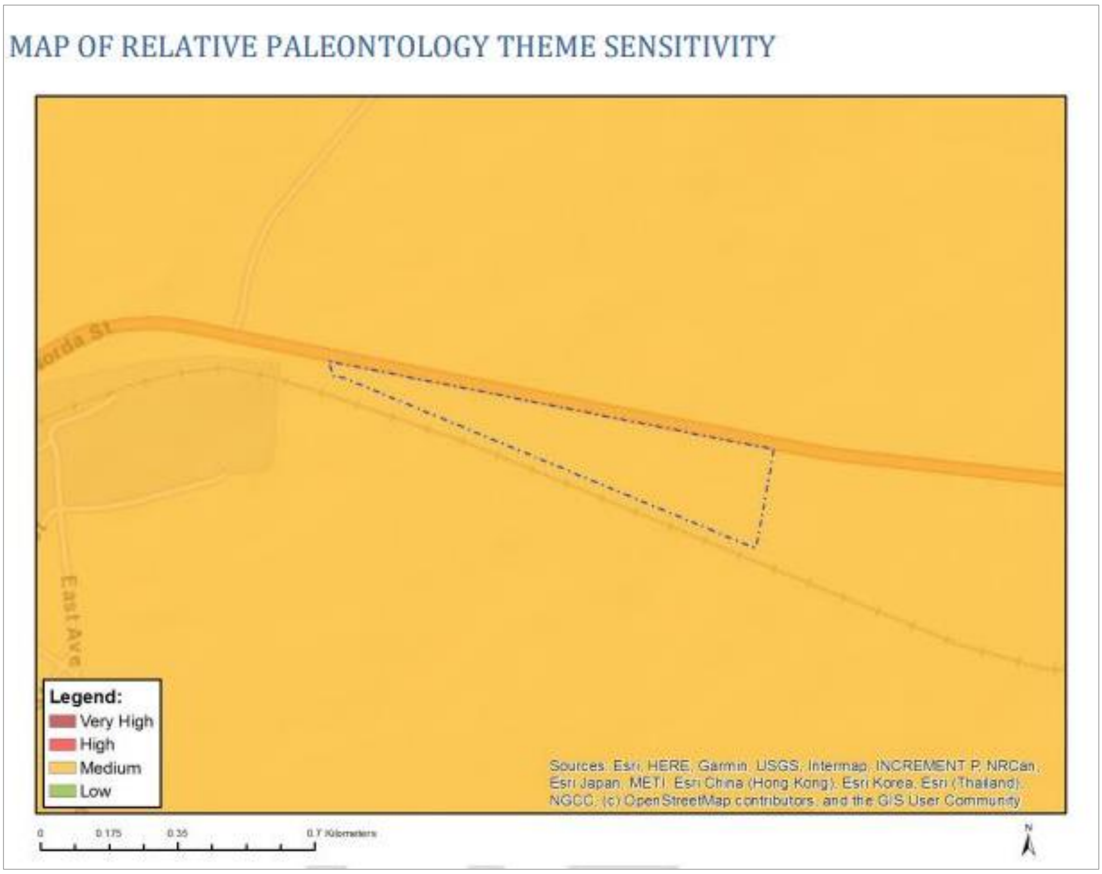

Figure 100: Palaeontological Sensitivity map indicating that the project footprint is located within a region of Medium sensitivity (DFFE Screening Tool).

10.13.2.2 South African Heritage Resources Information System

The information to follow was obtained from the desktop Palaeontological Impact Assessment (Butler, 2023) (contained in Appendix D4).

The surface geology indicates that the proposed site is underlain by the Karoo Dolerite Suite. The PalaeoMap of the South African Heritage Resources Information System (SAHRIS) (Figure 101) indicates that the Palaeontological Sensitivity of the Karoo dolerite Suite is Zero as it is igneous in origin and thus unfossiliferous (Almond et al., 2013). However, the Geotechnical Report of the development indicates that the study area is at depth underlain by the Ventersdorp Supergroup. SAHRIS indicates that the Ventersdorp Supergroup has a Moderate Palaeontological Sensitivity.

A Moderate Palaeontological Significance has been allocated to the development footprint. It is therefore considered that the proposed development will not lead to detrimental impacts on the palaeontological resources of the area.

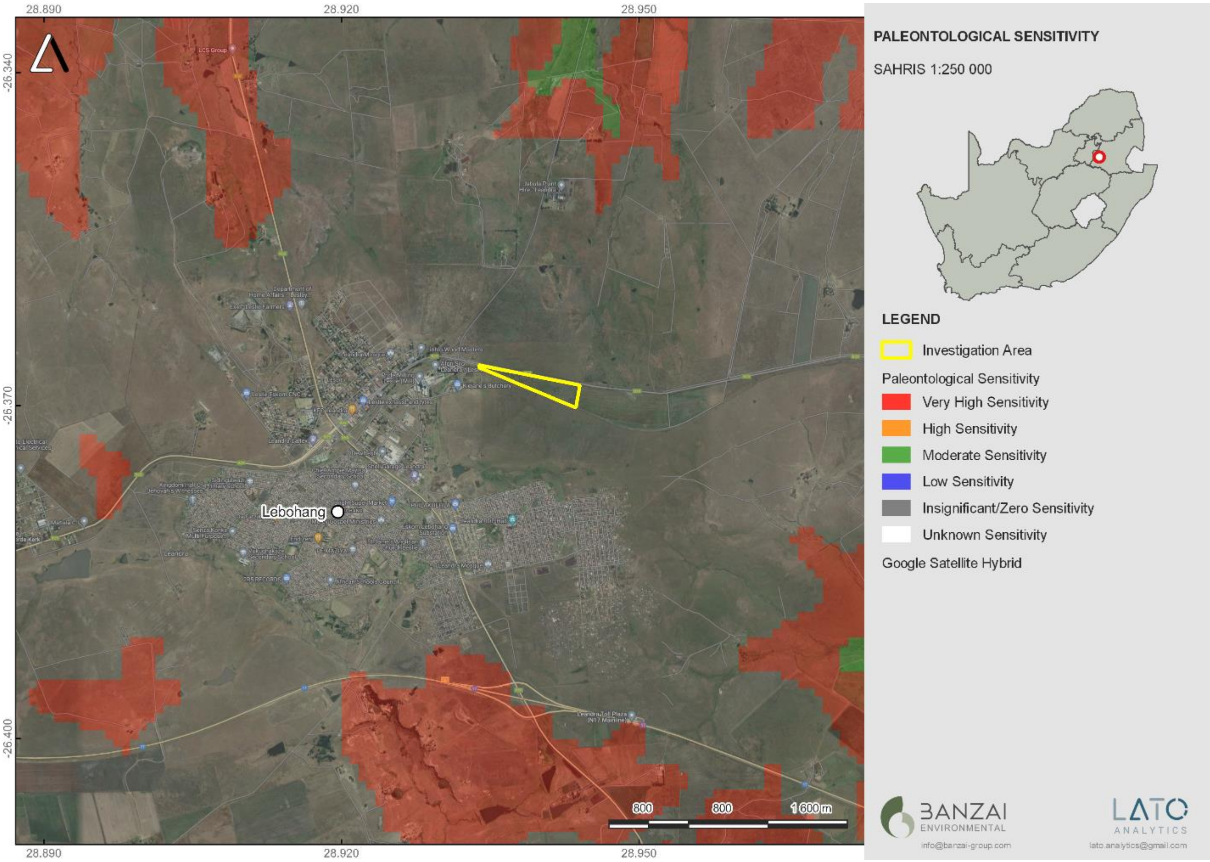

Figure 101: Extract of the 1:250 000 SAHRIS PalaeoMap (Butler, 2023)

10.14 Land Capability

10.14.1 General Description

The project implementation area is vacant and is not cultivated. Fallow lands and old fields occur to the north and south of the site, with cultivated areas to the east (see Figure 81 above).

10.14.2 DFFE Screening Tool

According to the Screening Tool, the injection site has high sensitivity from an agricultural perspective (Figure 102). The tool shows that field crops occur on the site. It is noted that from historical aerial imagery it appears that the site has not been cultivated in at least the last 20 years.

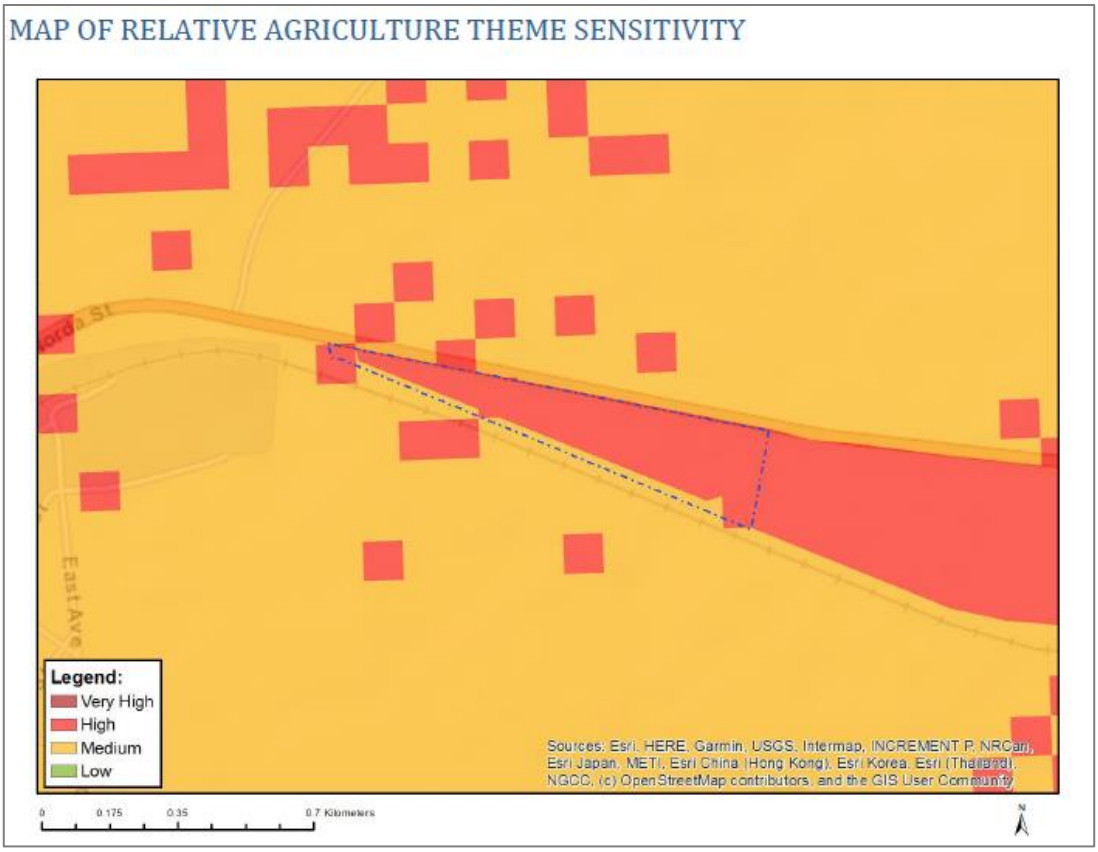

Figure 102: Map of relative agriculture theme sensitivity (DFFE Screening Tool, 2023)

11 Impact Identification and Assessment

11.1 Introduction

This section identifies and assesses the relevant environmental impacts that may be caused by the Project's construction, operational, and decommissioning phases. An environmental impact is understood to be any change that occurs in the project area and its surroundings (DAI and IDI), at the level of the environmental features under analysis (presented in Section10 above), and that results directly or indirectly from the implementation of the Project.

The impact assessment methodology undertaken for the Basic Assessment is presented in Section 11.2. An overview of the cumulative impacts is presented in Section 11.16.

This section was supplemented with information from the ESIA Report that was compiled by NEMUS for the Project.

11.2 Assessment Methodology and Criteria

Each potential impact will be identified by its root cause (the project activity or action) that will result in an impact (change of the current conditions, both positive and negative) on a receptor (environmental aspect that will be affected).

The potential impact will be defined as either a positive impact (benefit) or a negative impact. In addition, the impact will be defined as direct or indirect, and, if pertinent, cumulative.

The main goal is to identify the environmental and social impacts associated with the Project at and around the site, including direct and indirect, short, and long term, and cumulative impacts. The focus will be on both positive and negative impacts on the bio-physical, chemical, social, economic, and cultural components of the environment associated with the project's life-cycle.

The methodology that was employed to assess the significance of the potential environmental and social impacts consisted of the following:

- Defining the nature of the potential impact;
- Rating of the potential impact; and
- Determining the overall significance of the impact.

11.2.1 Defining the Nature of the Potential Impact

Terms for defining the nature of an impact are presented in the following table.

Table 38: Definition of impact nature

Term	Definition
Positive Impact (Benefit)	An impact that is considered to represent an improvement on the baseline or introduces a positive change
Negative Impact	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor
Direct Impact	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (e.g., between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality)
Indirect Impact	Impacts that result from other activities that are encouraged to happen because of the Project (e.g., in-migration for employment placing a demand on resources)
Cumulative Impact	Impacts that act together with other impacts (including those from concurrent or planned future third-party activities) to affect the same resources and/or receptors as the Project

11.2.2 Rating of the Potential Impact

Each potential impact will be rated based on a set of criteria, including its spatial and temporal scales, intensity, and probability (see tables below). For each criteria a scale will be used ranging from no or negligible impact to major impacts. The magnitude of the impact is a function of these criteria.

Table 39: Definition of impact magnitude

Impact Magnitude – The degree of change brought about in the environment	
Extent	• On-site – impacts that are limited to within the site boundaries; • Local – impacts that affect an area in a radius of 2 km around the site; • Regional – impacts that affect regionally important resources or are experienced at a provincial or regional scale; • National – impacts that affect nationally important resources or affect an area that is nationally important/ or have macro-economic consequences; • Transboundary/International – impacts that extend beyond country borders or affect internationally important resources.
Duration	• Temporary – impacts are predicted to be of short duration and intermittent/occasional; • Short-term – impacts that are predicted to last only for the duration of the construction period; • Long-term – impacts that will continue for the life of the Project, but ceases when the Project stops operating; • Permanent – impacts that cause a permanent change in the affected receptor or resource (e.g., removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.
Intensity	**Biophysical environment** – intensity can be considered in terms of the sensitivity of the receptor; • Negligible – the impact is not detectable; • Low – the impact affects the environment in such a way that natural functions and processes are not affected; • Medium – where the affected environment is altered but natural functions and processes continue, albeit in a modified way;

Impact Magnitude – The degree of change brought about in the environment	
	• High – where natural functions or processes are altered to the extent that it will temporarily or permanently cease.
	Socio-economic environment – intensity can be considered in terms of the ability of project affected people/communities to adapt to changes brought about by the project: • Negligible – there is no perceptible change to people's livelihood or health; • Low – people/communities can adapt with relative ease and maintain pre-impact livelihoods and health; • Medium – able to adapt with some difficulty and maintain pre-impact livelihoods and health but only with a degree of support; • High – those affected will not be able to adapt to changes and continue to maintain-pre impact livelihoods and health

Table 40: Definition of impact probability

Impact Probability – The likelihood that an impact will occur	
Unlikely	The impact is unlikely to occur
Likely	The impact is likely to occur under most conditions
Definite	The impact will occur

11.2.3 Determination of the Overall Significance of the Impact

Once a rating is determined for magnitude and likelihood, Table 41 can be used to determine the significance of the impact. An impact may be negative or positive and therefore the final significance rating is colour coded as seen in Table 42 below.

Table 41: Definition of impact significance

Significance Definitions	
Null or Negligible	An impact of negligible significance is where a resource or receptor will not be affected in any way by a particular activity, or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels.
Low Significance	An impact of low significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value.
Moderate Significance	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is As Low as Reasonably Practicable (ALARP). This does not necessarily mean that "moderate" impacts must be reduced to "low" impacts, but that moderate impacts are being managed effectively and efficiently.
High Significance	An impact of high significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. A goal of the EIA process is to get to a situation where the project does not have any high residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be high residual impacts after all practicable mitigation options have been exhausted (i.e., ALARP has been applied). An example might be the visual impact of a development. It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the Project.

Table 42: Impact significance colour codes

Colour codes for the significance classification used in the impact assessment		
Negative	**Significance**	**Positive**
	Null or Negligible	
-	Low	+
-	Moderate	+
-	High	+

11.2.4 Determination of the Risk Level

The Project risks will be classified according to the following matrix.

Table 43: Definition of the risk level

Determination of the risk level			
Severity (Significance)	**Likelihood (Probability)**		
	Unlikely	Likely	Definite
High	Moderate	High	Very High
Moderate	Low	Moderate	High
Low	Low	Low	Moderate
Negligible	Acceptable	Acceptable	Acceptable

Generally, impacts of negligible or low significance are acceptable. Impacts of moderate or high significance require mitigation and impacts of high significance may be classified as unacceptable.

Detailed impact description, justification, and assessment for the considered environmental and social factors are presented below.

11.3 Climate and meteorology

11.3.1 Construction Phase

Considering the spatial and temporal scale of the activities to be undertaken as part of the Project in relation to the meteorological and climatic system in question, it is considered that these impacts have virtually no magnitude, being negligible.

11.3.2 Operational Phase

Given the purpose of the research Project, during the operational phase the action of injecting CO_2 so that it is captured in geological formations will lead to a reduction of the CO_2 which would otherwise be released into the atmosphere. This is therefore an impact that is considered positive and, even though currently in a small-scale pilot research phase.

Table 44: Operational phase impacts on Climate and meteorology

Dimension	Assessment
Nature	Positive
Directionality	Indirect
Extent	Regional
Duration	Permanent
Intensity	Low
Probability	Definite
Significance	Low

The Air Quality Study is contained in Appendix D5.

11.3.3 Decommissioning Phase

Considering the spatial and temporal scale of the activities to be undertaken as part of the Project in relation to the meteorological and climatic system in question, it is considered that these impacts have virtually no magnitude, being negligible.

11.3.4 Summary

According to the present assessment, for the construction and decommissioning phase, no significant impact was identified.

Regarding the operational phase, the action of injecting CO_2 to be captured in geological formations will have a positive impact on the climate as it implies the reduction of CO_2 in the atmosphere. Nevertheless, bearing in mind that this is a pilot project with low injection volumes, the impact is of low significance.

11.4 Geology and Topography

With geology being a key factor in the potential for permanent CO_2 storage, the geological environment is directly affected by the implementation of the Project. The main potential impact is related to the action of CO_2 injection into the geological formation which could result in a rearrangement of the structure.

For a better understanding of the potential impacts considered, a description is provided below.

11.4.1 Construction Phase

Drilling for geological characterization and injection well

- Punctual changes in the geological structure.

The drilling operation can lead to local and punctual changes in the geological structure (of the rock mass) due to micro fracturing locally and occasionally in the drilling area of influence. Despite the size of the two boreholes to be drilled (for characterization and injection), the geological system is capable to rearrange and adapt the stress distribution.

- Punctual changes in the topography and geomorphology

The removal of topsoil can lead to punctual changes in the topography and geomorphology. Soil removal is only carried out at the drilling site.

Site Establishment

- Punctual compaction and erosion

The site establishment can cause compaction, which may increase erosion. Once the compaction occurs, there is a change in the natural drainage conditions, which may increase the erosive phenomena. However, this is a small-scale project and the infrastructure to be installed will have a total area of about 3,500 m^2.

The assessment is presented in Table 45.

Table 45: Construction phase impacts on geology and topography

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On site
Duration	Short to Long-term
Intensity	Low
Probability	Definite
Significance	Negligible

11.4.2 Operational Phase

CO_2 Injection

- Unexpected leakage of CO_2 and increase of punctual rock porosity.

Considering the purpose of the operational phase (i.e., injection of CO_2 to be store in a geological formation), this action can potentially lead to alterations to the geological structures. Due to the injection process and until temperatures reach equilibrium, there may be an impact in the rock mass structure (at the micro level) and in thermodynamic and chemical properties of the storage formation, with the risk of induced seismic activity and potential ground heave or soil cave-ins (having similarities with natural gas storage due to the natural rock mass system change).

This potential impact can result in unexpected leakage of CO_2 due, for example, to the appearance of micro-fractures which allow CO_2 to move. On the other hand, the impact may also result in an increase of punctual rock porosity leading to a local increase in storage capacity. However, projects such as "Kevin Dome Carbon Storage Project" indicates that the potential for inducing seismic effects is small and therefore no *"measurable migration of CO_2 from the storage formation to the surface or into another area in the subsurface"* occurs and *"there is no more than an imperceptible risk of inducing seismic events due to increased reservoir pressure"* (U.S. Department of Energy, 2013).

The assessment is presented in Table 46.

Table 46: Operational phase impacts on geology and topography

Dimension	Assessment
Nature	Negative / Positive [2]
Directionality	Indirect
Extent	Not measurable [3]
Duration	Long-term [4]
Intensity	Low
Probability	Likely
Significance	Negligible

[2] Negative as it allows the CO_2 movement and positive because it can lead to a punctual increase in the rock porosity.
[3] Depends on the existing fracture and microfracture system and on the rock mass response to the injection. As such, its extent is not measurable at this point of assessment. Further research into seismic modelling will provide more details.
[4] Dependent on the mineralization process. According to the information presented throughout this report, a duration of at least 2 years is expected (estimated time for the mineralization process according to the injection technologies adopted).

For an in-depth analysis it will be necessary to consider the seismic profiles to be carried out in the next phase of the project.

11.4.3 Decommissioning Phase

The decommissioning phase of the Project is not expected to affect the geology and topography environment, with no positive or negative impacts to be considered.

11.4.4 Summary

According to the present assessment, for the construction phase, two potential actions of impacts generation were identified (drilling operation and site establishment). Considering the project and activities scale, the potential impacts generated were recognized as having negligible significance since "the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels".

Regarding the operational phase, the main action is the CO_2 Injection that may lead to unexpected leakage of CO_2 and/or increase of punctual rock porosity. These impacts are projected to "be imperceptible from natural background levels" and consequently, negligible. During the decommissioning phase no impacts are expected to occur.

11.5 Soils

The potentially impact-generating actions that may be associated with the Project's construction phase, overall, have the negative impacts of erosion and soil pollution/contamination. Regarding the Operational Phase, impacts are mainly indirect. An assessment of the potential impacts is provided below for each project phase.

11.5.1 Construction Phase

Construction of the Operational Area

- Pollution/contamination of the soil

The construction of the operational area may lead to soil pollution/contamination, which may result from an accidental situation or not, namely from the spillage of pollutant substances such as oils, fuels, and grease, as well as from effluents originating from the normal activity of a building site. The impact assessment is shown in Table 47 below.

Table 47: Construction phase impacts on soil from Construction of the Operational area - Pollution/contamination of the soil

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On site
Duration	Permanent
Intensity	Medium
Probability	Unlikely
Significance	Low

- Punctual soil compaction and erosion

All activities involving the mobilization of machinery and vehicles enhance site soil compaction. Soil compaction, in turn, leads to soil erosion which may affect the water absorption capacity of the land. Nevertheless, this impact will only be present during the construction phase and the environment (natural system) is not expected to be affected. The impact assessment is shown in Table 48 below.

Table 48: Construction phase impact on soil from Construction of the Operational area - Punctual soil compaction and erosion

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On site
Duration	Short-term
Intensity	Low
Probability	Definite
Significance	Negligible

Drilling (land preparation)

- Loss of organic matter and erosion

In the areas where drilling will take place, soil must be removed and temporarily deposited. This activity may cause indirect negative impacts associated with the loss of organic matter locally and water runoff caused by rainfall. However, the removal will be take place over a short period at the drilling site and the soil will be replaced at the end of the operational phase. Moreover, if the necessary measures are taken the soil can be productive.

Site Establishment

- Soil compaction and erosion

Aligned with the impacts presented for the geological environment, the site establishment can cause soil compaction, which may increase erosion. Soil compaction is the result of the earth-moving process required for the installation of infrastructure. Once the compaction occurs, there is a change in the natural drainage conditions, which may increase erosion. Additionally, the site establishment may cause soil sealing. However, this is a small-scale project where the infrastructure to be installed will cover a total area of about 3,500 m^2.

Table 49: Construction phase impacts on soils from drilling and site establishment: loss of organic matter and erosion; soil compaction and erosion

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On site
Duration	Long-term
Intensity	Low
Probability	Definite
Significance	Negligible

11.5.2 Operational Phase

CO_2 Injection

- Soil quality change

The injection process can cause the release of abnormal quantities of CO_2 in a short period of time, whether accidental or not (due, for example, to pipeline ruptures and casing leaks). The released CO_2 may thus react and affect the quality of the soil leading to a possible soil pH reduction. This can result in O_2-depleted soils and mobilization of heavy metals. However, it is considered that the affected environment should have the capacity to adapt, and it should be noted that the existing soil in the project area naturally needs measures to make the soil productive. Furthermore, by taking best practice measures, this impact can be minimized.

- Soil subsidence

Once induced seismicity phenomena occur (possible impact on the geological environment), soil subsidence can occur. The assessment of this impact is expected to be of the same significance as the impact assessment for the geological environment (Table 46).

CO_2 Storage

- Soil quality change

Over the storage time, gradual leakage of CO_2 may occur due to formation fracturing, which in turn (like the impact identified for CO_2 injection) can lead to loss of soil quality, decrease in pH and resulting in O_2-depleted soils and mobilization of heavy metals. As it is the result of the fracturing system, the assessment of this impact is expected to be of the same significance as the impact assessment for the geological environment (Table 46).

Table 50: Operational phase impacts on soils: Soil quality change; Soil subsidence; and Soil quality change

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	On site [5]
Duration	Permanent
Intensity	Medium
Probability	Unlikely
Significance	Negligible

11.5.3 Decommissioning Phase

- Soil replacement

In the decommissioning phase, with topsoil replacement and site rehabilitation to take place, it is considered that there is an attempt to restore the pre-project situation. The impact assessment is presented in Table 51.

Table 51: Decommissioning phase impacts on soils

Dimension	Assessment
Nature	Positive
Directionality	Direct
Extent	On site
Duration	Permanent
Intensity	Low

[5] Regarding the impact " soil quality change " generated by the possible leakage of CO_2 through the fracture system, it is noted that the extent is not measurable at this point of assessment (as mentioned in the impacts on geology).

Dimension	Assessment
Probability	Definite
Significance	Low

11.5.4 Summary

Following the assessment carried out, regarding impacts on land it was concluded that in the construction phase the potential impacts resulting from the activities of the construction of the operational area, drilling (land preparation) and site establishment. The construction of the operational area may result in pollution/contamination of the soil. This impact, which could be minimized with the implementation of best practices, once it occurs will affect the surrounding natural system, although it is expected to be of low significance. The remaining potential impacts that could result from construction activities are expected to be negligible.

In the construction phase, the activities that potentially generate impacts are the injection and storage of CO_2. These activities, which can lead to changes in soil quality and its subsidence, should proceed according to best practice measures that seek to minimize the occurrence of impacts. It is therefore considered that, being unlikely to occur, once they do, their significance should not be relevant in relation to the reference situation.

As a result of the decommissioning activity involving the re-establishment of the removed soils, a positive impact occurs, although of low significance considering the scale of the activity and the Project.

11.6 Groundwater

The assessment below is based on the Hydrogeological Study that was undertaken for the Project. A copy of the specialist report is contained in Appendix D6.

11.6.1 Construction Phase

Considering the activities that comprise the construction phase - drilling, construction of the operational area (and respective injection well), and site establishment - the impact on groundwater is related to the potential occurrence of an on-site accident. The on-site accident may occur due to a spillage and leakages of oil tanks, vehicles or machinery used.

However overall, considering the hydrogeological framework, no significant impacts are expected for the construction phase of the project, once all activities that will be undertaken are usually carried out according to standards of environmental protection.

Table 52: Construction phase impact on groundwater– On-site accident

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	On site
Duration	Temporary
Intensity	Low
Probability	Unlikely
Significance	Negligible

11.6.2 Operational Phase

To ensure that risks are minimised, carbon dioxide injection and storage projects are subject to stringent requirements. Therefore, site selection and the management of geological reservoirs are subject to extensive research - such as the current project.

Despite the studies conducted to date, two potential impacts are highlighted during the operational phase:

- Potential groundwater quality degradation - if leaks occur during project implementation.
- Potential changes in groundwater flow - due to pressure perturbations.

Potential groundwater quality degradation

The possibility of an accident involving the migration/leakage of CO_2 towards the karstic aquifer that overlay the basalts (Transvaal dolomites) and shallower aquifers is considered a potential impact on groundwater that may occur until the mineralisation process is complete.

The adverse effects of potential CO_2 migration from the injection zone to overlying aquifers are highly dependent on the presence of fractures. Fracturing creates a secondary high permeability relative to the surrounding hard/crystalline medium, and, therefore, more or less interconnected pathways for CO_2 mobilisation from depth to the surface.

However, this impact is mitigated since:

- The area selected for CO_2 storage does not have extensive or important aquifers for human use that could potentially be contaminated in the event of a leak;
- The injection and storage of CO_2 will take place in lavas of the Ventersdorp Supergroup, which are mainly overlain by metasedimentary and crystalline metavolcanic hard rocks with low interconnected fractures and permeability, creating a

natural barrier to CO_2 migration to the shallow groundwater and reducing potential pathways of leakage;

- The chemistry of basalts potentially allows the injected CO_2 to react with magnesium and calcium to create the stable carbonate mineral forms of calcite and dolomite, potentially trapping the carbon permanently in the solid mineral structure (NETL, 2023);
- Mineral carbonation in basaltic formations, unlike in sedimentary environments, is expected to occur on a time scale of weeks to months;
- The reservoir is supported by volcanic rocks, and as such the potential negative impact of groundwater intrusion is absent, unlike one of the main options used to store CO_2 (deep saline formations); and
- The geological setting of the site and the depth of storage reduce the release and migration of CO_2, while the low permeability and interest of the aquifers should mitigate the significance of groundwater contamination.

However, if the groundwater quality of the karstic aquifer overlying the basalts is affected following an accident, the impact is negative and moderately significant, given the potential loss of a local water reservoir.

Table 53: Operation phase impact on groundwater– Potential risk of groundwater quality degradation due to an accident with CO_2 leakage

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	On-Site
Duration	Temporary
Intensity	Low to Moderate
Probability	Unlikely
Significance	Low

Changes in groundwater flow

CO_2 pressure applied into geological storage can locally modify groundwater flow patterns.

Shallow groundwater is known to partially contribute to the sustainability of wetlands in the project area and as such could be affected by this change.

However, considering the significant CO_2 storage depth and low permeability of the medium, groundwater flow to surface-dependent wetlands is not expected to be affected to the point of stopping feeding them.

Table 54: Operation phase impact on groundwater– Changes in groundwater flow

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	On-Site
Duration	Permanent
Intensity	Low
Probability	Unlikely
Significance	Low

11.6.3 Decommissioning Phase

Although the injection process will be complete after two years, there is a risk of leakage and migration of carbon dioxide through the geological fracturing system. This risk, associated with the mineralisation process, thus implies a risk of groundwater contamination (similar to the potential risk for the operational phase).

Table 55: Decommissioning phase impact on groundwater– Potential risk of groundwater quality degradation

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	On-Site
Duration	Temporary
Intensity	Low
Probability	Unlikely
Significance	Low

11.6.4 Summary

No significant impacts to groundwater are expected during any of the Project's phases.

Despite this, during the operational and decommissioning phases, due to the action of CO_2 injection, the following impacts stands out:

- Potential localised contamination of the aquifers that overlies the basalts as a result of an accident with CO_2 mobilisation from depth through the surface - however, as the geological context does not allow for significant aquifer development, the potential negative impacts of changes in groundwater quality are, in general, considered to be minor. However, there is a risk that in the event of an accident, CO_2 could reach the karst aquifer above the basalts, as well as the shallower aquifers, which would have a moderate negative impact.

- Potential changes in groundwater flow due to CO_2 storage pressures and consequently to wetland recharge, are expected to be of minor significance.

11.7 Surface Hydrology

11.7.1 Construction phase

The activities during the Project's construction phase may impact surface hydrology and its physical and chemical characteristics, such as the following:

- Potential indirect contamination from construction support activities such as drilling and vehicle, equipment and machinery usage; and
- Worker water and wastewater service demands.

Given the small scale of the Project and its footprint, these are relatively small effects. Nonetheless, the application of the general mitigation measures presented in Section 12.2 below should minimize the resulting impacts to *negative*, *indirect*, with *local* extent, *short-term* duration, *low* intensity, and *unlikely* probability, yielding a *negligible* significance.

Table 56: Construction phase impacts on surface hydrology after minimization

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	Local
Duration	Short-term
Intensity	Low
Probability	Unlikely
Significance	Negligible

11.7.2 Operational phase

The activities of the Project's operational phase may impact surface hydrology in several ways, including the following:

- Project process and worker water and wastewater service demands;
- Potential indirect contamination from project support activities such as vehicle, equipment and machinery usage;

- Injected and unmineralized CO_2 leaking and dissolving into subsurface aquifers, indirectly acidifying connected surface water resources; and
- Direct increased water needs for the Water-CO_2 solution technological alternative.

The effects of these activities can be summarized into two categories, each assessed separately, namely exposure to contamination and increased service demand.

Exposure to contamination

Throughout the Project's operational phase, the injection of CO_2 and associated transport and industrial activities may compromise surface water resource quality through industrial hazards and accidental surface leakage, as well as indirect acidification.

Project activities may lead to accidental surface CO_2 solution leakage or other more traditional industrial hazards such fuel, oils, lubricants, or other hazardous substances. These hazards lead to an increased exposure of water resources to potential contamination from potential spills or leaks from vehicles, equipment, and machinery.

If the injected CO_2 solution is not completely mineralized, pockets of injected CO_2 may leak or be progressively dissolved into groundwater, contributing to its acidification and potentially release nearby deposited metals and heavy metals into the water resources (Eldardiry & Habib, 2018), changing redox potential and degrading biological conditions (Van De Ven & Mumford, 2020), (Zheng, *et al*., 2021). The contaminated groundwater may then be surfaced through discharge or extraction, indirectly deteriorating surface water resource quality.

Considering the temporary nature of the Project, these effects should be contained in time and scale. Nonetheless, the resulting impacts are *negative*, *indirect*, with *local* extent, *short-term* duration considering the project's duration, *low* intensity, and *unlikely* probability. With the implementation of the proposed measures, namely the use of temporal ditches, contamination traps, and bunding of storage tanks (see Section 12.2), this impact will have *low* significance.

Table 57: Operational phase impacts on surface hydrology from exposure to contamination after minimization

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	Local
Duration	Short-term
Intensity	Low
Probability	Unlikely

Dimension	Assessment
Significance	Low

Increase service demand

The Project's activities will induce additional demands on freshwater supply and wastewater treatment resulting from the following:

- Industrial activities, which require feed water;
- Worker service needs, leading to increased demand of potable water and treatment of the resulting wastewater; and
- Relevant additional feed water needs for the supply of sufficient process water if the chosen technological alternative is based on a water-CO_2 solution.

It has been found that direct CCS implementation in power plants leads to additional constraints on freshwater resources (Eldardiry & Habib, 2018), which may be justified by increased process water needs (applicable to the assessed project) or by a general decrease of power production efficiency, which leads to additional cooling needs (specific impact for power plants). For the assessed Project in particular, the pilot-scale operation represents a relatively small, temporally limited increase of local water needs.

Given the introduction of a new industrial activity with the associated workforce in the project area, additional potable water supply and wastewater management needs will result from Project operation. The Project includes the construction of temporary potable water and feed water storage facilities, easing the potential spiking pressure on the local supply system. On the other hand, treatment for wastewater to be generated on the project area must be accounted for in Project design, allowing for impact minimization on surface water resources.

The aggregate impact of the described effects is *negative*, *indirect*, with *local* extent, *short-term* duration given the project's duration, *low* intensity (*moderate* without mitigation), and *certain* probability. Accordingly, the resulting impact should have *low* significance.

If the injection is to be made through the injection of a Water-CO_2 solution, an additional impact occurs given the relevant increase in water demand on the local water resources, with the associated need for treatment up to industrial grade. This will be a *conditional negative direct* impact with *regional* extent (given the scale of the supplying system), *short-term* duration, *low* intensity, *certain* probability (for this technological alternative scenario), preliminarily assessed with *low* significance given the temporary nature of the Project.

Table 58: Operational phase impacts on surface hydrology from increased service demand after minimization

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Short-term
Intensity	Low
Probability	Definite
Significance	Low

11.7.3 Decommissioning phase

The activities during the Project's decommissioning phase will be similar to the construction phase activities, including the following possible effects on surface hydrology:

- Potential indirect contamination from construction support activities such as ground sealing and vehicle, equipment and machinery usage; and
- Worker water and wastewater service demands.

Both the small scale of the Project and its footprint lead to the conclusion that, with the application of the general mitigation measures presented on Section 12.2, these components of the decommissioning phase should have negligible impacts on surface hydrology, albeit *negative*, *indirect*, with *local* extent, *short-term* duration, *low* intensity, and *unlikely* probability.

Table 59: Decommissioning phase impacts on surface hydrology after minimization

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	Local
Duration	Short-term
Intensity	Low
Probability	Unlikely
Significance	Negligible

During and after decommissioning, the Project may have legacy impacts on surface hydrology through potential indirect leaks from the injection well or seepage from the receiving formations into surface resources via groundwater interaction. These impacts represent the continuation of the impacts identified during the operational phase on exposure to indirect contamination from impacted groundwater.

The resulting impacts are likely to be *negative*, *indirect*, with *local* extent, *medium-term* duration given the project's scale, *low* intensity, and *unlikely* probability, and as such have a *low* significance.

Table 60: Legacy decommissioning phase impacts on surface hydrology from potential indirect leaks

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	Local
Duration	Long-term[6]
Intensity	Low
Probability	Unlikely
Significance	Low

11.7.4 Findings from Specialist Study

Watercourses in relation to the project implementation area are shown in Figure 48 above. The Kromdraaispruit, which is a perennial river, is located north of the injection site and flows in a northerly direction away from the site. A drainage line flows across the injection site in a southerly direction towards a small dam located near Lebohang. Three wetlands were observed within a 500 m radius of the injection site, namely two small Dep and one large CVB.

The impact assessment from the Freshwater Assessment (van Rooyen, 2023) (contained in Appendix D1) is tabulated below.

Table 61: Impact assessment from Freshwater Assessment (van Rooyen, 2023)

Nature: Drainage line function change, soil compaction, pollution, increase of runoff and erosion.		
Activity: Vegetation clearance around drainage line may increase the erosion potential due to increase runoff. Pollution highly possible due to construction equipment and vehicles.		
	Without mitigation	**With mitigation**
CO_2 Storage		
Probability	Unlikely (2)	Rare/Remote (1)
Duration	Short term (2)	Short term (2)
Extent	Local (2)	Local (2)
Magnitude	Low (4)	Minor (2)
Significance	**16 (Low)**	**6 (Low)**

[6] Until the mineralization process is complete.

Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Moderate
Irreplaceable loss of resources?	Low	Very Low
Can impacts be mitigated?	Yes	

11.7.5 Summary

The identified impacts of the Project on surface hydrology are generally related to potential contamination and increased service needs, with transversally negligible to low significance levels.

During the construction phase, project impacts result from support activities and related potential contamination and water and wastewater demands, albeit with negligible impacts given short-term duration and the application of general mitigation measures.

The Project's operation phase represents a local increase of water and wastewater service demands, particularly so if the injection fluid is a Water-CO_2 solution, a relative increase of potential surface water contamination risk, and the potential indirect exposure to acidified groundwater resources from project-associated leaks or seepage. These impacts have low significance given the short-term duration, low probability, and the implementation of proposed general measures.

The decommissioning phase impacts are partially similar to the construction phase impacts, resulting from decommissioning activities with negligible significance, but also may result from potential indirect contamination of surface water resources through leakage from the injection well or receiving formations, with low significance.

11.8 Waste management

In order to assess the impact of the Project on waste management, the different categories of waste expected during the construction, operation and decommissioning phases have been identified, taking into account existing national legislation. The waste characterisation will be mainly qualitative, as no quantitative data are available for the waste to be generated during each phase of the Project.

Inadequate management of waste generated by the Project may lead to contamination of soil, air, and water resources, resulting in adverse impacts on ecosystems in the project area and its sphere of influence, which may prove to be significant. Under current legislation, waste management is the responsibility of the producer, who is obliged to promote the separation of waste and deliver it to a licensed facility.

Waste management measures will therefore be recommended, considering the different types of waste generated during the different phases of the Project, and seeking wherever possible to ensure the recovery, reuse and recycling of waste rather than its disposal. If these minimization measures are adopted and proper waste management is carried out, it is possible that impacts will be negligible to null.

11.8.1 Qualitative assessment

11.8.1.1 Construction Phase

In the construction phase it is necessary to manage waste from the following activities:

- Site Establishment -
  - Levelling of ground for access;
  - Access roads and parking area;
  - Construction of storage facilities;
  - Construction of shelter for security personnel;
  - Installation of site offices, ablution facilities and support infrastructure.
- Drilling; and
- Construction of the operational area.

The type and quantity of waste generated during the construction phase will depend on the type of soil and geological structure of the site, the working equipment and structures, and the characteristics of the facilities supporting the workers.

In the construction phase, the following waste materials are anticipated:

- General Waste -
  - Vegetation waste generated by site cleaning, includes, but is not limited to, leaves, grass trimmings, and woody wastes;
  - Building and demolition waste, from the construction of the structures that support the execution of the project (e.g., storage facilities, shelter, or offices) and roads and parking areas;
  - Excavated earth material (soil and bedrock) from the drilling;
  - Waste with characteristics similar to domestic waste, produced in the area of the work site, as such, paper, plastic, tin, and/or glass from the office, workshop and processing area.
- Hazardous Waste, mainly the result of accidental spills or breakdowns, such as contaminated soil. It can also include used oils; oil filters; absorbent materials contaminated with hydrocarbons; and packaging waste contaminated with hydrocarbons; and
- Wastewater from the sanitary and social facilities on site.

During the construction phase, the main waste generated will be drilling waste. It is expected that large quantities of excavated earth material will be produced as a result of drilling at 1,800 m. However, it is the production of hazardous waste that is likely to have the greatest environmental impact, although it is expected to be in small quantities or none.

11.8.1.2 Operational Phase

During the operational phase, and more specifically during the CO_2 injection activities in the project area, the following categories of waste are expected to be generated:

- General Waste -
  - Building and demolition waste, as a result of infrastructure maintenance; and
  - Waste with characteristics like domestic residues.
- Hazardous Waste, as result of possible maintenance of the equipment and potential accidental spillages; and
- Wastewater from the sanitary and social facilities on site.

Although the quantities of waste that will be generated during the operational phase are unknown, it is expected that these quantities will not have an impact on the capacity of operators and facilities to manage the different types of waste, as the quantities of waste are expected to be small.

It is important to note that the CO_2 capture process, a stage prior to injection, may produce specific wastes (solid and liquid); solvent air scrubbing processes may produce degraded solvent residues. The amount of waste produced during this process depends on the solvent used and the stage at which the process is carried out. Post-combustion capture processes produce significantly more degraded solvent than pre-combustion capture processes (IPCC, 2005).

The composition of the waste produced during the capture process, which depends on the process used, may determine whether it is classified as hazardous waste, and therefore the content of the waste will change the most appropriate type of treatment and disposal.

The impact of the capture process is expected to be characterised and evaluated as part of an independent process for a capture pilot project.

The transport of CO_2 is not expected to generate any waste other than that resulting from the periodic maintenance of the vehicles, which is not exclusive to the Project.

11.8.1.3 Decommissioning Phase

The decommissioning phase mainly involves the generation of construction and demolition waste from the dismantling and reconversion of the construction materials used. There is also the potential for hazardous waste to be generated from accidental spills. Waste with similar characteristics to domestic waste and wastewater will also be generated, but to a lesser extent than in the previous stages. As with any phase of the Project, it is important to ensure that the waste generated is properly managed.

11.8.2 Final Destination of the Generated Waste

It is expected that all waste generated will be disposed of at the Leandra Landfill, which is the closest waste management facility to the project area. The disposal of hazardous waste in a landfill depends on the characteristics of the landfill and the type of licence it has. If hazardous waste cannot be disposed of at the Leandra Landfill, it will be disposed of at the nearest permitted landfill. The Holfontein Hazardous Waste Disposal Site is located in Benoni, Gauteng Province. According to its licence (12/9/11/L975/3), Holfontein is a Class H:H (Class A) landfill.

As verified, although Leandra Landfill is a facility with a primary function as a landfill, it can also accommodate other types of waste. Therefore, if there is no possibility to treat or recover certain fractions, such as recyclables, in this facility, landfilling will take place.

There is the possibility of taking the rock extracted by drilling to a quarry or asphalt plant to be used as a resource for building, road construction and or quarrying recovery. This transfer of resources is in line with the development of the municipality's projects, namely the Integrated Housing Strategy (as referred to in the spatial planning section) and the improvement of national and provincial roads.

During the decommissioning phase, in order to restore the project area to its previous condition, the soil that was removed during the construction phase can be put back onto the affected area. This use ensures that the soil removed is not regarded as a waste.

The following destinations are therefore envisaged for the solid by-products generated:

- Landfill site: vegetation waste, building and demolition waste, hazardous waste, and waste with similar characteristics to domestic waste;
- Quarries or asphalt plant: bedrock from the drilling; and
- Rehabilitation of the project area: soil from the site establishment. It should be suitably stockpiled for use during rehabilitation.

It is expected that the disposal and treatment of wastewater from on-site sanitary and social facilities will comply with national laws and regulations.

11.8.3 Classification of the Potential Impacts

The classification of the impacts depends on the categories of waste produced (which depend on the level of hazard and contamination), the quantities (which are not known), the conditions of temporary storage (it is expected that there will be appropriate containers for the types of waste produced) and the final destination. However, the production of waste in itself causes negative impacts because its production represents a new undesirable factor compared to the pre-existing situation.

The classification of potential impacts will be divided by final destination and by hazard. The assessment is therefore divided into:

- Non-hazardous waste sent to licenced landfill (vegetation waste, building and demolition waste, and waste with similar characteristics to domestic waste);
- Hazardous waste sent to licenced landfill;
- Products sent to quarries or asphalt plants (bedrock);
- Products used in the rehabilitation of the project area (soil); and
- Wastewater.

Table 62 below summarizes the phase at which the waste types will be produced.

Table 62: Waste types during project phases

Waste Types	Construction Phase	Operational Phase	Decommissioning Phase
Non-hazardous waste	-	-	-
Vegetation waste	✓	*N/A*	*N/A*
Building and demolition waste	✓	✓*	✓✓
Waste with similar characteristics to domestic waste	✓	✓	✓
Bedrock	✓✓	*N/A*	*N/A*
Soil	✓	*N/A*	*N/A*
Hazardous waste	✓*	✓*	✓*
Wastewater	✓	✓	✓

Legend:
✓*: residues with the potential to be generated, if so, in small quantities
✓: the production of this type of product is expected
✓✓: expected to be the categories with the most significant volumes

11.8.3.1 Non-Hazardous Waste Sent to Landfill

As mentioned in the previous Sections, although the generation of non-hazardous waste is certain, it will not be in significant quantities and as such is not expected to disrupt the normal operation of local waste management services. As these are non-hazardous wastes and if good management practices and mitigation measures are applied, the management of these wastes is expected to present a low environmental risk and therefore the significance of this impact is expected to be limited.

This waste is expected to be disposed of at the Leandra Landfill, as it is the closest waste disposal facility, which is located in the GMLM and approximately 2 km from the project area. As the Leandra Landfill, although licensed, may not fully comply with the minimum conditions required by national regulations, the impact will not be negligible. Once in the landfill, the impact of this waste will be beyond the scope of the Project.

The classification of potential impacts related to non-hazardous waste sent to landfills, assuming the implementation of best practices and mitigation measures, is shown in the table below.

Table 63: Impacts of non-hazardous waste sent to landfill

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Permanent
Intensity	Low
Probability	Definite
Significance	Low

11.8.3.2 Hazardous Waste Sent to Landfill

It is expected that this waste will be disposed of at the Holfontein Hazardous Waste Disposal Site. As hazardous waste, it poses a high environmental risk, especially if the disposal site does not meet all the necessary safety requirements. This waste type will be properly stored and handled at the site before it is delivered to a licensed haulage contractor, and good waste management practices and mitigation measures will be implemented throughout the implementation of the Project. Although this waste may be generated, it is not certain that it will, and the potential for generation is minimized if adequate workplace safety measures are followed. Similarly, the impacts caused will remain after the end of the Project under consideration. The classification of potential impact in relation to the landfilling of hazardous waste, assuming the implementation of best practices and mitigation measure, is shown in the table below.

Table 64: Impact of hazardous waste sent to landfill

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Permanent
Intensity	Medium
Probability	Unlikely
Significance	Low

11.8.3.3 Waste Sent to Quarries or Asphalt Plants

It is expected that the rock extracted during drilling will be sent to a facility that uses it as a resource, such as an industrial quarry or asphalt plant. It is anticipated that this will be directed to the Leandra quarry as this is the closest facility, approximately 3km away. The extracted rock is expected to be used as a resource within the timeframe of the Project with an undetectable impact intensity. The classification of potential impact related to waste sent to a facility to be used as a resource is shown in the table below.

Table 65: Impact of products sent to quarries or asphalt plants

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Short-term
Intensity	Negligible
Probability	Definite
Significance	Negligible

11.8.3.4 Products Used in the Rehabilitation of the Project Area

It is expected that the extracted soil layer will be used to reinstate the project area during the decommissioning phase. If the mitigation measures are followed, mainly the maintenance of soil quality during the storage period, the magnitude of the impact is not expected to be detectable. The table below shows the classification of the potential impact associated with the waste used in the rehabilitation of the project area.

Table 66: Impact of products used in the rehabilitation of the project area

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On-site
Duration	Long-term
Intensity	Negligible
Probability	Definite
Significance	Negligible

11.8.3.5 Wastewater

It is expected that negligible volumes of wastewater will be generated during all project phases. If this waste is properly managed and treated, with the implementation of good management practices, the impact is expected to be null.

11.8.4 Summary

In terms of waste management, the following impacts are expected throughout the construction, operation, and decommissioning phases, with the implementation of mitigation measures:

- Null impacts on wastewater management;
- Negligible negative impacts on the use of resources generated by the Project on quarries and restoration of the project area; and
- Minor negative impacts of landfilling of non-hazardous and hazardous waste;

11.9 Environmental Quality

11.9.1 Landscape and Light Pollution

Artificial light can cause a range of negative impacts on human health and negative impacts on ecosystems (Figure 103), as the physiology and ecology of several animal species, including humans, depend on cues provided by the natural day-night cycle or seasonal patterns (Widmer, *et al*., 2022). The effects on ecosystems are difficult to quantify due to the multitude of factors that can influence the results. Light pollution is highly variable and depends on the amount of light directed towards the sky, atmospheric pollution, weather conditions, and the direction from which it is seen.

The significance of the light pollution impact will depend on the length and period of the day during which the work takes place, the intensity and direction of the light, and the distance to the receptors. If light sources are used during daylight hours, they will have a null impact. The impacts of light pollution only become significant at night.

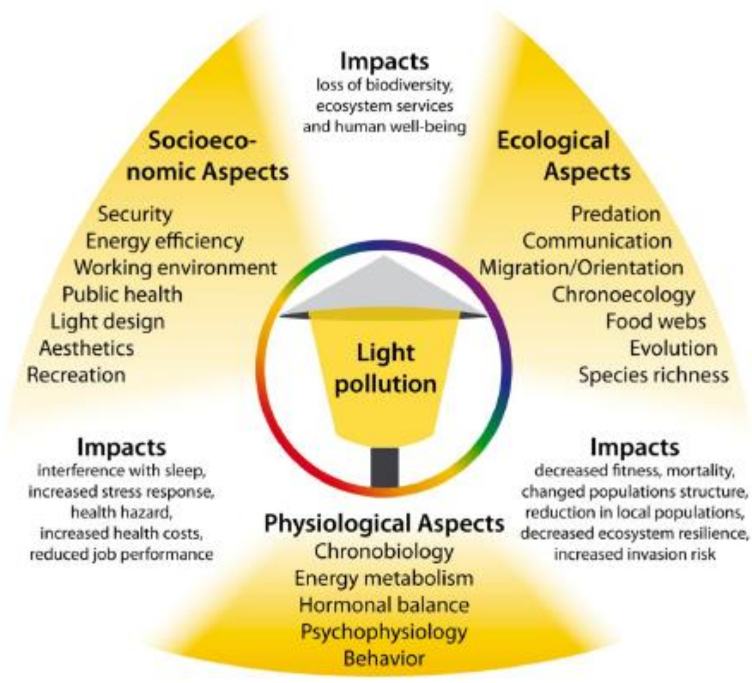

Figure 103: Interplay of adverse impacts related to light pollution at the interface of ecology, socio-economy and physiology (Widmer, *et al*., 2022)

Of the project phases, only the construction phase will operate at night as it will run 24 hours a day for 6 months. The operational and decommissioning phases are expected to take place mainly during the day.

11.9.1.1 Construction Phase

During the night-time period of the construction phase, it is expected that artificial lighting sources will be used to ensure visibility and safety at work. As such, there will be a potential impact of artificial lighting on the surrounding area of the project site.

The closest human receptors are residential areas, the nearest of which are located approximately 1 km from the project site. If light propagation in the project area is not limited, it may reach several receptors at some distance. However, given the distance from human receptors, the amount and intensity of light reaching the population is expected to be low and not cause significant changes in people's lifestyle or health.

With regard to fauna and flora, species in the vicinity of the project site are able to adapt to human presence. Therefore, the environmental impact is expected to be such that natural functions and processes will not be affected.

Although high intensity impacts are not expected, some mitigating measures can be applied to ensure that this does not happen. The classification of the potential impacts associated with the construction phase at night is shown in the table below.

Table 67: Construction phase impacts - Light Pollution (night-time)

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Short-term
Intensity	Negligible[1]; Low[2]
Probability	Definite
Significance	Negligible[1]; Low[2]

Notes: 1 - socio-economic environment; 2 - biophysical environment.

11.9.1.2 Operational Phase

The impact is null as the operational phase is expected to take place during daylight hours.

11.9.1.3 Decommissioning Phase

The decommissioning activities are expected to take place during daylight hours, and as such the impacts are null.

11.9.1.4 Summary

Artificial light at night can have a number of negative impacts on human health and on ecosystems. The assessment carried out predicts that negative impacts will occur during the construction phases. This impact is negligible for the population and of minor importance for ecosystems. However, the adoption of mitigation measures is recommended to ensure these low levels of significance.

11.9.2 Noise and Vibration

11.9.2.1 Noise

Noise is considered a public health problem as the effects of excessive noise exposure can damage human health with consequences ranging from sleep disturbance, mood swings, reduced ability to concentrate, reduced performance at work or school, behavioural changes, stress, fatigue, headaches and high blood pressure.

Noise has a greater impact at night than during the day since there are fewer sources of noise and their intensity is lower, making the impact of the sources that do exist more significant. In addition, most of society is asleep at night, so any noise can be disruptive.

In 2009, the World Health Organisation (WHO) published a report entitled “Guidelines for Night Time Noise in Europe” (WHO, 2009) , which presents key findings on the effects of noise on human health during sleep. This report states that sleep and wellbeing at night are disturbed when noise levels in outdoor spaces exceed 42 dB(A).

During the Project, noise emissions from the construction, operational and decommissioning phases are expected to have an impact on the noise environment. As such, the activities to be carried out may generate noise levels exceeding those recommended by SANS 10103 (Figure 58). The main sources of noise emissions foreseen by project phases and the sources of greatest concern in terms of their impact are shown in Table 68.

Table 68: Main sources of noise emissions by project phase

Source	Phase		
	Construction	Operational	Decommissioning
Construction and demolition equipment for site establishment, construction of the operational area and dismantling of site infrastructure	✓✓	-	✓✓
Drilling equipment	✓✓✓	-	-
CO_2 injection equipment	-	✓	-
Road traffic (especially heavy vehicles) for the transport of the equipment and structures necessary for the development of all the phases of the project and for the transport of CO_2;	✓✓*	✓✓*	✓✓*
Power generators	✓✓✓	✓✓	✓✓
Noise from the presence of workers	✓	✓	✓

<u>Legend:</u> - no noise is expected to be emitted; ✓ expected to occur, but not significant; ✓✓ expected to occur; ✓✓ expected to occur and of greater concern in terms of impact; Notes: * Mainly outside the project area

Noise from the drilling equipment is of particular concern, as this is a source that will operate continuously (24h/day) within a time span of 6 months and is expected to emit high levels of noise. There is also concern about the noise from the power generator during the construction phase, as it will operate 24 hours a day, similar to the drilling equipment.

Construction and demolition equipment and the power generator during operation and decommissioning have high noise levels for long periods, but it is expected to operate only during the day-time.

Road traffic noise is also expected to be of high intensity, affecting mainly sensitive receptors, but will be mainly occasional and predominantly during the day, with impacts mostly outside the project area.

Noise from workers (e.g., chatting and using the support facilities) and from the injection equipment is expected to be residual in relation to the other equipment (such as the generator and the drilling equipment) and also to occur during the daytime.

The equipment to be used for the Project is not known in detail, which presents a challenge for noise assessment. However, reference values are needed to assess potential noise levels. Noise levels values differ greatly from one device to another, and also within the same device there are variations depending on its characteristics, such as power rating, dimensions, capacity and type of use. Noise also impacts differently depending on the emission frequency (octave band) by the equipment.

Table 69 shows typical sound pressure levels associated with some of the equipment expected to be used during the Project. This information has been obtained from the British Standards Institution (BSI) – Standard BS 5228-1:2009, "Code of practice for noise and vibration control on construction and open sites – Part 1" (BSI, 2014).

Table 69: Sound level data on site equipment and site activities (BSI, 2014)

Activity	Equipment	Sound pressure level at 10 m
Clearing site	Dozer	75 dB(A)
	Tracked excavator	78 dB(A)
	Wheeled backhoe loader	68 dB(A)
General site activities	Articulated dump truck	81 dB(A)
	Lorry movements on access road	88 dB(A)
Power	Diesel generator for site cabins	74 dB(A)
	Petrol driven generator for power tools, site machines and ancillary equipment	83 dB(A)
Ground investigation drilling	Cable percussion drilling rig (150 mm diameter / 75 m depth)	74 dB(A)
Drilling	Tracked hydraulic drilling rig (100 mm bore)	86 dB(A)

Note: the highest values were considered by the precautionary principle.

Thus, in the project area, the most significant noise sources for each phase of the Project (Table 68) are expected to have the following noise levels (Table 69):

- Construction: drilling with 86 dB(A) and power generator with 83 dB(A); and
- Operational and Decommissioning phase: power generator with 83 dB(A).

Although there are certain sources that have a major significance and have higher noise levels, it is important to keep in mind that simultaneous noise from several sources in the same location can result in an increase in noise levels.

Decibels are measured on a logarithmic scale, so noise levels cannot be added by standard addition. Combining two noises of the same level (±1 dB) will increase the noise level by 3 dB. However, if there is a difference of more than 10 dB between two sounds, there will be no combined increase in noise level (the higher power will cover the other sound). The decibel summation rules are summarised in Table 70.

Table 70: Rules for combining noise levels (United States Regulatory Commission, 2012)

When two decibel values differ by:	Add the following to the higher decibel value:
0 or 1 dB(A)	3 dB(A)
2 to 3 dB(A)	2 dB(A)
4 to 9 dB(A)	1 dB(A)
10 dB(A) or more	0 dB(A)

Taking into account the main sources described above, it is considered that the maximum noise levels to be emitted during each phase of the Project in the implementation area will be as follows:

- Construction phase: 88 dB(A); and
- Operational and decommissioning phase: 83 dB(A).

It should be emphasised once again that these values depend on a large number of factors and that they can only be considered as reference values.

In order to determine the impact of noise levels near sensitive receptors within the study area (Figure 61) it is necessary to know what noise level is predicted to reach them.

Base 10 logarithmic equations are used to calculate noise levels at a given distance from the source (e.g., construction noise levels at a sensitive site) and to determine the distance the construction noise will travel before being attenuated by ambient noise levels (United States Regulatory Commission, 2012).

To determine construction noise levels at a specific distance, the following equation can be used (United States Regulatory Commission, 2012):

$$Lp\ (R2) = Lp\ (R1) - \alpha * \log\left(\frac{R2}{R1}\right)$$

Where:
L_p (R1) = Known sound pressure level at the first location;
L_p (R2) = Unknown sound pressure level at the second location;
R1 = Distance from the noise source to location of known sound pressure level;
R2 = Distance from noise source of unknown sound pressure level;
α = 25 for soft ground and 20 for hard ground. For point source noise, a spherical spreading loss model is used. These alpha (α) values assume a 7,5 dBA reduction per doubling distance over soft ground and a 6,0 dBA reduction per doubling distance over hard ground.

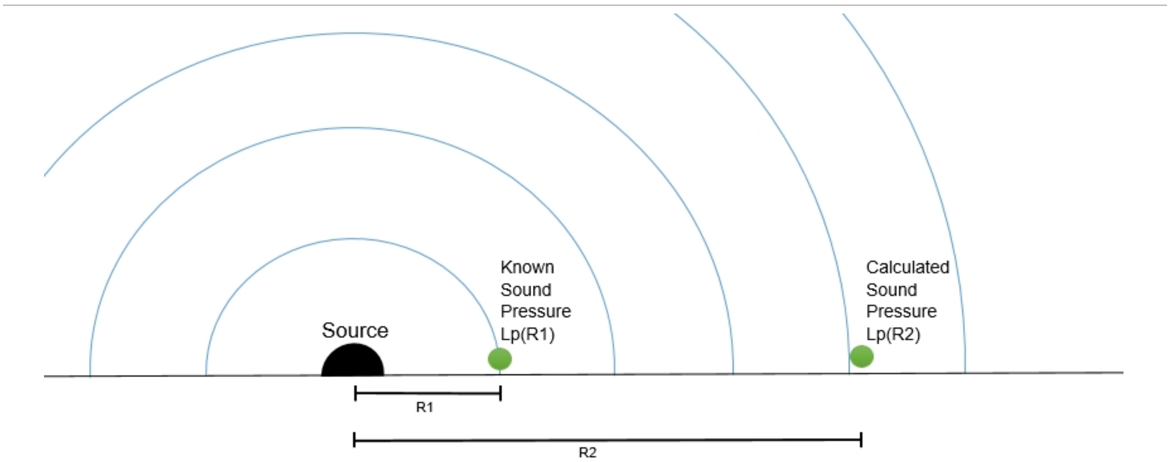

Figure 104: Sound Attenuation (WKCgroup, 2021)

The following equation can be used to determine the distance a point source of construction noise travels before it is attenuated to the ambient sound level (U.S. Regulatory Commission, 2012):

$$D\ = D0 * 10^{\left(\frac{Construction\ Noise\ Level\ - Ambient\ Sound\ Level\ in\ dB}{\alpha}\right)}$$

Where:
D = the distance from the noise source
Do = the reference measurement distance
α = 25 for soft ground and 20 for hard ground. For point source noise, a spherical spreading loss model is used. These alpha (α) values assume a 7.5 dBA reduction per doubling distance over soft ground and a 6.0 dBA reduction per doubling distance over hard ground.

The following terms can be defined (Mindat.org; Hudson Institute of Mineralogy, 2023)

- **Soft ground**: “part of a mineral deposit that can be mined without drilling and shooting. It is commonly the upper, weathered portion of the deposit”;
- **Heavy ground:** “rock about underground openings that does not stand well and requires timbering”.

This means that the project area, including the surrounding area, is considered to be framed by "soft ground" (α = 25).

Table 71shows the expected sound level at a given distance from the project area, without taking into account external factors that may affect sound propagation (such as wind, humidity and acoustic barriers), without taking into account mitigation measures and assuming that there is no accumulation of sound levels along the route.

Table 71: Expected noise level emitted in the project area at a given distance

Sound pressure level at	
1 km (nearest sensitive receptors)	
Construction phase	38,0 dB(A)
Operational and decommissioning phase	33,0 dB(A)
1,5 km (buffer mid-point)	
Construction phase	33,6 dB(A)
Operational and decommissioning phase	28,6 dB(A)
2 km (buffer range)	
Construction phase	30,5 dB(A)
Operational and decommissioning phase	25,5 dB(A)

Table 72: Distance from the noise source before it is attenuated

Phase	Sound pressure at 10 m	Period	Distance to attenuated (approx.)
Construction phase	88,0 dB(A)	Day (45 dB)	525 m
		Night (35 dB)	1 318 m
Operational and decommissioning phase	83,0 dB(A)	Day (45 dB)	331 m
		Night (35 dB)	832 m

It is therefore verified that the previously outlined study area (2 km buffer) is appropriate. The maximum distance at which the generated noise can disturb the sensitive areas in the current situation is approximately 1,3 km.

However, there are several factors that can affect these values, namely wind speed and direction. If the wind is blowing in the direction of the sensitive areas, it can increase the propagation range, or if it is blowing in the opposite direction, it can reduce the maximum range. The existence of several parameters that can alter the analysis made, which is very variable, requires greater caution with this environmental descriptor.

The assessment of the potential impacts will be based on various criteria, including the duration of the occurrence, the reversibility of the effects on sensitive receptors and the magnitude of the impact, i.e., difference between perceived noise level at the sensitive areas and site standard noise level situation [45 dB(A) day-time and 35 dB(A) night-time]. The magnitude assessment (based on Figure 59), and predicted community response, will be assessed as follows:

- Difference of less than or equal to 0 dB (A): negligible without complaints;
- Difference from 0 to 10 dB(A): low, with sporadic complaints;
- Difference from 5 to 15 dB(A): medium, with widespread complaints; and
- Difference of more than 10 dB(A): high, with threats or vigorous community/group action.

The potential impact of noise generated in the project area on sensitive areas (in the study area) will be assessed, as well as the potential impact of road traffic in the area of influence, in both cases without considering cumulative effects.

A. <u>Construction Phase</u>

During the construction phase it is expected that noise levels generated in the project area at night will cause sporadic complaints from the local community in sensitive areas within 1 km to 1,3 km of the project area (without any mitigation measures), as the noise level they are expected to experience [38 dB(A)] will be 3 dB(A) higher than the local standard noise level [35 dB (A)]. This impact will be limited to the period of the construction phase, a maximum of 6 months and their effects are reversible. The likelihood of the impact occurring in the community is dependent on the various factors indicated in the Section 10.9.2.3.

In addition, the impact on human health and well-being is not expected at night, as the logarithmic sum of these noise levels will be lower than 42 dB(A) (defined by the WHO).

Being a low noise difference and a considerable distance away, it is anticipated that the implementation of mitigation measures would allow the community to avoid noise-related complaints. On their own, mitigation measures could allow the significance of the overnight impact to become negligible. Due to the uncertainty associated with the parameters and values used in the assessment this impact cannot be considered negligible. However, it is always good practice to apply mitigation measures to control the associated impacts and ensure that the wellbeing and health of the community is not compromised.

As well as affecting communities, noise has the potential to affect the surrounding ecosystems, with emission levels reaching 88 dB(A) at around 10 metres away from the drilling equipment. Given that the species present on the site adapt well to human activities and that there is already high intensity point sources from transport corridors in the vicinity of the project area, the magnitude of the impact is not expected to further affect existing natural ecosystem functions and processes.

The classification of the potential impacts associated with the construction phase is shown in the table below.

Table 73: Construction phase impacts - Noise

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Short-term
Intensity (without mitigation measures)	Negligible[1]; Low[2; 3]
Intensity (with mitigation measures)	Negligible[1; 2] Low[3]
Probability	Likely[1; 2]; Definite[3]
Significance (without mitigation measures)	Negligible[1]; Low[2; 3]
Significance (with mitigation measures)	Negligible[1]; Low[2; 3]

Notes: 1 - socio-economic environment at day-time; 2 - socio-economic environment at night-time; 3 - biophysical environment.

B. <u>Operational Phase</u>

During the operational phase, no complaints are expected from the local community in the sensitive areas as the noise level to be experienced [33 dB(A)] is below the local standard [minimum 35 dB (A)]. Similar to the construction phase, the impact on ecosystems will not alter their functioning. The classification of the potential impacts associated with the operational phase is shown in the following table.

Table 74: Operational phase impacts - Noise

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Long-term
Intensity	Negligible
Probability	Likely[1;] Definite[2]
Significance	Negligible

Note: 1 - socio-economic environment; 2 - biophysical environment.

C. Decommissioning Phase – Project Area

Similar to previous project phases, no complaints by the community are expected during decommissioning and the impact on the nearest ecosystems will not alter their functioning. The classification of potential impacts associated with the decommissioning phase is shown in the following table.

Table 75: Decommissioning phase impacts - Noise

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Long-term
Intensity	Negligible
Probability	Likely[1;] Definite[2]
Significance	Negligible

Note: 1 - socio-economic environment; 2 - biophysical environment.

D. Road Traffic (outside the project area)

The Project is expected to increase the flow of heavy vehicle traffic compared to the existing situation for the transport of equipment and CO_2, thus contributing to an increase in noise levels on these transport corridors. This impact is intermittent, occurring only during the movement of vehicles and for the duration of the Project. If mitigation measures are implemented, it is expected that this impact will not affect or alter the well-being of the surrounding communities. This contribution to the noise level is also not expected to be detectable by ecosystem species, given the existing situation. The following table shows how the potential impacts associated with road traffic are classified.

Table 76: Road traffic impact - Noise

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Temporary
Intensity	Negligible
Probability	Definite
Significance	Negligible

11.9.2.2 Vibration

During the Project, the activities that are expected to generate the highest levels of vibration are soil drilling (during the construction phase) and the movement of heavy vehicles such as trucks and earth movers (during all phases of the Project).

According to the "Environmental Impact Report of the Sacramento Natural Gas Storage Project" (Dudek, 2010), drilling vibration can exceed 80 VdB (vibration decibels) at the wellhead during drilling operations.

The propagation of noise is highly dependent on geological and soil characteristics. The assessment of vibration impacts from the project activities is therefore dependent on the characterisation of the vibration propagation conditions in the ground. This characterisation will be assessed by the "Carbon Capture Utilisation and Storage Project: 3D Seismic Survey and Drilling – Environmental and Social Impact Assessment". However, the referenced EIR (Dudek, 2010) indicates that construction activities, such as a heavy truck driving over large potholes or bumps, could cause perceptible vibrations within approximately 15,24 m (50 ft). Therefore, although the detectability of vibration is highly dependent on the type of soil at the construction site, the type of equipment used, and the structure of the building receptor, it is anticipated that vibrations originating from project activities can only cause annoyance to a sensitive receptor within approximately 15 metres of the project area.

As the nearest vibration receptor is located approximately 600 metres (industrial premises) from the proposed wellhead location, temporary impacts associated with Project related vibration would not be significant. The existence of occasional sources of high-intensity vibration from trains travelling on the railway line and from vehicles circulating on the surrounding roads makes this impact negligible in view of the existing situation.

11.9.2.3 Summary

The following noise impacts are expected:

- ❑ Impacts of the construction phase arising from the project area -
  - Short-term negative impact, with negligible significance during daytime hours; low significance during night-time hours for the community in the identified sensitive areas; and low significance for the surrounding ecosystems.
- ❑ Impacts of the operational and decommissioning phase arising from the project area -
  - Negative long-term effects that are negligible for the population in the identified sensitive areas and for ecosystems.
- ❑ Impacts of road traffic (outside the project area) -
  - Negative impact, temporary and of negligible significance.

The impacts resulting from vibration are expected to be negligible in relation to the existing situation.

11.9.3 Air Quality

11.9.3.1 Construction Phase

During the construction phase, the main actions that may cause environmental impacts are:

- General activities and the operation of support infrastructure;
- Operation of equipment, particularly drilling;
- Construction and installation of infrastructure; and
- Periodic maintenance of the equipment.

All the above-mentioned actions may cause the following impacts:

- Emission of dust; and
- Emission of pollutants.

However, given the size of the Project and considering the implementation of best practice measures, these impacts are considered negative but of negligible significance.

Table 77: Construction phase impacts – emission of dust and pollutants

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Temporary
Intensity	Negligible
Probability	Definite
Significance	Negligible

11.9.3.2 Operational Phase

The Air Quality Study (contained in Appendix D5) provides an understanding of how air quality will potentially be affected with the implementation of the Project during the operational phase.

The air quality assessment during the project's exploration phase was carried out through the modelling of atmospheric pollutant dispersion at a local level. To do so, the inventoried emissions representative of the Project was considered, namely those associated with road traffic and the operation of the generators.

Regarding road traffic, an estimation of the worst-case circulation scenario was taken, which considers approximately 5 heavy vehicles per day during 250 days of the year, from the CO_2 capture site (Sasol Secunda) to the planned storage location. Due to the relatively low number of vehicles that will be circulating, no significant impact on local air quality is expected from road traffic emissions.

As for the generators, although they may be used for emergency situations, a more conservative scenario was adopted, assuming their regular use, with an operation of 16 hours per day for 250 days in a year.

Based on the information presented above, it is not expected that the established reference values for ambient air quality, aimed at protecting human health, will be exceeded. It is anticipated that the locations with higher concentration levels will be those closest to the traffic routes and the location where the generators will be implemented.

Furthermore, the risk of rupture and potential CO_2 release into the atmosphere was analyzed during transportation by heavy vehicle, storage in tanks, and in the reservoir. Despite the low probability of a leakage occurring (less than 10%) (IPCC, 2005), it was considered relevant to verify whether the release scenario tends to promote concentration levels in the ambient air that would jeopardize human health.

The objective was to evaluate, through the application of a mathematical model, the concentrations of CO_2 in the ambient air generated in each assessed rupture scenario. The estimated values were subsequently compared to the representative CO_2 concentration levels of the location where the Project will be implemented (around 419 ppm), knowing that “a CO_2 concentration greater than 7-10% in air would pose immediate dangers to human life and health” (IPCC, 2005). It is worth emphasizing once again that the probability of a leak occurring is relatively low (less than 10%) considering the relevance that the Project will have in combating the issue of climate change.

Table 78: Operational phase impacts – air quality deterioration due to concentrated release of CO_2

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Temporary
Intensity	Low to Moderate
Probability	Unlikely

Dimension	Assessment
Significance	Low to Moderate

Table 79: Operational phase impacts – air quality deterioration due to gradual leakage of CO_2.

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Temporary
Intensity	Low
Probability	Likely
Significance	Low

11.9.3.3 Decommissioning Phase

The possible impacts and their assessment arising from the decommissioning phase will be similar to the impacts verified in the construction phase given that the activities are of the same nature.

11.9.3.4 Summary

With the implementation of the Project, it is considered that air quality is negligibly affected during the construction and decommissioning phases (this being a pilot project and therefore small in size). Regarding the operational phase, where the injection process will occur, two impacts have been identified as negative:

- The possibility of deterioration of air quality due to the local release of CO_2 as a result of an accident - considered to be of low to moderate significance.
- The possibility of air quality deterioration due to the gradual release of CO_2 during the mineralization process through fractures in the rock mass - considered to be of low significance.

The assessment of the impacts described above is based on the specialist Air Quality Study, which is contained in Appendix D5.

11.10 Fauna and Flora

This section presents the expected potential impacts of the activities arising from the project on the fauna and flora.

11.10.1 Construction Phase

During the construction phase, considering the characteristics of the Project, the main actions likely to generate impacts on ecosystems and biodiversity are expected to be the following:

- Operation, movement and assembly of machinery and vehicles;
- Soil movement;
- Placement of protection fences;
- Increased noise;
- Removal of vegetation for:
  - Construction and installations of infrastructure (e.g., construction yard); and
  - Installation of the construction site.
- Spread and/or establishment of alien and/or invasive species.

These actions will have direct or indirect impacts on existing habitats, flora, and fauna, namely:

- Loss of flora and fauna;
- Isolation and fragmentation of habitats;
- Disturbance of faunal communities (e.g., by noise and continuous human presence); and
- Contamination of the habitat with hazardous materials (e.g., oils and fuels, in addition to herbicides for clearing the workspace).

The main impacts will consist in the destruction of grassland for the placement of the warehouse, machinery and other infrastructure and the noise to which birds are usually sensible. The transport of materials, waste and dust clouds from human presence, and potential oil leakages from machinery may cause some small degree of habitat degradation.

Due to the size and characteristics of the operation, none of these impacts are likely to be significant.

<u>Loss of flora and fauna</u>

The construction and assembly of machinery and infrastructure will remove vegetation and may destroy habitat and lead to the loss of fauna. The construction and assembly of machinery and infrastructure is not likely to have a high impact on fauna, apart from casual casualties by the movement of vehicles for transportation of materials. The valuation of impact significance varies according to the ecological value, the size of the allocation, and the characteristics of the habitat eliminated. Thus, since the area is mainly occupied by anthropologically modified grasslands, and artificial land, most species having high mobility and due to the low ecological value and size of the affected area we attribute a *low significance* to the elimination/loss of flora and fauna impact.

Table 80: Impact assessment on "Ecology" (construction phase): "Elimination/loss of flora and fauna"

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On site
Duration	Long-term
Intensity	Low
Probability	Definite
Significance (without mitigation)	Low
Significance (expected post-mitigation)	Negligible

Isolation and fragmentation of habitats

During construction phase, the project will partially isolate the reserved area for the project implementation occupying about 10 ha. The building/placing of the fence will remove the access to the area by some low-mobility animals.

Due to the small size of the Project, and the low ecological value of the affected habitats (in this case, modified Grassland), we attribute a *low significance* to the impact.

Table 81: Impact assessment on "Ecology" (construction phase): "Isolation and fragmentation of habitats"

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On site
Duration	Long-term
Intensity	Low
Probability	Definite
Significance (without mitigation)	Low
Significance (expected post-mitigation)	Negligible

Disturbance of faunal communities

During the construction phase, the movement of vehicle, transportation of materials and construction/placement of infrastructure and machinery will create additional noise to which the local fauna is sensitive. The noise will disturb the biodiversity and likely scare away sensitive species, such as birds, which are very sensitive to visual alteration of the landscape and noise. Due to the unlikelihood of threatened species to be present and the small size of the Project it is attributed the following assessment:

Table 82: - Impact assessment on "Ecology" (construction phase): "Disturbance of faunal communities"

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Long-term
Intensity	Low
Probability	Definite
Significance (without mitigation)	Low
Significance (expected post-mitigation)	Negligible

11.10.2 Operational Phase

During the operation phase, the main foreseeable impacts are related to:

- Presence of machinery for CO_2 storage.
- Operation of machinery and transportation of materials (CO_2), with the risk of oil (or other materials) spills; and
- Maintenance activities.

During the operational phase the following impacts are expected to be caused to terrestrial ecology:

- Degradation of conservation status and loss of habitats;
- Disturbance and deterioration of fauna populations; and
- Release of CO_2

<u>Degradation of conservation status and loss of habitats</u>

During the operational phase, as with the construction phase, the fence to be installed around the injection site will prevent access to the area by non-flying animals such as low mobility mammals, leading to habitat isolation. High mobility animals (e.g., birds, bats and some reptiles will continue to have access to the area).

The transport of CO_2 from the source sites to the storage site in the project area, can potentially contaminate the ecosystems with leakages and while being stored, presenting a potential environmental hazard. The waste and dust clouds from human presence, and potential oil leakages from machinery may cause some small degree of habitat degradation, but such impacts are already either normal occurrences in the region, since it neighbours an urban area, or will increase slightly. The transportation of material is not likely to have other impacts.

The assessment of this impact significance varies according to the ecological value, the size, and the characteristics of the habitat degraded. Thus, since the area is mainly occupied by anthropologically modified grasslands and is of small size we attribute a *low significance* to the degradation of conservation status and loss of habitats.

Table 83: Impact assessment on "Ecology" (Operational phase): "Degradation of conservation status and loss of habitats"

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Long-term
Intensity	Low
Probability	Definite
Significance (without mitigation)	Low
Significance (expected post-mitigation)	Negligible

Disturbance and deterioration of fauna populations

During the operational phase, the movement of vehicles, transportation of materials and operation of machinery will create additional noise to which the local fauna is sensible. The noise will disturb the biodiversity and likely scare away sensitive species such as birds, which are very sensitive to visual alterations of the landscape and noise. Despite these risks, a *low significance* is attributed to this impact due to the small size of the project implementation area.

Table 84: Impact assessment on "Ecology" (Operational phase): "Disturbance and deterioration of fauna populations"

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Long-term
Intensity	Low
Probability	Definite
Significance (without mitigation)	Low
Significance (expected post-mitigation)	Negligible

Disturbance and deterioration of fauna populations - Release of CO_2

The main potential impact is the possible unwanted release/escape of CO_2 through fissures, either close or far away from the project area.

The presence of fissures in the cap rock layer can potentially allow the leakage of CO_2. Yet, even if CO_2 migrates through the fissures is also possible for it to undergo mineralization before reaching the surface and, consequently, still be stored underground within the basaltic formation (IEAGHG, 2011).There is still need for testing and investigation (reviewed in Aminu, *et al*., 2017). The only studies accessing the impacts of CO_2 on fauna focus on marine life, where CO_2 leakage can potentially create deoxygenation areas and lead to hypoxia (Eugenio, *et al*., 2015). One example that shows the potential consequences of this impact is the volcano at the Mammoth Mountain where the underground release of CO_2 (in high concentrations), is killing all the vegetation in the leakage area (USGS, 2023). A similar event may occur in case of high concentration of CO_2 leakages. The potential impact of leakage has been a topic of debate for a long time, but the scientific community seems positive about the process and it has been emphasised that "if the storage sites are carefully selected and the technical infrastructure is well designed, the risks are virtually eliminated" (Hanson, *et al*., 2022).

Depending on the amount of gas released, and on the air quality modelling, it may have *none or low significance*, or, if concentrations are very high, it may lead to the increase concentration of CO_2 in areas like trenches or depressions creating CO_2 concentration zones that would lead to fauna asphyxiation with *high significance* impact.

Table 85: Impact assessment on "Ecology" (Operational phase): "Disturbance and deterioration of fauna populations - Release of CO_2"

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Long-term
Intensity	Low to high
Probability	Unlikely
Significance (without mitigation)	Low to high
Significance (expected post-mitigation)	Low to moderate

11.10.3 Decommissioning Phase

The impacts expected from decommissioning activities are similar to those of the construction phase sharing the same significance, particularly with regards to contamination of habitats and disturbance of wildlife communities. A additional impact is the restoration of the habitats that can occur after removing infrastructure and machinery.

- Disturbance of faunal communities (e.g., by noise and continuous human presence);
- Contamination of the habitat with hazardous materials (e.g., oils and fuels, in addition to herbicides for clearing the workspace); and
- Restoration of the habitats.

After the dismantling of project infrastructure and removal of machinery is completed, monitoring must be undertaken to ensure that:

- No leakages of CO_2 occur, in the affected area and surroundings, by the Project since the leakage of CO_2 can potentially cause the death of vegetation and stop any ecological process (vegetation and air monitoring to detect any CO_2 leakage).

If such measures to quickly detect negative impacts are adopted, it will be possible to detect any potential CO_2 leakage and implement mitigation measures to avoid/mitigate impacts on biodiversity.

Restoration of the habitats

Due to the small size of the project implementation area, the damage is not expected to be significant. Any restoration required should also be of small dimensions, thus, this is a *positive* impact of *low magnitude* and *significance* for modified habitats, such as artificial and agricultural areas, but will have a *medium to high magnitude* and *moderate to high significance* if leakage occurs in sensitive habitats that possess high ecological value.

Table 86: Impact assessment on "Ecology" (decommission phase): "Restoration of the habitats"

Dimension	Assessment
Nature	Positive
Directionality	Indirect
Extent	On site
Duration	Long-term
Intensity	Low to high
Probability	Likely
Significance	Low to high

11.10.4 Findings from Specialist Study

The information contained below was extracted from the Terrestrial Biodiversity Compliance Statement (Human, 2023) (contained in Appendix D2).

The Screening Report classified both the animal and plant theme sensitivity as 'medium'. Following the field survey findings, both the animal and plant species themes may be re-classified as having 'low' sensitivities. This is since the project area is largely modified and there is limited suitable habitat available to support the regular occurrence of any flora or faunal SCC within the project area.

Due to the low sensitivity of the project area a Terrestrial Biodiversity Compliance Statement was compiled. The impacts identified by the Terrestrial Ecologist are tabulated below. All residual impacts had a low significance after the consideration of the proposed mitigation measures.

Table 87: Potential impacts to terrestrial ecology (Human, 2023)

Impact 1	**Destruction, fragmentation and degradation of habitats and ecosystems**
Problem	Construction activities will require clearing of natural habitat, to be replaced by the infrastructure. This will result in permanent local loss of habitat. Daily operational activities will permanently damage habitat and fragment it further.
Type	Direct
Nature	Negative
Phases	Construction and operational
Impact 2	**Spread and/or establishment of alien and/or invasive species**
Problem	Establishment and continued spread of alien invasive plants due to the clearing and disturbance of indigenous vegetation
Type	Indirect
Nature	Negative
Phases	Construction and Operational
Impact 3	**Direct mortality of fauna**
Problem	Mortality of fauna due to higher traffic (Vehicles and staff) on site
Type	Direct
Nature	Negative
Phases	Construction and Operational
Impact 4	**Reduced dispersal/migration of fauna**
Problem	Internal roads, fencing and infrastructure will cut off migratory routes of faunal populations
Type	Direct
Nature	Negative
Phases	Construction and Operational
Impact 5	**Environmental pollution due to water runoff, spills from vehicles and erosion**
Type	Direct and Indirect
Nature	Negative

Phases	Construction and Operational
Impact 6	**Disruption/alteration of ecological life cycles (breeding, migration, feeding) due to noise, dust, and light pollution.**
Problem	Construction and maintenance vehicles moving around on site
Type	Direct and Indirect
Nature	Negative
Phases	Construction and Operational
Impact 7	**Staff and others interacting directly with fauna (potentially dangerous) and flora or poaching of animals and plants**
Problem	Staff interacting/ killing/ poaching fauna or flora species
Type	Direct
Nature	Negative
Phases	Construction and Operational

11.10.5 Summary

Most of the impacts are considered of low significancy and may increase into moderate or high significance under some specific circumstances. They essentially revolve around the destruction of grassland for the placement infrastructure, the use of machinery, the noise to which many animals are usually sensitive and some potential contaminations from oil leakage. These small degree impacts are already normal human pressures that exist in the area and are not likely to cause significant damage to biodiversity due to the size and characteristics of the operation. The most serious impact is the potential CO_2 leakage from the underground storage which requires continuous monitoring.

11.11 Sensitive Habitats

There are no protected areas in proximity to the injection site, and the project’s buffer does not include any Sensitive Habitat or protected areas.

The main natural/semi-natural habitats present in the affected area, including the indirectly affected area, are agriculture lands and grasslands.

The closest area with protection status is the Devon Protected Environment, which more than 5 km away from the IAI.

11.12 Land Use and Spatial Planning

The assessment of the Project's impact on land use planning and constraints needs to take into consideration its effects on the implementation of development models established in strategic development programmes and plans and in land management instruments, as well as the degree to which the applicable constraints and restrictions are affected. This assessment also considers the land use for the Project.

11.12.1 Construction Phase

The construction phase of the Project represents a set of spatially and temporally limited activities that may have effects on land use planning and associated constraints. This section addresses the possible impacts resulting from the site establishment, drilling operations and construction of the injection well (approximately 1,800 m), for six months, 24 hours a day. The following parameters will be assessed:

- Contribution to the fulfilment of the development models;
- Land occupation, possible conflict with the development of housing areas;
- Disturbance of the roads;
- Land use planning restrictions; and
- Civil aviation sensitivity.

11.12.1.1 Development Models

During the construction phase, the Project is expected to lead to a positive and direct impact on job creation, which is one of the objectives stipulated in the provincial and municipality development plans. However, the number of employment opportunities expected to be created is limited (creation of a small number of jobs with minor impact on the local community) of a certain duration (in the construction period). It is also expected that preference will be given to local communities. The classification of the potential impact regarding the fulfilment of local development models in the construction phase is presented in the table below.

Table 88: Construction phase impacts - fulfilment of the development models

Dimension	Assessment
Nature	Positive
Directionality	Direct
Extent	Regional
Duration	Short-term
Intensity	Low
Probability	Definite
Significance	Low

11.12.1.2 Land Occupation

Accoring to the Local Spatial Framework (Figure 75), the implementation area falls within a zone in the "Future Development" land use category. In accordance with the Integrated

Housing Strategy the project implementation area is located in a housing development area in the period 2019 to 2034. The occupation of the study area for the construction phase will therefore have a direct and negative impact by precluding housing development (restricted to the boundaries of the implementation area) during the construction phase. However, it is expected that this impact will not affect local development as it will occur in a limited space and in a short period of time compared to that foreseen in the Integrated Housing Strategy. In other words, the development of the area can start after the end of the Project, and it is possible to implement the project phases. The assessment of the potential impact regarding the land occupation in the construction phase is presented in the following table.

Table 89: Construction phase impacts - land occupation

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On-site
Duration	Short-term
Intensity	Low
Probability	Definite
Significance	Low

11.12.1.3 Disturbance of the Roads

During the construction phase equipment and structures will have to be transported to the project implementation area. It is expected that during the construction phase more vehicles will circulate compared to the reference situation. However, it is not expected that the increase in flow will be significant and as such, that there will be no impact on the circulation of other users (null impact).

11.12.1.4 Land Use Planning Restrictions

As discussed in Section 10.11.3.6 above, there are no land use planning restrictions for the project area. Hence, the impact of the Project is null regarding possible constraints.

11.12.1.5 Civil Aviation Sensitivity

As discussed in Section 10.11.3.7, the Screening Tool identified high sensitivity in terms of civil aviation in the project area, and any equipment that exceeds 15 m in height may constitute an obstacle to aviation. An obstacle to aviation is a direct negative impact.

As mentioned, it is anticipated that the drilling equipment to be used during the construction phase will be the highest feature on the site. It is not expected that the respective equipment will exceed 15 m in height, however if it does the impact caused by this will affect the aircraft circulation, which can be adapted but with difficulties. The classification of the potential impact regarding the civil aviation sensitivity in the construction phase is presented below.

Table 90: Construction phase impacts - civil aviation sensitivity

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On-site
Duration	Short-term
Intensity	Medium
Probability	Unlikely
Significance	Low

11.12.2 Operational Phase

The operational phase of the Project represents a set of procedures that are also spatially and temporally limited, but which may have effects on land use and spatial planning. This section addresses the possible impacts resulting from the CO_2 capture, transportation, and injection, for 24 months. The following parameters will be assessed:

- Contribution to the fulfilment of the development models;
- Land occupation, possible conflict with the development of housing areas;
- Disturbance of the Provincial Route R29; and
- Land use planning restrictions.

11.12.2.1 Development Models

During the construction phase it is expected that the Pilot Project will contribute to the achievement of the following objectives stipulated by the development programmes and strategies: local job creation, affects mainly the municipality; reduction of the carbon footprint, by capturing carbon dioxide that would otherwise be released into the atmosphere, meaningful for the district municipality and province; and scientific development (technology and innovation) and eco-innovation, assists at national level.

The contribution of the operational phase for job creation and for the reduction of the carbon footprint will be limited and only occur during a short period (only a few employment opportunities and CO_2 emission reductions). As for technology development, the knowledge acquired during the execution of the Project will endure, contributing to the development of similar larger projects at national level. The classification of the potential impact regarding the fulfilment of local development models in the operational phase is presented in the table below.

Table 91: Operational phase impacts - development models

Dimension	Assessment
Nature	Positive
Directionality	Direct
Extent	Regional/National
Duration	Short-term/Permanent
Intensity	Low/High
Probability	Definite
Significance	Low/High

11.12.2.2 Land Occupation

Similar to the impact on land use during the construction phase, the occupation of the study area for the operational phase will preclude the Integrated Housing Strategy for the 2019-2034 period. The difference is that the construction phase is expected to take 24 months. However, and in view of the possible period of the strategy implementation, it is anticipated that the municipality can easily adapt the timing of the housing development actions that will take place in the project area. The classification of the potential impact regarding the land occupation (possible conflict with the development of housing areas) in the operational phase is present in following table.

Table 92: Operational phase impacts - land occupation

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On-site
Duration	Short-term
Intensity	Low
Probability	Definite
Significance	Low

11.12.2.3 Disturbance of the Provincial Route R29

For the execution of the operational phase two to six large trucks are expected to travel on the Provincial Route R29 daily (for the transport of cryogenic CO_2). As no disruption to normal traffic is expected, the impact is considered to be null.

11.12.2.4 Land Use Planning Restrictions

There are no land use planning restrictions for the project area, as such, the impact of the project is null with regard to possible constraints.

11.12.3 Decommissioning Phase

This section addresses the possible impacts resulting from the dismantling of site infrastructure. The following factors will be assessed:

- Disturbance of the roads; and
- Change of the projected local development.

11.12.3.1 Traffic Disturbance

During decommissioning, equipment will have to be transported to the project implementation area for site dismantling. Thereafter, equipment and structures will be removed from the site. It is expected that during the decommissioning phase more vehicles will circulate compared to the situation at present. However, the increased flow is not expected to affect the normal traffic on the roads, so this impact will be null.

11.12.3.2 Change of the Projected Local Development

After decommissioning, the area is to be completely restored, becoming available for the implementation of other activities (e.g., compliance with the Integrated Housing Strategy). It is also anticipated that carbon injection will not alter soil quality in the implementation area and areas of influence. However, if there is a change in the soil quality of these areas it may affect the future use of these areas, thus changing the projected local development.

In the case of an area where residential development is planned, it is not anticipated that the change in soil quality will alter local planning (as is the case in the project area), and as such there will be no perceptible changes to the community. However, in areas where agricultural activities are planned/occurring, the change in soil quality (soil degradation) will affect/terminate production, forcing those affected to adapt, but with difficulties, as the soils in the surrounding area already have low agricultural potential.

The classification of the potential impact regarding the change of the projected local development in the decommissioning phase is present in following table.

Table 93: Decommissioning phase impacts - change of the projected local development

Dimension	Assessment
Nature	Negative

Dimension	Assessment
Directionality	Indirect
Extent	Local
Duration	Permanent
Intensity	Negligible/Medium
Probability	Unlikely
Significance	Negligible /Low

11.12.4 Summary

In terms of spatial planning and land use, the following impacts are expected during the construction, operation, and decommissioning phases:

- Alignment with development models/objectives: the impacts of the project on the achievement of local development objectives, which include job creation, carbon footprint reduction and technological development, are positive, direct, regional, or national, of short duration or permanent, low to high intensity, definitive and with a minor to major significance;
- Land occupation: the Pilot Project prevents housing development in the area where the Project is to be implemented during the construction and operation phases, postponing local development, and causing definitive direct negative impacts on the site of short duration, low intensity, and minor significance;
- Traffic disturbance: the Project does not impact the normal circulation of vehicles on the roads near the project area;
- Land use planning restrictions: There are no restrictions on land use in the project area, so there are no impacts relative to local land use constraints;
- Civil aviation sensitivity: during the construction phase, the project's drilling equipment may constitute an obstacle to aviation and as such affect normal air traffic. It is a direct negative impact, of short-term, of medium intensity, with low probability of occurrence (unlikely) and minor significance; and
- Change of the projected local development: changes in soil quality may affect local development plans, thus the Project may cause negative, indirect, local, permanent impacts, of negligible/medium intensity, but unlikely to occur and with negligible to minor significance.

11.13 Socio-Economic Environment and Public Health

11.13.1 Construction Phase

11.13.1.1 Generation of employment and income

Given that unemployment is very high and there is a lack of employment opportunities in the region, job creation is perceived by the people of Leandra as one of the main benefits associated with the Project.

However, it is expected that the labour required for the construction phase will be between 12 to 18 people, including the guards and the drilling team. Even though, the labour required at this stage may increase over the course of the Project, it is still very limited.

Moreover, the need for skilled labour could result in employment of outside workers, which will not benefit the local population.

Therefore, in the construction phase, the creation of employment opportunities is of negligible significance due to the low number of labour required at this stage and the duration of the impact (6 months). With enhancement measures related with the hiring of local people the impact can be of low significance.

Table 94: Construction phase impact: Generation of employment and income

Dimension	Assessment
Nature	Positive
Directionality	Direct
Extent	Regional
Duration	Short-term
Intensity	Low
Probability	Definite
Significance (without enhancement)	Negligible
Significance (post-enhancement)	Low

11.13.1.2 Security threats

There are negative impacts related to the risk of security threats to workers and theft or vandalism of the Project's equipment and construction site. As previously analysed, the high unemployment rate and high incidence of drug abuse in the study area, lead to a high prevalence of crime, theft and damage of private property.

This impact is of high significance given the instability and crime risks in the project area. However, the construction site will be fully fenced and other safety measures will be recommended to mitigate this impact. Therefore, with mitigation measures, this impact is of moderate significance.

Table 95: Construction phase impact: Security Threats

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Short-term
Intensity	Medium
Probability	Likely
Significance (without mitigation)	High
Significance (post-mitigation)	Moderate

11.13.1.3 Impact on the health and quality of life of local communities

The emission of dust resulting from the drilling and other emissions from the handling of construction material and the movement of construction machinery, will degrade air quality.

Also, the drilling is a noisy activity which will be carried out 24 hours a day for 6 months. During public consultation, noise from drilling work was listed as one of the largest concerns of the population. Moreover, the Project will require light fixtures to allow work at night.

However, only a small number of dwellings are within the Project's direct area of influence and even these are at a distance of more than 800 m from the site. The impact of the Project in terms of noise and air quality were further analysed in Section 11.9.2 and Section 11.9.3 above, respectively.

The impact of the Project on people's health and quality of life during the construction phase is expected to be of low significance.

Table 96: Construction phase impact: Health and quality of life of local communities

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Short-term

Dimension	Assessment
Intensity	Medium
Probability	Definite
Significance (without mitigation)	Low
Significance (post-mitigation)	Low

1.1.1. Operational Phase

11.13.1.4 Generation of employment, income, and skills

As indicated above, one of the major benefits of the Project perceived by the local community is job creation. It is estimated that during the operational phase, the labour required will be between 10 and 20 people, including the guard, operators, and technicians. The labour required at this stage of the Project may increase over the course of its implementation.

Even though unemployment is very high and there is a lack of employment opportunities in the region, the creation of employment is of low to moderate significance (with enhancement measures) due to the few number of employment opportunities that will be created. The impact will last throughout the operational phase, which is estimated to last 2 years.

Additionally, the Project is expected to create some long-term benefits for local contractors as well as their employees through capacity building and the acquisition of skills (spill over effects). This is a pilot project and, thus, the skill set obtained if the Project is successful will be highly valued, as there will not be many contractors and employees with experience in similar projects.

Table 97: Operational phase impact: Generation of employment, income, and skills

Dimension	Assessment
Nature	Positive
Directionality	Direct
Extent	Regional
Duration	Long-term
Intensity	Low
Probability	Definite
Significance (without enhancement)	Low
Significance (post- enhancement)	Low to moderate

11.13.1.5 Investment in the local economy

The investment of the Project is expected to boost the local economy through direct demand related to the implementation of the Project, namely transport companies, construction companies, catering companies, water supply and other services. As such, the use of local suppliers may contribute to the diversification of local employment opportunities and economic development.

Taking into consideration that the economy is shrinking and has a negative average annual economic growth, the investment in the local economy is expected to be of low to moderate significance with a post-enhancement measure.

Table 98: Operational phase impact: Investment in the local economy

Dimension	Assessment
Nature	Positive
Directionality	Direct & Indirect
Extent	Regional
Duration	Long-term
Intensity	Medium
Probability	Definite
Significance (without enhancement)	Low
Significance (post-enhancement)	Low to Moderate

11.13.1.6 Security threats

The impact related to security threats analysed for the construction phase also applies to the operational phase.

Similarly, there is a risk to the workers' safety as well as a risk of theft or vandalism of the Project's equipment and injection site.

This impact is of high significance given the instability and crime risks in the Project's indirect area of incidence. However, with mitigation measures, the significance of this impact becomes moderate.

Table 99: Operational phase impact: Security Threats

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Long-term
Intensity	Medium
Probability	Likely

Dimension	Assessment
Significance (without mitigation)	High
Significance (post-mitigation)	Moderate

11.13.1.7 Increase in road traffic

During the operational phase, there will be an increase in traffic movement of trucks with 20-tonne tankers along the Provincial Route R29. It is estimated that the project will need 2 to 6 trips per day between the Sasol Secunda Plant and the Project's site during the 2 years of the operational phase. The increase in movement of vehicles may result in greater disturbance and decreased wellbeing for those communities closest to the working area and along the transportation route.

The region of the Project has intensive mining, manufacturing, and petrochemical activities and, thus, the R29 already has truck traffic. Therefore, the increase in road traffic caused by the Project will be of low significance.

Table 100: Operational phase impact: Increased Road traffic

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Long-term
Intensity	Low
Probability	Definite
Significance	Low

11.13.1.8 Impact on the health of local communities

During the operational phase of the Project, there may be smaller or larger scale storage leakages, which are further analysed in Section 11.17 below, with potential harmful impacts for the health of local communities.

Even though the smaller scale storage site leakages are likely to occur, they are of low significance due to its dispersion over time and space, which are not likely to meaningfully harm people.

A large-scale storage leakage is unlikely to occur with the adoption of best practice measures in the workplace. However, if an accidental large-scale release happens, the leakage of CO_2

may form a heavier-than-air cloud with a concentration high enough to harm people and degrade air quality.

The effects of the degradation of air quality can be manifested through the increased incidence of respiratory and cardiovascular diseases.

Even though the intensity of a large-scale storage leakage is high, as those affected may suffer serious health consequences, it is unlikely to occur. Hence, the impact is of moderate significance. With mitigation measures, the impact can be of low significance.

Table 101: Operational phase impact: Health of local communities

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local
Duration	Long-term
Intensity	High
Probability	Unlikely
Significance (without mitigation)	Moderate
Significance (post-mitigation)	Low

11.13.1.9 Public opposition to the Project

Due to the risk of accidental releases of CO_2, there may be public opposition to the Project, which may lead to social instability and increase the security threats.

Additionally, if the Project's benefits do not meet expectations, the public opposition to the Project may increase. During public consultation, the need for job creation was emphasised by the community as one of the expected main positive benefits of the Project. However, as previously analysed, the labour required will be very limited. Thus, it is important to manage the expectations of the community.

Given that riots and vandalism of property are common in the study area, the public opposition to the Project is a negative impact of moderate significance.

Table 102: Operational phase impact: Public Opposition to the Project

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Local

Dimension	Assessment
Duration	Long-term
Intensity	Medium
Probability	Unlikely
Significance (without mitigation)	Moderate
Significance (post-mitigation)	Low to Moderate

11.13.1.10 Impacts on workers' health and safety

The Project is associated with a risk to the safety of workers, who will be dealing with a dangerous substance both during transport and storage. It is expected that workers will be trained for the health and safety standards of their work and that health and safety measures are imposed in the Project's DAI. Therefore, with mitigation measures, the significance of this impact is expected to be low.

Table 103: Operational phase impact: Workers' health and safety

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	Regional
Duration	Long-term
Intensity	Medium
Probability	Likely
Significance (without enhancement)	Moderate
Significance (post- enhancement)	Low

11.13.2 Decommissioning Phase

The activities in the decommissioning phase are not expected to generate socio-economic or human health impacts.

11.13.3 Pilot Project and Associated Potential Impacts

It should be noted that this Project is a pilot project that is meant to be adopted at a larger scale, if successful. Therefore, each positive socio-economic impact analysed has the possibility of being amplified if the Project is successful and has associated future benefits.

It is relevant to mention that the region of the Project has high levels of unemployment, a lack of employment opportunities, high poverty rates and inequality as well as low economic growth. Although the impact of this Project in employment and investment is low, if successful, it will open the possibility for future larger projects in the region, with greater positive impacts on employment, income, and economic growth.

Furthermore, while this Project does not capture enough CO_2 to improve the region's air quality, if there are more CCS projects with larger scales, they can significantly improve air quality, with a direct benefit to human health, particularly in respiratory and cardiovascular diseases.

SA's economy is supported by large scale coal-based energy system (Dhansay, et al., 2022), which is responsible for a relevant part of employment and growth. However, to comply with the Paris Treaty and international pressure to reduce carbon emissions, SA will have to reduce CO_2 emissions. CCS can be a way to reduce emissions without jeopardizing growth and employment. This Project plays an important role in testing the CCS technology.

These indirect impacts of the Project are likely to occur as there are already two pilot projects that were successful in testing CCS technology in basaltic formations, namely CarbFix at the Hellisheidi geothermal power plant in Iceland and Wallula in the Columbia River plateau, in the United States (Kamrajh, Hicks, & Dhansay, 2022).

The potential positive impacts are highly significant for the socio-economic context of the region (job creation, boost of employment, improve in air quality). Additionally, there are highly significant impacts at the national level related to the compliance with international treaties and reducing CO_2 emissions.

However, currently CCS technology is expensive and can exert pressure on the energy price in SA if adopted at a larger scale. While CCS is an efficient mechanism to reduce emissions in the short-term, additional policies and programs should be implemented to reduce CO_2 emissions in the transition to a low emissions economy, namely investments in solar and wind energy.

Table 104: Overall project impact: Pilot project and associated potential impacts

Dimension	Assessment
Nature	Positive
Directionality	Indirect
Extent	National
Duration	Permanent
Intensity	High
Probability	Likely
Significance	High

11.13.4 Summary

During the construction and operational phases, there will be job creation, albeit limited, which are positive impacts of low significance. During the two phases, it is still expected a negative impact related to security threats, which is of moderate significance with mitigation measures.

In the construction phase, dust, drilling noise and light fixtures will negatively impact the health and quality of life of local communities. However, due to the large distance between the construction site and households, the impact is of negligible significance with mitigation measures.

In the operational phase, there is a positive impact of moderate significance related to the investment in the local economy through direct demand related to the implementation of the Project.

During the operational phase, most of the socio-economic impacts of the Project are negative. First, there will be an increase in road traffic, which is expected to be of low significance. There will also be an impact on the health of local communities related to the risk of leakages of CO_2, which is a low significance impact with mitigation measures. Moreover, there may be public opposition to the Project, which is an impact of moderate significance. The impact on workers' health and safety is of low significance with the adoption of mitigation measures.

Lastly, it is important to note that the most beneficial positive impact of the Project is that this is a pilot project, which will test a technology, and, if successful, is meant to be amplified with potential future positive impacts in employment, income and economic growth as well as in the health of the population through improvements in the region's air quality. Furthermore, the Project may be a way for SA to comply with international environmental treaties while not giving up on its coal-based economic growth. The potential impacts associated with this pilot project are highly significant.

11.14 Cultural Heritage

An extract from the Heritage Impact Assessment (Kitto, 2023) (contained in Appendix D3) follows below.

The impact significance of the proposed Project on protected historical structures is low (with mitigation). Two extant historical structures and two sites with possible historical structure remains were identified, either on or just outside the southern boundary of the proposed injection site. These sites are avoidable.

The impact significance of the Project on graves is low (with mitigation). A potential grave site was identified as possibly located within or just outside the eastern boundary of the proposed injection site. This site is avoidable

The impact significance of the Project on intangible and living heritage resources is negligible as no living heritage sites were identified within or adjacent to the proposed injection site.

The impact significance of the proposed Project on archaeological resources is negligible to low as no archaeological sites or material were identified within or adjacent to the proposed Injection site.

Table 105: Construction phase impacts on Heritage Resources Historical Structures

Dimension	Assessment
Nature	Negative
Directionality	Indirect
Extent	On-site
Duration	Permanent
Intensity	High
Probability	Likely
Significance (without mitigation)	High
Significance (with mitigation)	Low

Table 106: Construction phase impacts on Heritage Resources Potential Grave/s

Dimension	Assessment
Nature	Negative
Directionality	Direct
Extent	On-site
Duration	Permanent
Intensity	High
Probability	Likely
Significance (without mitigation)	High
Significance (with mitigation)	Low

The operational and decommissioning phases of the Project are not expected to affect the identified heritage resources.

11.15 Impacts assessment summary

Considering the information provided in this section, Table 107 below provides a consolidated overview of the activities that could potentially cause impacts, based on the findings of the various specialist studies that were undertaken for the Project.

Table 107: Identification of activities that potentially cause impacts

Phase	Construction				Operational			Decommissioning	
Activity	Site Establishment	Drilling	Operational area construction	Project Implementation	CO_2 Transportation	CO_2 Injection and Storage	Project Implementation	Dismantling and recovery	Borehole sealing
Climate and meteorology							X		
Geology and Topography	X	X				X			
Soils	X	X	X			X		X	
Groundwater Hydrology			X				X	X	
Surface Hydrology		X		X		X	X	X	
Waste Management	X	X	X				X	X	X
Landscape and Light Pollution		X							
Noise and Vibrations	X	X	X		X	X		X	X
Air Quality	X	X	X		X	X	X		
Fauna and Flora	X	X	X		X			X	X
Sensitive Habitats	X	X	X		X			X	X
Land Use/Spatial Planning				X			X	X	
Socioeconomics/Public Health		X		X	X		X		

Table 108 below provides a summary of the impacts identified throughout this section. Impacts classified as negligible after the implementation of mitigation measures are not included in the table. It should be noted that all impacts classified as negligible have acceptable risk levels.

Table 108: Overall Impact Assessment

Impact	Phase	Signal	Directionality	Extent	Duration	Intensity	Probability	►	Significance [7]	Risk level[8]
CLIMATE AND METEOROLOGY										
Reduction of the CO_2 in the atmosphere	Operational	Positive	Indirect	Regional	Permanent	Low	Definite	►	Low	N/A
SOILS										
Pollution/contamination of the soil	Construction	Negative	Direct	On site	Permanent	Medium	Unlikely	►	Low	Low
Soil replacement	Decommission	Positive	Direct	On site	Permanent	Low	Definite	►	Low	N/A
GROUNDWATER HYDROLOGY										
Potential risk of groundwater quality degradation	Operational	Negative	Indirect	On Site	Temporary	Low	Unlikely	►	Low	Low
Changes in groundwater flow	Operational	Negative	Indirect	On Site	Permanent	Low	Unlikely	►	Low	Low
Potential risk of groundwater quality degradation	Decommission	Negative	Indirect	On Site	Temporary	Low	Unlikely	►	Low	Low
SURFACE HYDROLOGY										
Impacts from exposure to contamination	Operational	Negative	Indirect	Local	Short-term	Low	Unlikely	►	Low	Low
Impacts from increased service demand	Operational	Negative	Direct	Regional	Short-term	Low	Definite	►	Low	Moderate

[7] Considering the significance post-mitigation. It should be noted that for some impacts, the significance presented does not consider the implementation of mitigation measures, as they are not applicable.

[8] Considering Table 43: Definition of the risk level.

Impact	Phase	Signal	Directionality	Extent	Duration	Intensity	Probability	►	Significance [7]	Risk level[8]
Legacy impacts on surface hydrology through potential indirect leaks	Decommission	Negative	Indirect	Local	Long-term	Low	Unlikely	►	Low	Low
WASTE MANAGEMENT										
Impacts of non-hazardous waste sent to landfill	All Phases	Negative	Direct	Regional	Permanent	Low	Definite	►	Low	Moderate
Impact of hazardous waste sent to landfill	All Phases	Negative	Direct	Regional	Permanent	Medium	Unlikely	►	Low	Low
LANDSCAPE AND LIGHT POLLUTION										
Light Pollution (night-time) – Biophysical Environment	Construction	Negative	Direct	Local	Short-term	Low	Definite	►	Low	Moderate
NOISE AND VIBRATIONS										
Noise impact in socio-economic environment at night-time and biophysical environment.	Construction	Negative	Direct	Local	Short-term	Low	Definite	►	Low	Moderate
AIR QUALITY										
Air quality deterioration due to concentrated release of CO_2	Operational	Negative	Direct	Local	Temporary	Low to Moderate	Unlikely		Low to moderate	Low
Air quality deterioration due to gradual leakage of CO_2	Operational	Negative	Direct	Local	Long-term	Low	Likely		Low	Low
FAUNA AND FLORA										
Disturbance and deterioration of fauna populations, release of CO_2	Operational	Negative	Direct	Regional	Long-term	Low to high	Unlikely	►	Low to moderate	Low
Restoration of the habitats	Decommission	Positive	Indirect	On site	Long-term	Low to high	Likely	►	Low to high	N/A
LAND USE AND SPATIAL PLANNING										
Fulfilment of the development models	Construction	Positive	Direct	Regional	Short-term	Low	Definite	►	Low	N/A
Land occupation	Construction	Negative	Direct	On site	Short-term	Low	Definite	►	Low	Moderate
Civil aviation sensitivity	Construction	Negative	Direct	On site	Short-term	Medium	Unlikely	►	Low	Low
Fulfilment of the development models	Operational	Positive	Direct	Regional / National	Short-term / Permanent	Low/High	Definite	►	Low to High	N/A
Land occupation	Operational	Negative	Direct	On site	Short-term	Low	Definite	►	Low	Moderate

Impact	Phase	Signal	Directionality	Extent	Duration	Intensity	Probability	►	Significance [7]	Risk level[8]
Change of the projected local development	Decommission	Negative	Indirect	Local	Permanent	Negligible / Medium	Unlikely	►	Negligible to Low	Acceptable / Low
SOCIOECONOMICS AND PUBLIC HEALTH										
Generation of employment and income	Construction	Positive	Direct	Regional	Short-term	Low	Definite	►	Low	N/A
Security threats	Construction	Negative	Direct	Local	Short-term	Medium	Likely	►	Moderate	Moderate
Impact on the health and quality of life of local communities	Construction	Negative	Direct	Local	Short-term	Medium	Definite		Low	Moderate
Generation of employment, income and skills	Operational	Positive	Direct	Regional	Long-term	Low	Definite	►	Low to moderate	N/A
Investment in the local economy	Operational	Positive	Direct & Indirect	Regional	Long-term	Medium	Definite	►	Low to moderate	N/A
Security threats	Operational	Negative	Direct	Local	Long-term	Medium	Likely	►	Moderate	Moderate
Increase in road traffic	Operational	Negative	Direct	Regional	Long-term	Low	Definite	►	Low	Moderate
Impact on the health of local communities	Operational	Negative	Direct	Local	Long-term	High	Unlikely	►	Low	Low
Public opposition to the project	Operational	Negative	Direct	Local	Long-term	Medium	Unlikely	►	Low to moderate	Low
Impacts on workers' health and safety	Operational	Negative	Direct	Regional	Long-term	Medium	Likely	►	Low	Low
Pilot project and associated potential impacts	Not applicable	Positive	Indirect	National	Permanent	High	Likely	►	High	N/A

11.16 Cumulative Impacts

Table 109 lists the relevant Plans, Strategies and/or Projects that were considered in the cumulative impacts assessment conducted by the specialists (taking also into consideration the information of the Screening Tool).

Table 109: Plans and projects that may lead to cumulative impacts

Incentive, restriction, or prohibition	Overall objective	Project involvement
Air Quality-Highveld Priority Area Management Plan	The overall objective is to guarantee that the ambient air quality in the Highveld Priority Area complies with all national ambient air quality standards (Department of Environmental Affairs, 2011)	Mpumalanga Province is included in the Highveld Priority Area. The general objectives of the Pilot CO_2 Storage Project contribute positively to the implementation of this plan. **Study involved:** Air Quality
Strategic Gas Pipeline Corridors-Phase 8: Rompco Pipeline Corridor	Identification of geographical areas important for the development of the strategic gas transmission pipeline infrastructure within South Africa (Department of Environment, Forestry and Fisheries, 2021)	The project area is included in the Strategic Gas Pipeline Corridors. Overall, this project is not expected to have an impact on the implementation of the Pilot CO_2 Storage Project. **Study involved:** Land Use and Spatial Planning.
Integrated Housing strategy (2019-2034)	Considering the future demand for housing, the main objective is to develop an integrated housing in the different development nodes for a 20-year planning period up to 2034 (GMLM, 2014).	Leslie and Lebohang are included in the Integrated Housing Strategy. The simultaneous implementation of the strategy and the Pilot CO_2 Storage Project may lead to cumulative impacts. **Study involved:** Waste Management

Based on the above, the possible cumulative impacts are listed in Table 110 below.

Table 110: Cumulative impacts

Environmental Factor	Cumulative Impacts
Climate and meteorology	No potential cumulative impacts are expected.
Geology and Topography	No potential cumulative impacts are expected.
Soils	No potential cumulative impacts are expected.
Groundwater Hydrology	No potential cumulative impacts are expected.
Surface Hydrology	The identified impacts occur to varying degree throughout project phases and include: • Potable and process water demands; • Wastewater collection and treatment demands; • Potential direct contamination of surface water or indirect contamination through groundwater connections.

Environmental Factor	Cumulative Impacts
	Overall, the identified impacts are cumulative with the existing pressures and local users for water and wastewater services. The local hydrological ridge characteristics point to these cumulative effects being felt mostly downstream from the study area, where the confluence of effluents from regional pressures further constraint water resource quality and quantity.
Waste management	There is a potential cumulative impact on the production and management of construction and demolition waste with the development of the Integrated Housing Strategy of GMLM. However, due to the existence of two licensed and operational landfill sites in GMLM, waste management services are not expected to be affected. This is also expected to be unaffected as there is a long period (until 2034) over which the Integrated Housing Strategy will be implemented. The project area also intersects with the Strategic Gas Pipeline Corridors - Phase 8: Rompco Pipeline Corridor. As such, construction of the underground gas pipeline may occur in the vicinity of the project area. Significant volumes of construction and excavation waste will be generated during the installation of the pipeline. However, there is no estimated start date for the installation of the gas corridor as it is still under study. Therefore, the Project is not expected to have cumulative impacts on waste management.
Landscape and Light Pollution	There are no known projects in operation or under development in the immediate vicinity of the project area during the night period. Therefore, no potential cumulative impacts are expected.
Noise and Vibration	The identified noise impacts are cumulative with other noise sources such as traffic on transport corridors, construction works that may occur in the study area (2 km buffer) and other human activities in the vicinity. However, these impacts will be temporary, and the noise levels generated by the Project are not expected to significantly increase the existing noise levels at Leandra. In terms of vibration, cumulative impacts are expected with the circulation of vehicles on the road, with the passage of the train on the railway line. However, the addition of the vibrations caused by the Project is not expected to cause additional impacts compared to the existing situation. Therefore, no potential cumulative impacts are expected.
Air Quality	No potential cumulative impacts are expected.
Fauna and Flora	Impacts from oil leakage and contamination due to vehicle and machinery use are cumulative with the contamination that already occur in the region due to the vehicle traffic in the surrounding areas and the human presence. Impacts from noise are also cumulative with noise from traffic and urban settlements. Given the project scale, the cumulative impacts are assessed as having low significance.
Sensitive Habitats	No potential cumulative impacts are expected.
Land Use and Spatial Planning	No potential cumulative impacts are expected in terms of spatial planning and land use associated with other projects to take place in the municipality, namely the Strategic Gas Pipeline Corridors-Phase 8: Rompco Pipeline Corridor and the Integrated Housing strategy.
Socioeconomics and Public Health	No potential cumulative impacts are expected.
Cultural Heritage	No potential cumulative impacts are expected.

11.17 CO_2 Leakage Risk Assessment

11.17.1 Introduction

Given the nature, activities, and purpose of the Project, there are potential risks that should be paid special attention to. The main potential risks are related to the possibility of CO_2 leakage, which may occur throughout the CO_2 system. In general, the following two types of leakage can be distinguished:

- Large scale storage leakage - for example, from an injection well failure, or a transportation system failure; and
- Smaller scale storage site leakages - for example, from geological faults (associated with the nature of the rock mass or induced) or leaking wells.

These two types of leakage can result in:

- Large scale storage leakage - CO_2 might form a heavier-than-air cloud with concentrations high enough to harm people and wildlife; and
- Smaller scale storage site leakages - gradual, diffuse release of CO_2 that may go unnoticed, and impact, soil, water, and flora through acidification.

Overall, this risk, that may result mainly from the operational phase, can pose health and safety risks and environmental impacts, as can be seen from the impact assessment carried out in Section 11.13.1.8 above. The following potential impacts are note:

- Deterioration of air quality;
- Deterioration/contamination of groundwater and surface water quality;
- Deterioration of fauna populations; and,
- Impacts on the health and safety of the population.

11.17.2 Large Scale Storage Leakage

The large-scale release of CO_2 is mainly associated with accidents. The potential for accidents involves:

- Accidents in the operational area, mainly related to the rupture of the injection pipeline, rupture of the cryogenic storage tanks and leaks during the injection process (through the injection wells); and
- Accidents during transport, mainly associated with rupture of the truck storage tanks.

For an assessment of the risk, it is essential to consider the quantities of CO_2 that are involved in this process.

- Accidents in the operational area - for the present evaluation the following is considered:
  - Rupture / leakage in the pipeline and injection holes - the injection should be at least 40 tons per day, considering the injection target of 10,000 tons of CO_2 at the end of two years, up to, approximately 100 tons per day, considering 50,000 tons.
  - Rupture in cryogenic tanks - the storage per tank is, at most, 100 tons.
- Accidents during transportation - for the present assessment it is considered that:
  - Rupture / leakage of the storage tanks of the trucks - the transport capacity per truck is 20 tons.

The release of large quantities (especially considering the maximum quantities associated with each risk, 100 tons and 20 tons, respectively) may be associated with a high significance of environmental and human health factors. Regarding human health, it should be noted that, according to the IPCC *“A concentration of CO_2 greater than 7–10% in air would cause immediate dangers to human life and health”* (IPCC, 2005).

However, with the implementation of best practice and mitigation measures, presented in Section 13, the likelihood of occurrence is expected to be unlikely.

11.17.3 Smaller Scale Storage Site Leakages

Regarding the potential for CO_2 leakage over time, the IPCC, despite being more directed towards the study of storage in saline formations, indicates the following:

“With regard to global risks, based on observations and analysis of current CO_2 storage sites, natural systems, engineering systems and models, the fraction retained in appropriately selected and managed reservoirs is very likely (probability of 90 to 99%) to exceed 99% over 100 years, and is likely to exceed 99% over 1000 years. Similar fractions retained are likely for even longer periods of time, as the risk of leakage is expected to decrease over time as other mechanisms provide additional trapping.”

Additionally, the article "Bearing the Cost of Stored Carbon" makes a brief approach with regard to the potential for CO_2 leakage making reference to a maximum potential for CO_2 leakage of 0.1% per year of what is injected, i.e. 1% after 10 years of injection (Vinca, *et al*., 2018).

On the other hand, it is also necessary to consider the factors discussed Section 5.7, where it is stated that according to the two pilot projects based for the development of the present Project (CarbFix and Wallula) the mineralization process should end after two years of injection.

Therefore, considering the following:

- Maximum injection quantity between 10,000 and 50,000 tons;
- Maximum mineralization time of 4 years (counting two years of injection and two years after the end of the operational phase to ensure that the mineralization process occurs); and
- Leak reference of 0.1% per year;

The potential for leakage until the mineralization process is expected to be complete could be between 10 and 50 tons per year and thus a total of 40 to 200 tons considering the 4 years since the beginning of the operational phase.

This release, which should be monitored in terms of its dispersion over time and space, is assessed as being of low significance and likely to occur.

It should be noted that the spatial dispersion of CO_2, in the event of a leak, is expected to occur easily, since the project area is flat with no obstacles to dispersion. Additionally, there is little population occupation of the project's area of influence.

11.17.4 Risk Assessment

The risk assessment is presented below.

Table 111: CO_2 Leakage risk assessment

Determination of the risk level			
Risk	**Severity (Significance)**	**Likelihood (Probability)**	**Risk Level**
Large scale storage leakage	High	Unlikely	Moderate
Smaller scale storage site leakages	Low	Likely	Low

For further details a simulation of the air quality is presented in Appendix D5.

12 IMPACT MITIGATION

12.1 Introduction

Following the environmental impact assessment carried out in Section 11 above, this section identifies the measures that should be adopted to mitigate the Project's negative environmental impacts and enhance the positive impacts.

The primary goal of the measures is to implement the Project in the most environmentally optimal manner to safeguard the interests of the community and the biophysical environment. The purpose is that no high significance impacts occur after mitigation measures have been implemented and that all residual impacts are of low significance or negligible.

12.2 General Measures

12.2.1 Construction Phase (Best Practice Measures)

The measures outlined below are best practice measures and result from the various sensitivities identified during the Basic Assessment. A single measure can be advantageous for a wide range of environmental factors and should therefore be the foundation for the development of any construction project. Being primarily related to construction phase activities, it is thus intended to be integrated into the EMPr to ensure the effective implementation of the Project. Below are examples of good practices that should be reflected in project development.

Pre-Construction Phase

- Communication of the construction works to the stakeholders, namely in the surrounding area.
- Implementation of a grievance redress mechanism to address concerns and complaints.
- Provide environmental training and awareness-creation for the Project team and workers involved in the construction phase.
- Schedule the execution of the construction phase with a view to reducing the level of disturbance to fauna.
- Implement the EMPr (contained in Appendix F).

Site Establishment

- The infrastructure to be developed should have close access to avoid or minimize earth movement and fauna disturbance.

- The occasional destruction of vegetation cover for site establishment must be limited to strictly necessary areas.
- Minimize the disturbance caused by the access opening within the Project Implementation Area, minimizing land occupation outside the areas that will be subsequently occupied by the access.
- Provide adequate signage and fencing at the Project Implementation Area.
- The parking area must be paved and equipped with an effective system of storm water run-off control.

Drilling and Operational Area Construction

- The occasional destruction of vegetation cover, cleaning and soil removal for these activities must be limited to strictly necessary areas.
- Once the topsoil is stripped off, ensure it is stored properly for later reuse during the decommissioning phase.
- Plant biomass and other waste must be removed and properly handled for final disposal, giving priority to its reuse.
- The materials produced as a result of the drilling operation should be stored in a dedicated stockpile until final disposal.
- Ensure that methods and equipment are chosen with consideration to minimizing noise and dust generation (mainly in the drilling operation).
- Ensure that all existing equipment and machinery is in good condition and regularly maintained.
- All construction vehicles should adhere to a low-speed limit to avoid dust emission and collisions with susceptible species.

Waste Management

- Implement a Waste Management Plan (included in the EMPr).
- Ensure the correct temporary storage of waste produced, according to its type and in accordance with the prevailing legislation. Containment/retention of possible spills must be anticipated. It is forbidden to dispose of waste, even temporarily, in watercourses and maximum infiltration areas.
- The waste produced in the social areas and comparable to urban waste must be deposited in containers specifically designed for this purpose, and, if possible, recycled.
- Used oils, lubricants and resins should be stored in suitable, leak proof containers for subsequent disposal, preferably recycling.
- The quantities of waste generated, and their final destinations must be recorded.
- Ensure the appropriate final destination for domestic effluents from social facilities, in accordance with the legislation in force.

- In the event of contamination (and whenever chemical products are spilled on the ground), the contaminated soil should be collected, if necessary, with the help of an appropriate absorbent product, and sent for final destination.
- Provide contamination traps and ensure bunding of storage tanks.

12.2.2 Operational Phase

The main general impact affecting all environmental factors during the operational phase is CO_2 leakage. This leakage may result from an accident or due to the occurrence of fugitive gases (CO_2 leakage through the geological formation - the fault system).

As a mitigation measure during this phase, it is essential to ensure:

- The existence of an emergency plan for immediate action and remediation/minimization in case of the occurrence of CO_2 release - both considering the occurrence of an accident and the perception of the existence of CO_2 concentration values above the allowed ones. This plan should be developed considering the environmental factors that may be affected and the different possible sources of release.
- If leakage occurs at a storage site, remediation to stop the leakage could involve standard well repair techniques or the interception and extraction of the CO_2 before a potential leakage. Early detection of a leak should initiate planned remediation to stop the leak and treat the damage.

Furthermore, the following is required:

- The cryogenic CO_2 site storage tanks and the truck tanks for the CO_2 transportation must be regularly maintained, as well as all the machinery and equipment involved in the injection process.
- Workers that will deal directly with CO_2 throughout the entire capture, transport and storage process should receive specific training and use personal protective equipment.

To ensure the proper implementation of mitigation measures and that all possible accidents are addressed; continuous monitoring is required of the following environmental features:

- Air Quality; and
- Surface water and groundwater

This continuous monitoring must occur throughout the operational phase and for a minimum of three years after the end of the Project. This minimum period was identified by considering the estimated time for the mineralization process to occur, which according to the information in Section 5.7.2 is estimated to be 2 years, and with a period of verification of potential CO_2

leakage through the rock mass fault system. At the end of this period, the monitoring process should be adapted to the results of the occurrence of any leaks.

12.3 Climate and Meteorology

Given the expected impacts, it is considered that the implementation of the measures identified in the previous section are adequate to minimize the potential impacts.

12.4 Geology and Topography

Considering that the impacts on geology have been assessed as negligible, it is considered that the implementation of best practice measures should be efficient to minimize potential impacts.

12.5 Soils

12.5.1 Construction Phase

Given the impact assessment, it is considered that the implementation of best practice measures should be efficient to minimize potential impacts. However, the following requirements are highlighted:

- Once the topsoil is stripped off, ensure it is stored properly for later reuse during the decommissioning phase. Storage must be guaranteed without impacting the soil quality and must be protected with impermeable covers;
- Implement an effective system of storm water run-off control;
- Control vehicle passage and control dust; and
- In the event of contamination, contaminated soil should be collected and properly disposed of.

12.5.2 Operational Phase

During the operational phase the mitigation measures are considered to be the same as the measures set out in the previous section for the construction phase. During this phase, the most relevant measure are related to possible contamination, mainly by carbon dioxide.

- The contaminated soil should be collected, if necessary, with the help of an appropriate absorbent product, and sent for final destination.

12.6 Groundwater Hydrology

12.6.1 Detailed Design Phase

The proposed measures focus on accident mitigation and the protection of aquifers, in particular of the deep karst rocks (Transvaal Group Dolomites) and the shallow aquifer supported by the Karoo rocks, which may have higher hydrogeological interest in the area, as well as the connection of wetlands to groundwater:

- Set up a monitoring program to detect any potential CO_2 leaks and to determine the impacts on groundwater quality. This monitoring program should include a hydrocensus in a 1km buffer around the injection area, identifying groundwater wells and their characteristics, as well as any additional mitigation measures required. The monitoring program should also include the wetlands in the buffer area.
- Conduct a monitoring program on the Karstic aquifer supported by the Transvaal Supergroup Dolomites to assess any CO_2 leaks and define mitigation measures required.
- Development an emergency response plan, particularly for a CO_2 leak accident.

12.6.2 Construction Phase

Any project such as this is subject to specific environmental protection standards and therefore, in the event of an accident, mitigation measures will be taken immediately to ensure the least possible impact.

Section 12.2 above presents a list of general measures related to best practices that are usually implemented for a project of this nature.

The following additional measure is proposed:

- Interconnection between hydrogeological units should be avoided throughout the injection well to prevent potential groundwater mixtures between aquifers and to mitigate impacts in case of an accident with a leakage.

12.6.3 Operational Phase

The main potential impact during the operational phase in terms of groundwater is the potential for an accident involving CO_2 leakage. Monitoring, as stated in Section12.2.2, is standard practice for this type of project and no other impacts were identified that would warrant further mitigation impacts measures for groundwater.

The foreseen environmental baseline monitoring of the storage site and inadvertent migration of CO_2 from it throughout the soil to the surface is considered sufficient to mitigate potential impacts over discontinuous shallow aquifers developed where fracturing/weathering is more extensive.

However, any interference with wells, springs or wetlands in the Project's area of influence due to an accident should be followed by the appropriate corrective measures and the necessary reinstatement.

12.6.4 Decommissioning Phase

The sealing of the injection wells should be carried out with bentonite to prevent any possible leakage of the CO_2.

12.7 Surface Hydrology

Given the impact assessment developed, it is considered that the implementation of best practice measures should be efficient to minimize potential impacts.

The following mitigation measures proposed in the Freshwater Assessment (van Rooyen, 2023) also need to be implemented:

- Limit the area to be cleared of vegetation and associated soil disturbances, as much as possible.
- No stockpiles should be located within the drainage line that flows across the injection site.
- No waste disposal is permitted within the drainage line and associated buffer zone.
- Establish a dedicated vehicle maintenance area and wash-bay, where suitable storm water management measures are in place to prevent pollution.
- Manage storm water from drill site and camp site to avoid environmental contamination and erosion.
- Storm water runoff from workshop, vehicle maintenance area, wash-bay and other potential pollution sources will be collected and treated in hydrocarbon separation pits/tanks before discharged to the environment.
- All equipment and vehicles should be regularly inspected for leaks and should be refuelled outside of the buffer zones. In addition, all stationary equipment and vehicles should be equipped with drip trays.
- All spillages should be appropriately treated.

12.8 Waste Management

In order to address the impacts described in Section 11.8 above, the following mitigation measures need to be implemented.

Management and Prevention

- Prevent or minimize the generation of waste as far as practicable.
- Substituting raw materials or inputs with less hazardous or toxic materials, or with those where processing generates lower waste volumes.
- Re-use or recycling of waste products must be encouraged on site.
- Ensure the sorting of the waste generated by the construction site in accordance with legislation.
- Open burning is prohibited, and no waste may be buried on the site.
- Keep an up-to-date record of the quantities of waste generated and their final destination.
- The product storage area and the vehicle parking area must be drained into a retention basin which is sealed and isolated from the natural drainage network to prevent accidental spillage of oils, fuels or other hazardous products contaminating the soil and water. This waste must be treated as hazardous waste.
- In the event of a chemical spill on soil, the contaminated soil should be collected, if necessary, using a suitable absorbent product, and stored and sent for final disposal or collection by a licensed operator. An oil spill kit must be available, and employees must be trained in emergency spill procedures as well as the use of the spill kit.
- Any significant spillage of chemicals, fuels, or other hazardous products during the life of the project should be reported to DFFE (as per NEMA), DWS (as per NWA) and other relevant authorities.
- Only the workshop and service area should be used for regular vehicle maintenance, repairs, and servicing. Drip trays must be provided for emergency repairs to equipment that cannot be taken to the workshop. This waste must be treated as hazardous waste.
- Facilities should have chemical sanitation facilities. These structures must be anchored (to prevent them from falling over) and must be serviced at least once a week for the duration of the project by a registered liquid waste processor.
- Wastewater must not be discharged into the environment and measures to contain the wastewater and safely dispose thereof must be implemented.
- Chemical storage areas must be located on level ground to prevent off-site migration of any spilled product. The floor of the storage area must be impermeable to prevent spillage from entering the soil or groundwater.

Storage

- Ensure proper temporary storage of waste generated, according to its nature and in compliance with applicable legislation.
- Hazardous waste should be stored in suitable leakproof containers.
- Limiting access to hazardous waste storage areas to employees who have received proper training.

- Minimizing hazardous waste generation by implementing stringent waste segregation to prevent the commingling of non-hazardous and hazardous waste to be managed.
- Any fuel/used oil tanks must have secondary containment in the form of an impermeable bund wall and base within which the tanks sit, raised above the floor, on plinths. The bottom of the bund must slope towards a sump of sufficient size.
- Contaminated water must not mix with clean water and must be contained until collected;
- Waste must be stored in a manner that allows for inspection between containers to monitor leaks or spills.
- Ensure adequate storage of soil intended for remediation of the project area, in particular to protect it from climatic factors and possible contamination.

Monitoring

- Regular visual inspection of all waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labelled and stored.
- The site manager must establish a formal inspection routine to check all equipment in the bund area, as well as the bund area itself, for malfunctions or leaks. All valves and outlets should be checked to ensure that they are intact and that they are securely closed.

Treatment and Disposal

- Ensure that the different categories of waste are collected and treated by a licensed facility, according to national legislation.

12.9 Environmental Quality

12.9.1 Landscape and Light Pollution

To control the impact of artificial lighting at night during construction and operation, the following mitigation measures are recommended:

- Install lighting only where it is needed.
- Design the installations to maximise the utilisation factor.
- Adjust the electrical power to the level required to maintain safe working conditions. Avoid installing more power than necessary.
- Reduce direct light towards the sky and at angles close to the horizontal (control the light propagation direction). Good lighting should be directed to where it is needed, avoiding sky and side diffusion.
- LED or compact fluorescent lamps (CFLs) are preferable. By switching to LED lighting, luminance can be reduced without loss of visibility.
- Avoid blue lights at night.

- Outdoor lighting with a high blue content is likely to have a much wider geographical reach than lighting with a lower blue content.
- White light sources with a high blue content are also known to increase glare and to impair human vision, particularly in the ageing eye. Blue light has been shown to adversely affect the behaviour and reproduction of wild animals in natural environments at night.
- Limit necessary road traffic during all phases of the project to daytime hours where possible.
- Where possible, use opaque fencing that does not allow light to pass through to define the project area.

12.9.2 Noise and Vibration

It is recommended that these mitigation measures are applied at all stages of the project, with priority being given to their application during the construction phase:

- Whenever possible, activities involving the emission of high noise levels should be limited to normal working days and hours.
- If construction work is to take place after working hours, all communities potentially affected by noise should be notified in advance between 2 and 4 weeks prior to construction.
- Prevent local communities from potential disturbance and record all noise related complaints for investigation and resolution.
- Use equipment and vehicles with lower sound power levels.
- Install silencers on fans.
- Where possible install suitable mufflers on engine exhausts and compressor components.
- Stationary noisy equipment (e.g., power generators) should be placed as far away from the sensitive receivers as possible, and facing away from them.
- Where possible, place noisy stationary equipment in acoustic enclosures.
- All power generators must be placed on a level area/footing to minimize vibration noise.
- Where possible, install temporary noise barriers between well drilling and sensitive receptors such that noise levels at nearby residences are reduced. The height of the noise barrier shall be determined based on the size of the drilling equipment to be used. Acoustic barriers must be continuous and have a minimum continuous surface density of 10 kg/m^2 to minimize sound transmission through the barrier. Barriers should be located as close to the source to be effective.
- Vehicles and machinery used in the works shall be operated and maintained in good condition and in accordance with their respective instruction manuals. All vehicles must be in a road worthy condition in terms of the National Road Traffic Act, 1996 (Act No 93 of 1996).

- The maintenance of the equipment and vehicles will be carried out and recorded to certify its accuracy.
- Ensure the adoption of good driving practices, such as:
  - Minimize the reversing manoeuvres of the equipment to avoid the nuisance associated with reversing alarms;
  - Reduce unnecessary acceleration and braking when arriving and leaving sites;
  - Ensuring compliance with speed limits for all heavy vehicles;
  - Reducing project traffic routing through community areas wherever possible;
  - Limit the use of noisy signals, including horns, whistles, alarms and bells to safety warnings only.
- Workers must:
  - Use personal protective equipment (PPE);
  - Check the maintenance status of equipment and tools;
  - Use the right tools and not necessarily the fastest ones; and
  - Reduce the time spent using equipment with high noise levels, interspersing work with other activities.
- Noise control in the project area and sensitive areas shall be implemented for the control and safety of workers and the community of Leandra. Noise monitoring programmes should be designed and carried out by trained specialists. Typical monitoring periods should be sufficient for statistical analysis and may be as long as 48 hours, using noise monitors capable of collecting data continuously over this period or hourly or more frequently as appropriate. Monitors should be placed approximately 1.5 m above the ground and no closer than 3 m to a reflective surface (e.g., wall);
- If noise levels above those predicted by this assessment are reported, additional noise reduction measures must be taken.

12.9.3 Air Quality

Given the expected impacts, it is considered that the implementation of the measures identified in the Section 12.2 are adequate to minimize the potential impacts.

12.10 Fauna and Flora

12.10.1 Construction Phase

The following mitigation measures were proposed in the Terrestrial Biodiversity Compliance Statement (Human, 2023):

- Restrict impact to development footprint only and limit disturbance in surrounding areas.
- Implement the following measures to control invasive alien plants:
  - The objectives of managing invasive alien plant are as follows –

    - To ensure that alien plants do not become established on site;
    - To ensure that alien plant species do not become dominant in all or parts of the landscape;
    - To implement a monitoring programme to detect the presence of alien plant species as well as to monitor the success of the management measures.
- Control measures –
    - A prevention strategy should be established, including regular surveys and monitoring for invasive alien plants, effective rehabilitation of disturbed areas and prevention of unnecessary disturbance of natural areas. Prevention could also include measures such as washing the working parts and wheels of earth-moving equipment prior to it being brought onto site, visual walk-through surveys every month.
    - Keeping up to date on which weeds are an immediate threat to the site is important, but efforts should be planned to update this information on a regular basis. When new Invasive Alien Plant Species are spotted an immediate response of locating the site for future monitoring and either hand-pulling the weeds or an application of a suitable herbicide should be planned. It is, however, better to monitor regularly and act swiftly than to allow invasive alien plants to become established on site.
    - If any alien invasive plants are found to become established on site, action plans for their control should be developed, depending on the size of the infestations, budgets, manpower considerations and time. Appropriate registered chemicals and other possible control agents should be considered in the action plans for each site/species. The key is to ensure that no invasions get out of control.
    - There are various means of managing invasive alien plants. These include mechanical, chemical and biological control.
- Develop a programme for long-term control, including monitoring specifications.

Additional mitigation measures are as follows:

- ❑ Carefully assess the presence of any SCCs before placing machinery and infrastructure.
- ❑ Report any animal casualties that may arise from the Project activities to local authorities and organizations (such as the NSPCA), namely with species with lower mobility, so that corresponding rescue actions can be coordinated.
- ❑ Place a fence that does not completely prevent the passage of fauna across the project site, particularly for lower-mobility species such as small mammals (rodents and moles, but also reptiles).

In addition, it is considered that the implementation of best practice measures should also support the minimisation of potential impacts to flora and fauna.

12.10.2 Operational & Decommissioning Phases

Beyond best practice measures, the most important mitigation measure during and after the operational phase is to carefully plan a monitoring programme that can quickly and if possible, preventively warn of any superficial CO_2 leakage from the underground storage.

The following mitigation measures were proposed in the Terrestrial Biodiversity Compliance Statement (Human, 2023) with egards to the rehabilitation of the site:

- No till planting technique is recommended to reduce further disturbance of soil and promoting opportunistic long lived alien species in the seedbank to grow.
- Reseeding of herbaceous plants typical to the area.
- All plant species for use by the project must be reviewed and approved by qualified specialists prior to use on site.
- Sodding may be done at any time of the year, but seeding must be done by sowing appropriate seed mixtures at the most suitable time under the guidance of a qualified specialist.
- Planting should preferably be done during the rainy season.
- Establish further specifications for sods, runners and hand seeding.
- All rehabilitated areas should be monitored to assess vegetation recovery. This should be for a minimum of three years after post-construction rehabilitation, but depends on the assessed trajectory of rehabilitation (whether it is following a favourable progression of vegetation establishment or not – this depends on the total vegetation cover present, and the proportion that consists of perennial growth of desired species).

12.11 Sensitive Habitats

Considering that no sensitive habitats were identified in the area, it is deemed that the implementation of best practice measures should be efficient to minimize the potential impacts.

12.12 Land Use and Spatial Planning

12.12.1 Construction Phase

The following measures are proposed to minimize the impacts of the construction phase in terms of civil aviation:

- Do not use equipment or structures that exceed 15 m in height, particularly those to be used for drilling; and
- If equipment or structures exceeding 15 m in height are used, they should be assessed by the Obstacle Evaluation Committee and recorded as potential aviation obstacles in the Electronic Terrain and Obstacle Database.

12.12.2 Operational Phase

No specific mitigation measures are expected to be required during the operational phase.

12.12.3 Decommissioning Phase

No specific mitigation measures are expected to be required during the decommissioning phase.

12.13 Socio-Economic Environment and Public Health

1.1.2. Construction and Operational Phases

To enhance the positive impacts identified for the construction and operational phases regarding the employment opportunities and investment in the local economy, the implementation of the following enhancement measures is recommended:

- Whenever possible, hire workers from Leandra, for project construction activities, contributing to the reduction of local unemployment and boosting the local economy while avoiding worker migration; and
- Acquire products and services (water supply, waste management, catering, cleaning services, among others) whenever possible from the local area, thereby contributing to the local economy.

To mitigate the negative impact related to security threats, the implementation of the following mitigation measures is recommended:

- Install a solid fence around the perimeter of the project implementation area. The fence should be at least 2,1 m high with reinforced barbed wire on top to get the fence height up to 2,8 to 3 m. If possible, electric fencing provides an added security. “No trespassing” signs should be installed along the fence.
- It is not recommended to use local security companies or organizations since the local drug cartels have a large influence in the project’s area and, thus, there is a risk that they will manipulate the security companies to their own advantage.
- Hire construction site security guards, which are present at the construction site 24 hours a day. The security guards should regularly inspect the fence perimeter to identify weak spots or evidence of tampering.
- If possible, use patrol dogs or patrol cars.
- Use security camera monitoring services.
- Limit the number of entrances to the construction site as much as possible and ensure only authorized people can enter the construction site.

12.13.1 Public Health - Construction Phase

For the negative impacts identified for the construction phase related to emissions and noise, the measures proposed in Section 12.9.2 and Section 12.9.3 are recommended.

12.13.2 Public Health - Operational Phase

In order to mitigate the negative impacts identified for the operational phase, the implementation of the following measures is recommended:

- In relation to the impact on the health of local communities:
  - Monitor the leakages of CO_2 and develop a contingency plan in case of a large-scale storage leakage; and
  - Provide access to health care for those injured by the Project's activities.
- In relation to the impact related to the potential public opposition to the Project:
  - Manage the community's expectations regarding employment opportunities; and
  - Inform the community about Project's activities at an early stage as well as a plan with a timeline of the activities that will be carried out.
- In relation to the impact on workers' health and safety:
  - Provide training to all workers regarding Occupational Safety and Health; and
  - Provide appropriate safety protection materials.

12.14 Cultural Heritage

The following mitigation measures were identified in the Heritage Impact Assessment (Kitto, 2023):

- A buffer of at least 20-30m must be placed around the railway culvert to ensure that during the construction phase, this structure is not damaged. • The materials demarcating the 30m buffer must be highly visible and made of durable material to ensure that they are still in place during the construction phase.
- At the onset of any site clearance activities for the proposed injection site construction, a walk-down of the area must be undertaken by a heritage specialist to monitor any unidentified grave sites. If an unidentified grave site is uncovered during site clearance or construction activities, a buffer of at least 30m must be placed around the site to ensure that during construction, the grave/s are not damaged.

13 Overall Assessment

13.1 Introduction

The section provides an overview of the residual environmental impacts of the Project, based on the assessment of the potential environmental and social impacts (Section 11) and identification of commensurate mitigation measures (Section 12).

13.2 Residual Environmental and Social Impacts

13.2.1 Overview

Residual impacts are the remaining impacts caused by the Project after the implementation of mitigation measures and taking into account the implementation of best practice measures in all project phases. To provide an overview of the assessment carried out, Table 112 summarizes the significance of the residual environmental and social impacts (identified in Table 108). It should be noted that for impacts classified as variable significance, the highest significance has been considered.

Table 112: Environmental significance of the impacts identified

Environmental Significance	Project Phase			
	Construction	Operational	Decommissioning	Total
Negative Impacts				
Null or Negligible	15	7	4	26
Low	9	11	5	25
Moderate	1	4	0	5
High	0	0	0	0
Positive Impacts				
Null or Negligible	0	0	0	0
Low	2	1	1	4
Moderate	0	2	0	2
High	0	1	1	2

The table above shows that the Project may potentially lead to 56 negative impacts of which 25 (45%) are associated with the construction phase, 22 (39%) are linked to the operational phase and 9 (16%) from decommissioning. Also, 8 possible positive impacts were identified, of which 2 (25%) arise from the construction phase, 4 (50%) from the operational phase, 2 (25%) from the decommissioning phase, and 1 from the overall project implementation. It is worth highlighting the positive high significance impact of shifting from the pilot project to a larger scale project, if successful.

13.2.2 Overall Qualitative Assessment

Based on Table 107 and Table 108 above, an overall assessment of the Project is made for all activities included in the three phases of the project life-cycle. Table 107 provides the informant for identifying potential impact-causing activities, while Table 108 provides the information for the qualitative assessment. The evaluation is based on the following criteria:

Nature

- Positive (+);
- Negative (-);

Duration

- Temporary (T);
- Short-term (ST);
- Long-term (LT);
- Permanent (P);

Significance

- Null or Negligible (0);
- Low (1);
- Moderate (2);
- High (3);

Table 113 below summarizes the outcome of the overall assessment provided in Section 11 above.

Table 113: Overall Qualitative Assessment

Phase	Construction				Operational			Decommissioning	
Activity	Site Establishment	Drilling	Operational area construction	Project Implementation	CO_2 Transportation	CO_2 Injection and Storage	Project Implementation	Dismantling and recovery	Borehole sealing
Climate and meteorology							+1P		
Geology and Topography	0	0				0			
Soils	0	0	-1P			0		+1P	
Groundwater Hydrology			0				-1T to -1P	-1T	
Surface Hydrology		0		0		-1ST	-1ST	-1LT	
Waste management	-1P	-1P	-1P				-1P	-1P	-1P
Landscape and Light Pollution		-1ST							
Noise and Vibrations	0	-1ST	0		0	0		0	0
Air Quality	0	0	0		-1LT to -2LT	-1LT to -2LT	-1LT		
Fauna and Flora	0	0	0		-1LT to -2LT			+1LT to +3LT	
Sensitive Habitats	0	0	0		0			0	
Land Use/Spatial Planning				-1ST and +1ST			-1ST and +1ST to +3P	0 to -1P	
Socioeconomics/Public Health		-1ST		-1ST to -2ST and +1ST	-1LT		-1LT to -2LT and +1LT to +2LT		

13.3 Environmental Feasibility of the Project

The Screening Tool identified the following environmental sensitivities related to the project area:

1. Agriculture - high sensitivity;
2. Civil Aviation - high sensitivity;
3. Palaeontology - medium sensitivity; and
4. Both Animal and Plant Species - medium sensitivity, with Terrestrial Biodiversity - very high sensitivity.

However, the following was determined during the Basic Assessment (including through the relevant site sensitivity verification and specialist studies):

1. The project implementation area is vacant. Although the land cover in Figure 81 above shows the site to consist of commercial croplands, from historical aerial imagery it appears that the site has not been cultivated in at least the last 20 years. The Project is temporary in nature and the site will be reinstated during the decommissioning phase to a pre-project state.
2. The sensitivity of the site from a civil aviation perspective is discussed in Section 10.11.3.7 and the potential impact of the Project to civil aviation is assessed in Section 11.12.1.5 as having a low significance, with mitigation measures provided in Section 12.12.1. The SACAA will be afforded an opportunity to review the draft BAR.
3. It was concluded in the desktop Palaeontological Impact Assessment that the proposed development will not lead to detrimental impacts on the palaeontological resources of the area.
4. Based on the findings of the Terrestrial Biodiversity Compliance Statement, the project area has experienced long-term and continuous disturbances, mostly due to the agricultural grazing practices and associated impacts. Hence, the project area is modified and as such is assigned a sensitivity rating of ‘Low’.

.The Site Sensitivity Verification Report is contained in Appendix D7

The following results from the impact assessment are noted:

- (46%) Negligible, and (45%) Low;
- (13%) Temporary, and (31%) Short-term; and
- (33%) On site, and (50%) Local.

Based on the above, the Pilot CO_2 Storage Project is considered to be environmentally viable.

14 Analysis of Alternatives

14.1 Introduction

Alternatives are the different ways in which the Project can be executed to ultimately achieve its objectives. Examples could include carrying out a different type of action, choosing an alternative location or adopting a different technology or design for a project.

The sub-sections to follow discuss the Project's alternatives considered during the Basic Assessment. By conducting the comparative analysis, the Best Practicable Environmental Option (BPEO) can be selected with technical and environmental justification. Münster (2005) defines BPEO as the alternative that "*provides the most benefit or causes the least damage to the environment as a whole, at a cost acceptable to society, in the long term as well as in the short term*".

The alternatives are further assessed below.

14.2 No-Go Alternative

The impacts of the no-go alternative are compared to the option of proceeding with the Project in Table 114 below.

Table 114: Comparing impacts between the No-Go Alternative and the Pilot CO_2 Storage Project

Environmental Factor	No-Go Alternative	Pilot CO_2 Storage Project
Climate and meteorology	Null	Positive
Geology and Topography	Null	Negligible
Soils	Null	Low
Groundwater Hydrology	Null	Low
Surface Hydrology	Null	Low
Waste Management	Null	Low
Landscape and Light Pollution	Null	Low
Noise and Vibrations	Null	Low
Air Quality	Null	Low to Moderate
Fauna and Flora	Null	Low to High
Sensitive Habitats	Null	Negligible
Land Use and Spatial Planning	Null	Low to High
Socioeconomics and Public Health	Null	Low to Moderate
Cultural Heritage	Null	Null

The no-go alternative is not preferred, as the objectives of the Project will not be met, and the associated benefits will not materialise. Although not proceeding with the Project would avoid the adverse environmental impacts, these impacts are considered to be manageable through the measures contained in the BAR and EMPr.

14.3 Technology Alternatives

The technological alternatives identified for the Project, as discussed in Section 5.7 above, include the following:

- Injection of supercritical CO_2; and
- Injection of water-CO_2 solution.

Considering the advantages and disadvantages of each alternative and the impacts presented and assessed throughout Section 11 above, the following difference is highlighted:

- The implementation of the injection of water-CO_2 solution implies an additional negative impact "given the relevant increase in water demand on the local water resources, with the associated need for treatment up to industrial grade", assessed to have low significance. However, this impact becomes more significant considering the perspective of scale if the Project is successful.

Despite the impact, it should be noted that both alternatives are based on successful pilot projects. Once the success of the Project has been assessed, it may be deemed viable to implement CCS on a larger scale. Taking this into consideration, at this stage, both alternatives can be considered as preferable.

15 ASSESSMENT LIMITATIONS

This section discusses the assumptions, uncertainties, and gaps in knowledge associated with this Basic Assessment.

Firstly, given the nature of the proposed Project, which is a pilot research project by the CGS, there are uncertainties associated with the limitations of knowledge and previous research studies. Despite this, the Project is grounded in two previously successful pilot projects where both alternatives under study were used (CarbFix at the Hellisheidi geothermal power plant in Iceland and Wallula in the Columbia River plateau, in the United States).

Nevertheless, there are several uncertainties with upscaling to an industrial-scale CO_2 injection venture, particularly in the context of fracture-controlled reservoir permeability. Should the Project be deemed to be successful, then the expansion of CCS will need to adhere to the prevailing environmental legal requirements,

Secondly, another uncertainty that could potentially influence the impact assessment is associated with the likelihood of CO_2 leakage occurring throughout the CCS process. The risk assessment of CO_2 leakage is presented in Section 11.17 above. To ensure the proper implementation of mitigation measures and that all possible accidents are addressed; continuous monitoring is required of air quality as well as surface - and groundwater. This continuous monitoring must occur throughout the operational phase and for a minimum of three years after the end of the Project. This minimum period was identified by considering the estimated time for the mineralization process to occur, and with a period of verification of potential CO_2 leakage through the rock mass fault system. At the end of this period, the monitoring process should be adapted to the results of the occurrence of any leaks.

The following additional limitations accompany the BAR:

- As the design of the Project is still in feasibility stage, and due to the dynamic nature of the planning environment, the dimensions and layout of the infrastructure may change during the detailed design phase.
- Regardless of the analytical and predictive method employed to determine the potential impacts associated with the Project, the impacts are only predicted on a probability basis. The accuracy of the predictions is largely dependent on the availability of environmental data and the degree of understanding of the environmental features and their related attributes.
- Assumptions and limitations listed within the Specialist Reports contained within **Appendix D** also have relevance**.**

It is considered that, overall, the current level of knowledge is adequate for the assessment of the main environmental impacts of the Project, which allows for the conclusions to be reached in this report and for decision-making by DFFE.

16 Public Participation

16.1 General

The purpose of public participation includes the following:

1. To provide I&APs with an opportunity to obtain information about the Project;
2. To allow I&APs to express their views, issues and concerns with regard to the Project;
3. To grant I&APs an opportunity to recommend measures to avoid or reduce adverse impacts and enhance positive impacts associated with the Project; and
4. To enable the Applicant to incorporate the needs, concerns and recommendations of I&APs into the Project, where feasible.

The public participation process for the proposed Project is governed by NEMA and the EIA Regulations. Figure 105 below outlines the public participation process for the Basic Assessment.

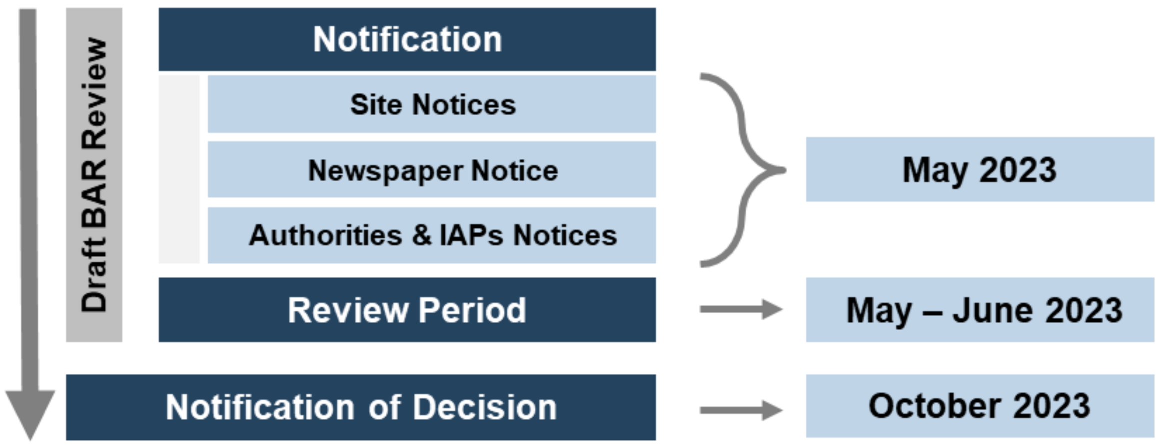

Figure 105: Outline of Public Participation Process

16.2 Database of I&APs

A database of I&APs, which includes authorities, different spheres of government (national, provincial and local), parastatals, ward councillors, stakeholders, landowners, interest groups and members of the general public, was prepared for the Project and is contained in Appendix E.

16.3 Landowner Consent

According to Regulation 39(1) of the EIA Regulations, if the proponent is not the owner or person in control of the land on which the activity is to be undertaken, the proponent must, before applying for an Environmental Authorisation in respect of such activity, obtain the written consent of the landowner or person in control of the land to undertake such activity on that land. This requirement does not apply *inter alia* for linear developments (e.g., pipelines, power lines, roads, etc.) or if it is a SIP as contemplated in the Infrastructure Development Act, 2014.

Landowner consent is included in the Application Form (see Appendix B).

16.4 Review of Draft BAR

16.4.1 Period to Review the Draft BAR

In accordance with Regulation 43(1) of the EIA Regulations, I&APs are granted an opportunity to review and comment on the draft BAR from **29 May until 28 June 2023**.

16.4.2 Notification of Review of Draft BAR

The following notifications were provided with regards to the review of the draft BAR (proof to be included in the final BAR):

- Authorities and I&APs contained in the database (refer to Appendix E) were notified via email;
- A notice was placed in The Citizen Newspaper, which is distributed nationally;
- A notice was placed in the Ridge Times Newspaper, which is distributed regionally;
- A notice was placed in The Bulletin, which is a regional online newspaper; and
- Site notices were placed on the boundary of the site.

16.4.3 Accessing the Draft BAR

The draft BAR can be accessed as follows:

- Hardcopies of the draft BAR were placed at the following libraries –
    - Secunda Public Library (1 Louwrens Muller St, Secunda, 2302);
    - Lebohang Public Library (1095 Butana Nkambula, Lebohang, 2265); and
    - Leandra Public Library (8 Pretorius Street, Eendrag, 2266).
- An electronic copy was uploaded to the following website, for downloading purposes: https://nemai.co.za/downloads/.

Copies of the draft BAR were provided to the following parties, which include key regulatory and commenting authorities with jurisdiction over the receiving environment:

- DFFE (including Biodiversity Conservation Unit);
- DARDLEA;
- MTPA;
- DWS Regional Office;
- DMRE;

- SAHRA;
- MPHRA;
- Mpumalanga Department of Public Works, Roads and Transport (DPWRT);
- GSDM; and
- GMLM.

16.4.4 Commenting on the Draft BAR

Comments on the draft BAR need to be forwarded in writing to the contact person below within the review period stipulated in Section 16.4.1 above (note that the Comment Sheet contained in Appendix H may be used for this purpose):

Contact Person:	*Donavan Henning*
Tel:	*(011) 781 1730*
Email:	*donavanh@nemai.co.za*
Postal Address:	*PO Box 1673, Sunninghill, 2157*

16.4.5 Comments Received on the Draft BAR

Comments received on the draft BAR will be incorporated into a Comments and Responses Report (CRR), which will also include responses from the Applicant, EAP and environmental specialists (as relevant). The CRR will be appended to the final BAR that will be submitted to DFFE for decision-making.

16.4.6 Public Meeting to Present the Draft BAR

A public meeting will be held during the review period to present the draft BAR and to provide I&APs with a platform for project related discussions. The details of the meeting are as follows:

- **Date:** 14 June 2023.
- **Time:** 10:00 AM – 12:30 PM.
- **Venue:** Difa Nkosi Hall, Leandra (coordinates: 26°22'35.08"S, 28°55'19.72"E).

16.5 Notification of DFFE's Decision

Registered I&APs will be notified after having received written notice from DFFE (in terms of NEMA) on the final decision for the Project. The notification will include the appeal procedure to the decision and key reasons for the decision.

17 CONCLUSIONS

17.1 Outcomes of the Basic Assessment

The following key tasks were undertaken during the Basic Assessment Process for the proposed Project:

- The Project's areas of influence were defined and assessed;
- Specialist studies were undertaken and the findings were incorporated into the BAR in terms of understanding the environmental status quo and sensitive features, assessing the potential impacts and establishing concomitant mitigation measures;
- Potentially significant impacts pertaining to the construction, operational and decommissioning phases of the Project were identified and assessed, and mitigation measures were provided;
- Alternatives for achieving the objectives of the proposed activity were considered;
- An EMPr was compiled (contained in Appendix F), which represents a detailed plan of action to ensure that recommendations for enhancing positive impacts and managing negative environmental impacts are implemented during the life-cycle of the Project. The EMPr also includes a Closure Plan, which addresses the management requirements for the decommissioning activities for the Project; and
- Authorities and I&APs were identified and notified of the review of the draft BAR.

The outcomes of these tasks are captured below.

17.2 Sensitive Environmental Features

Some of the sensitive and significant environmental features and aspects that are associated with the Project's receiving environment are listed below, for which mitigation measures are included in the BAR and EMPr (as relevant):

- The Kromdraaispruit, which is a perennial river, is located north of the injection site and flows in a northerly direction away from the site. A drainage line flows across the injection site in a southerly direction towards a small dam located near Lebohang. This drainage line and its buffer area of 32 m can be avoided with the implementation of the mitigation measures from the Freshwater Assessment. Three wetlands were observed within a 500 m radius of the injection site, namely two small depressions and one large channelled valley bottom wetland.
- The nearest dwellings within the Project's direct area of influence are more than 800 m from the injection site.
- The site is bordered by the road reserve of the R29 to the north and the railway servitude to the south. A 50 m buffer area was catered for in the site plan of the injection site, and the entire area will be fenced off.

- Access to the injection site will be directly gained from the R29 and all relevant traffic management measures will need to be implemented and the requirements of the DPWRT will need to be adhered to.
- Five heritage resources were identified within and adjacent to the injection site, which can be avoided with the implementation of the mitigation measures from the Heritage Impact Assessment.

A consolidated sensitivity map for the project area is provided in Figure 106 below.

17.3 Environmental Impact Statement

The rationale for the siting of the Project is based the following:

- The Mpumalanga Province, where the piloting of CCS is proposed, is home to power stations, mining and petrochemical industries and, as a result, the area is where the country's CO_2 emissions are most prevalent;
- The project area is characterized by a basaltic geological nature with CO_2 storage potential;
- The project area is located near to the Sasol Secunda Plant from where it is intended to source CO_2 for the pilot project; and
- The targeted site is vacant and the use of the property for the pilot project has been secured through a lease agreement between GMLM (landowner) and CGS (Applicant).

The following main conclusions are drawn from the Basic Assessment:

- The main negative impact identified is associated with the potential risk of CO_2 leakage, which was assessed in the BAR, including the risk assessment in Section 11.17 above. To ensure the proper implementation of mitigation measures and that all possible accidents are addressed, continuous monitoring is required of air quality as well as surface - and groundwater. This continuous monitoring must occur throughout the operational phase and for a minimum of three years after the end of the Project.
- The main positive impacts identified are associated with the potential of job creation, acquisition of knowledge and experience, investment in local economy, and reduction of the CO_2 in the atmosphere. Another potential positive impact to be considered, which extends beyond the scope of this Basic Assessment, is associated with the possible success of the Project. If successful, the present pilot project has the possibility of being upscaled and therefore of amplifying the positive impacts discussed in the BAR.

Both technical alternatives (i.e., injection of supercritical CO_2 or water-CO_2 solution) are based on successful pilot projects that are discussed in the BAR. At this stage, both alternatives are considered to be preferable.

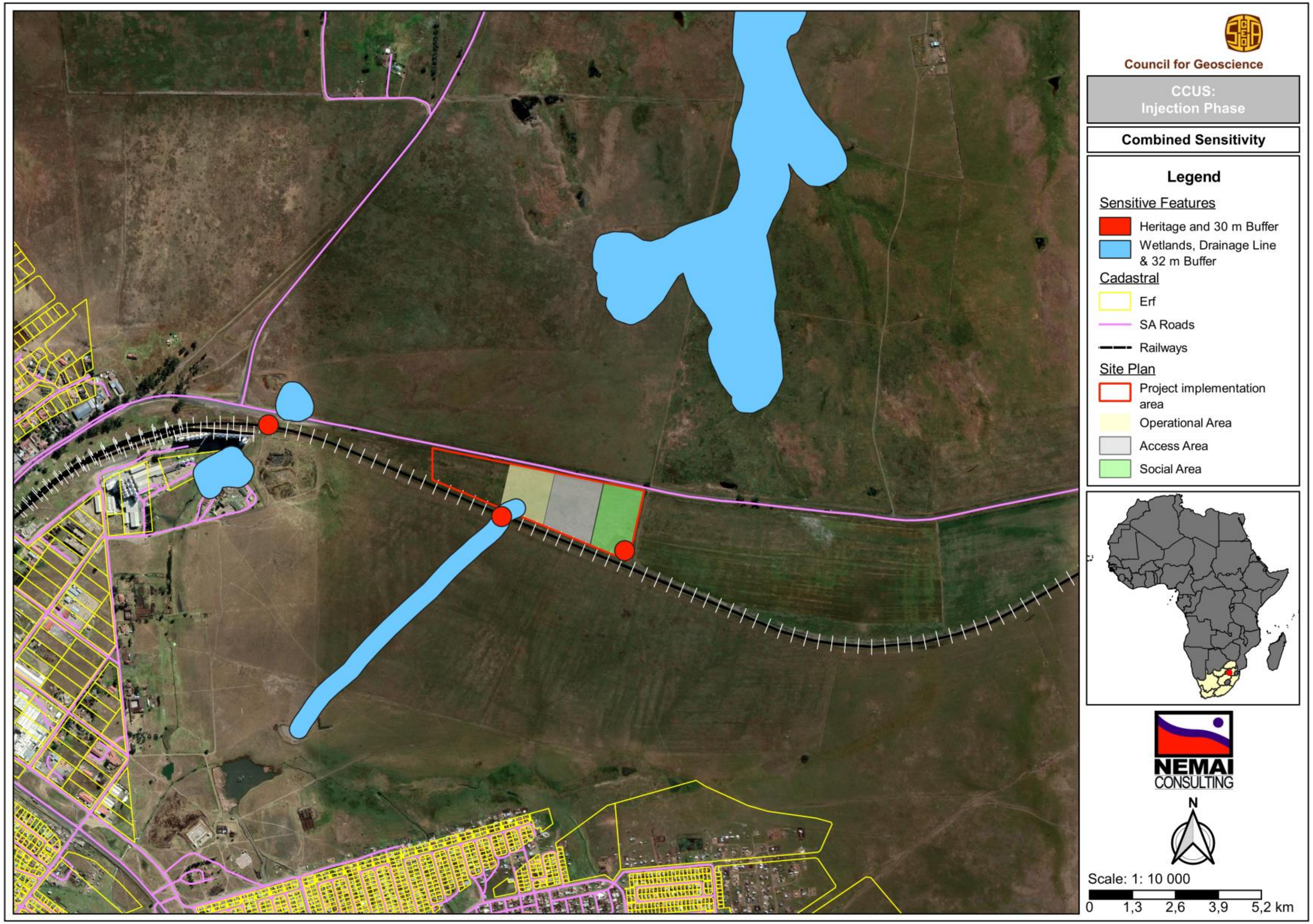

Figure 106: Combined sensitivity map

The impacts and risks assessed as part of the Basic Assessment Process that was undertaken for the Project are considered manageable with the effective implementation of the measures stipulated in this BAR as well as the EMPr and Closure Plan.

With the adoption of the mitigation measures included in the BAR and the dedicated implementation of the EMPr and Closure Plan, it is believed that the significant environmental aspects and impacts associated with this Project can be suitably mitigated. With the aforementioned in mind, it can be concluded that there are no fatal flaws associated with the Project and that Environmental Authorisation can be granted, based on the findings of the specialists and the impact assessment, through the compliance with the identified environmental management provisions.

It is further the opinion of the EAP and EIA team that the Basic Assessment was executed in an objective manner and that the process and BAR conform to the requirements stipulated in the EIA Regulations.

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APPENDIX A

MAPS

APPENDIX B

APPLICATION FORM

APPENDIX C

CV OF EAP

APPENDIX D

SPECIALISTS' REPORTS

APPENDIX D1 - Freshwater Assessment

APPENDIX D2 - Terrestrial Biodiversity Compliance Statement

APPENDIX D3 - Heritage Impact Assessment

APPENDIX D4 - Desktop Paleontological Impact Assessment

APPENDIX D5 - Air Quality Modelling

APPENDIX D6 - Hydrogeological Study

APPENDIX D7 - Site Sensitivity Verification Report

APPENDIX D8 - Declarations

APPENDIX E

DATABASE OF AUTHORITIES, STAKEHOLDERS & I&APs

APPENDIX F

EMPr & CLOSURE PLAN

APPENDIX G

OATH OF EAP

APPENDIX H

COMMENT SHEET