



Climate Change Assessment for the D3 Energy South Africa (Pty) Ltd Production Right Application (PR16), Free State Province

Project done on behalf of **Environmental Impact Management Services (Pty) Ltd**

Project Compiled by:

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Revision Record

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Rev 0	June 2026	For internal review
Rev 1	August 2026	Comments from EIMS and D3 Energy
Rev 2	September 2026	Additional comments from EIMS

EXECUTIVE SUMMARY

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake a Climate Change Assessment (CCA) for the proposed D3 Energy Production Right Application (PR16) (hereafter referred to as the project).

Project specific information, together with local and internationally published emission factors, were used to calculate Scope 1 (direct), and Scope 3 (indirect)¹ greenhouse gas (GHG) emissions for the proposed project. Locally published literature was referred to, to understand the projected changes to climate for the area.

The physical risks of climate change on the study area (based on the Green Book which references the Intergovernmental Panel on Climate Change (IPCC's) fifth assessment report (AR5) data) can be summarised as follows:

- Climate:
 - Temperature:
 - Baseline: 3 hot days (50th percentile) and annual average temperature of 15.9°C;
 - High mitigation climate situation (RCP4.5): increase in hot days by 8.5 days with an increase in temperature of 2.3°C (50th percentile);
 - Low mitigation climate situation (RCP8.5): increase in hot days by 8.9 days to 33.8 days (10th to 90th percentile) with an increase in temperature of 2.6°C (50th percentile).
 - Rainfall:
 - Baseline: average annual rainfall of 1 099 mm;
 - High mitigation climate situation (RCP4.5): increase of 2.2 extreme rainfall days with an increase in average annual rainfall of 163 mm (50th percentile);
 - Low mitigation climate situation (RCP8.5): increase of 2.1 extreme rainfall days with an increase in average annual rainfall of 226 mm (50th percentile).
- Hazards assuming the low mitigation climate situation (RCP8.5):
 - Wildfires: Isolated pockets of moderate and high increased risk of wildfires at settlements in the municipalities, but not within the project area with the projection of 23 fire danger days per year over the project area;
 - Drought: Isolated pockets at settlements within the municipalities are at very low risk of drought with the Standardized Precipitation Index (SPI) of -0.44 for the project area;
 - Exposure to heat extremes: some settlements within the municipalities are at high risk of encountering increasing heat stresses; and,
 - Flooding: the settlements within the study area are at slight to moderate risk of increased extreme rainfall days with isolated pockets of very low to moderate increase in exposure to urban flooding for the municipalities.

¹ It should be noted that no electricity from the grid will be used during the exploration and production activities. GHG emissions from Scope 2 will therefore be zero.

Based on information provided, the project is likely to result in an estimated total GHG emissions as follows:

- Scope 1 direct emissions:
 - 809 057 tonnes carbon dioxide equivalent (t CO₂e) over a 30-year period
 - 29 221 t CO₂e per annum
- Scope 2 indirect emissions:
 - No electricity from the grid will be used during the activities. GHG emissions from Scope 2 will therefore be zero.
- Scope 3 indirect emissions:
 - 1 930 635 t CO₂e over a 30-year period
 - 191 915 t CO₂e per annum

The GHG emissions from the project was calculated to represent 0.01% of the remaining South African annual budget for 2035. The contribution to the South African annual budget will also progressively increase throughout the life of the project as the country's Nationally Determined Contributions (NDCs) decrease.

The impact of the project on climate change was assessed to have a **moderate** negative risk rating for GHG emissions. This rating also applies if the more conservative GWP values (20 and 100 years) from the IPCC Sixth Assessment report are used.

The calculated CO₂e emissions from the project operations in the area (cumulative, taking into account: Tetra4 production, Motouane exploration and Rhino Oil and Gas exploration) for Scope 1 is estimated at a total of 197 189t CO₂e per annum.

Cumulative projects in the area would contribute approximately 0.06% of the remaining carbon budget per year and represent a contribution of 0.04% to the 2022 National GHG inventory total.

The impact of the cumulative projects on climate change was assessed to have a **high** negative risk rating for GHG emissions.

The CCA identified no climate-related reasons that would preclude consideration to obtaining Environmental Authorisation (EA). The assessment does not say there is no climate impact. It recognises the contribution while assessing whether the requested EA can be considered. However, as climate change results in a multidisciplinary impact (including, but not limited to, socio-economic, fauna and flora, ground and surface water, air quality), the CCA cannot be evaluated in isolation. Other disciplinary specialist impact assessments as well as cumulative impacts thus need to be taken into consideration to understand the full impact of the project.

In the event that this project is allocated a carbon budget, it will need to provide a greenhouse gas mitigation plan. The project will also be required to report CO₂e emissions annually via the SAGERS.

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LIST OF ACRONYMS AND SYMBOLS

AFF	Agriculture, Forestry and Fishing
Airshed	Airshed Planning Professionals (Pty) Ltd
AR3	IPCC's third assessment report
AR5	IPCC's fifth assessment report
AR6	IPCC's sixth assessment report
BAU	Business-As-Usual
°C	Degrees Celsius
CAIT	Climate Analysis Indicators Tool
CCA	Climate Change Assessment
CCRA	Climate Change Reference Atlas
CCS	Carbon Capture and Sequestration (or Carbon Capture and Storage)
CH ₄	Methane
CMIP	Coupled Model Intercomparison Project
CO ₂	Carbon dioxide
CO _{2e}	Carbon dioxide equivalent
DESNZ	UK Department for Energy Security and Net Zero
DFFE	Department of Forestry, Fisheries and Environment (previously DEA)
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EAPs	Environmental Assessment Practitioners
ECMWF	European Centre for Medium-Range Weather Forecasts
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Services (Pty) Ltd
ER	Exploration Right
ERA5	Fifth generation ECMWF (European Centre for Medium-Range Weather Forecasts)
GCMs	Global Climate Change Models
GDP	Gross domestic product
GG	Government gazette
GGFR	Global Gas Flaring Reduction Public-Private Partnership program
GHG	Greenhouse gases
GHGIP	National Greenhouse Gas Improvement Programme
GN	Government notice
GVA	Gross Value Added
GWP	Global warming potential
ha	Hectar
H ₂ O	Water vapour
HFCs	Hydrofluorocarbons
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogram
km	Kilometre
kWh	Kilowatt hour
l/p/d	Litres per person per day
LDAR	Leak Detection and Repair
LUCF	Land-Use Change and Forestry LUCF
LULUCF	Land Use, Land Use Change and Forestry

m	Metres
mm	Millimetres
mm/yr	Millimetres per year
MW	Megawatt
N ₂ O	Nitrous oxide
NAAQS	National Ambient Air Quality Standards
NACA	National Association for Clean Air
NAEIS	National Atmospheric Emission Inventory System
NCEP	National Centres for Environmental Prediction
NEM:AQA	National Environmental Management: Air Quality Act
NDCs	Nationally determined contributions
NOAA	National Oceanic and Atmospheric Administration
O ₃	Ozone
PFCs	Perfluorocarbons
ppm	Parts per million
PR	Production Right
PUFA	Polyunsaturated fatty acids
PV	Photovoltaic
RCA4	Rosby Centre regional model
RCPs	Representative Concentration Pathways
SAAELIP	South African Atmospheric Emission Licensing and Inventory Portal
SAAQIS	South African Air Quality Information System
SACNASP	South African Council for Natural Scientific Professions
SAGERS	South African Greenhouse Gas Emission Reporting System
SAWS	South African Weather Services
SF ₆	Sulfur hexafluoride
SPI	Standardized Precipitation Index
SSP	Shared Socioeconomic Pathway
SST	Sea surface temperatures
t	Tonne
TCFD	Taskforce for Climate-related Financial Disclosures
TJ	Terajoule
ton/ha	Tonne per hectare
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute
%	Percent

Note:

The spelling of “sulfur” has been standardised to the American spelling throughout the report. “The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, published, in 1990, a list of standard names for all chemical elements. It was decided that element 16 should be spelled “sulfur”. This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the “Gold Book”). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: <http://goldbook.iupac.org> (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.[doi: 10.1351/goldbook](https://doi.org/10.1351/goldbook))”

1 INTRODUCTION

Environmental Impact Management Services (Pty) Ltd (EIMS) were requested by D3 Energy South Africa (Pty) Ltd (D3 Energy) to undertake an Environmental Impact Assessment (EIA) process for their planned new Production Right (PR) area. The proposed PR area falls within a portion of the previously assessed ER315 (exploration right). Further, some of the activities being proposed by D3 Energy to be included in the production right, overlap with those previously assessed and authorised for the ER315 Amendment (specifically the northwestern part of the PR area). In brief the production activities will include the following:

- Provision for ongoing exploration drilling and seismic activities (preliminary seismic transects defined by the blue dashed lines in **Figure 1-1**).
- Existing wells may be 'worked over' and possibly included as production sites.
- Drilling and producing from approximately 43 production wells within the 4 identified well production corridors (as indicated in **Figure 1-1**). The intention being to assess these corridors in detail during the EIA process to allow for drilling and production within these corridors (assume a corridor width of 500 m).
- The installation of trenched sub-surface gas gathering pipelines (as indicated in **Figure 1-1**).
- The pipeline network will transport gas to a local production plant (either option A, B or C) located at approximately the positions indicated by the blue stars in **Figure 1-1**. The gas will be compressed to deliver compressed helium and methane and/or as an alternative where the gas will be liquified to produce Liquefied Natural Gas (LNG) and Liquefied Helium (LHe).
- Gas to power capacity of approximately 3 MW.

An alternative layout is also proposed (**Figure 1-2**).

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by EIMS to undertake a Climate Change Assessment (CCA) for the proposed D3 Energy Production Right Application (PR16) (hereafter referred to as the project). This report details the findings of the CCA undertaken for the project.

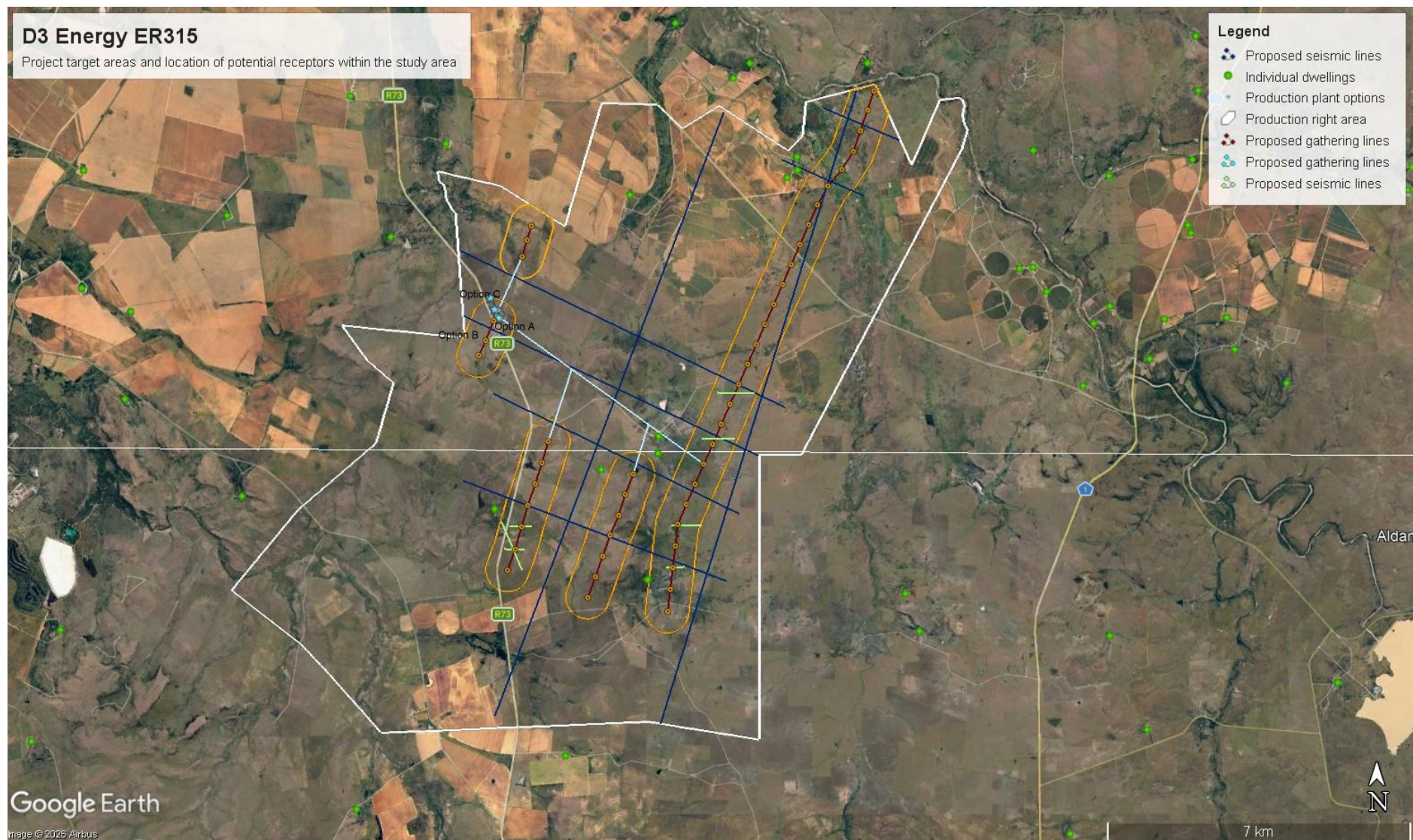


Figure 1-1: Location of the project site

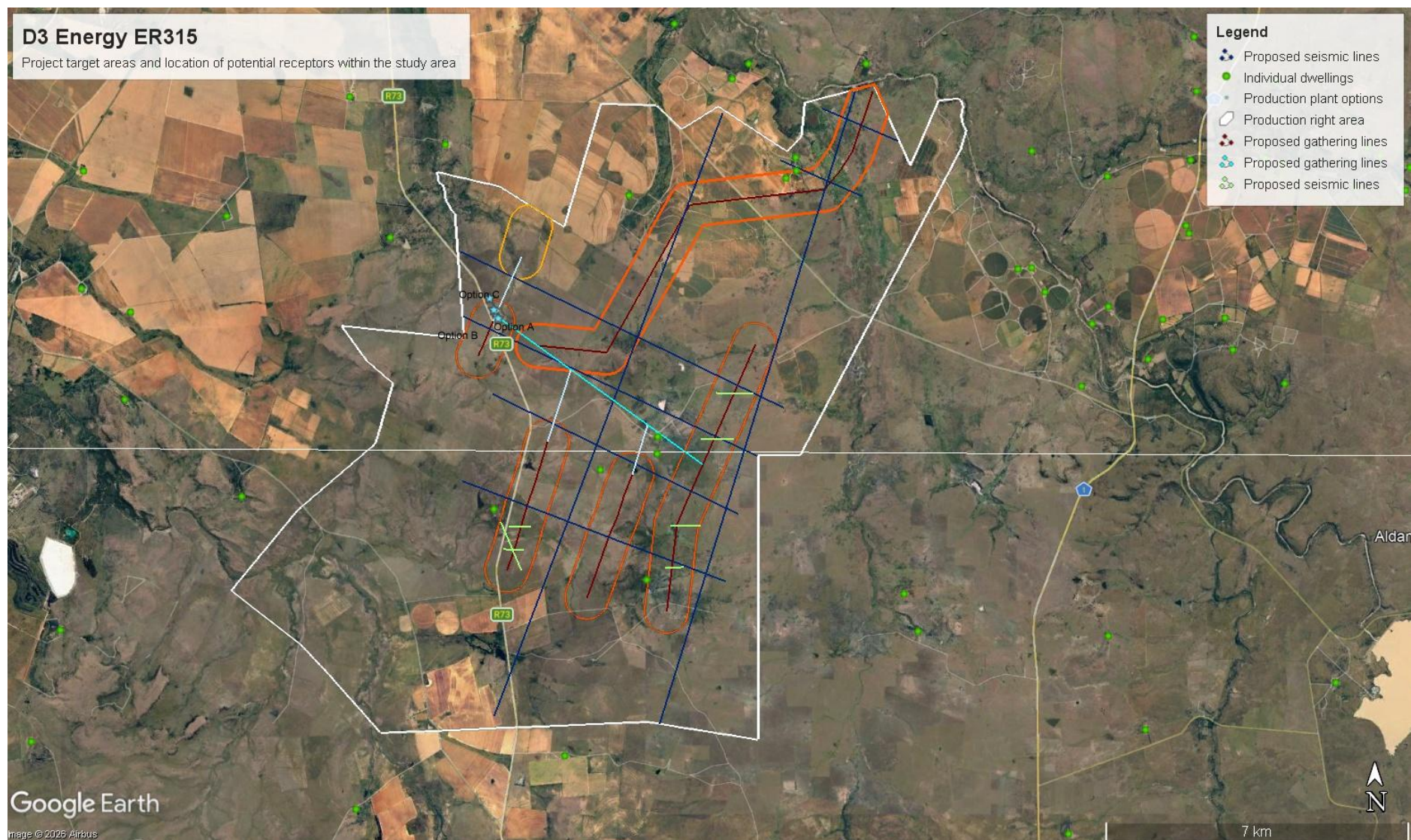


Figure 1-2: Location of the project site (alternative 1)

1.1 Scope of Work

The scope of work included a desktop Climate Change Assessment in line with the Consultation on Intention to Publish the National Guideline for Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licenses, and Waste Management Licenses, by:

1. Quantifying the greenhouse gas (GHG) emissions during the construction, operation, closure and decommissioning phases of the project compared to the global and national emission inventories; and compared to international benchmarks for the project.
2. Discussing the robustness of the project in terms of forecasted climate change impacts to the area over the lifetime of the project.
3. Discussing the vulnerability of communities in the immediate vicinity of the project to climate change.
4. Proposing management and mitigation strategies.
5. Preparation of a climate change statement report.

1.2 Specialist Details

1.2.1 Statement of Independence

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.2.2 Competency Profile – Gillian Petzer (*Pr. Eng., BEng Chemical (University of Pretoria)*)

Gillian Petzer started her professional career in Air Quality in 2000 when she joined British Research Establishment (BRE) in the UK after completing her Bachelor's Degree in Chemical Engineering at the University of Pretoria. She joined Airshed Planning Professionals in 2003, and is now a principal consultant at the company.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

Gillian is also actively involved in the National Association for Clean Air (NACA), is a member of the Institution of Chemical Engineers (IChemE) and is a registered Professional Engineer with the Engineering Council of South African (ECSA) (registration no. 20170315).

A comprehensive curriculum vitae of Gillian Petzer is provided in Appendix A.

The declaration of independence for Gillian Petzer is provided in Appendix B.

2 REGULATORY CONTEXT AND IMPACT ASSESSMENT CRITERIA

GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property is known as the greenhouse effect. Water vapour (H₂O), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄) and ozone (O₃) are the primary greenhouse gases in the earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO₂, N₂O and CH₄, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF₆), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 425.8 ppm in June 2025 (Lan, Tans, & Thoning, 2025). This increase of CO₂ in the Earth's atmosphere has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle (Lan, Tans, & Thoning, 2025). Anthropogenic CO₂ emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with waste processing and decomposition, deforestation, soil erosion and animal agriculture (IPCC, 2007).

The following sections describe the alignment of South African national policies regarding GHG emissions and reporting with international agreements and targets.

2.1 International Agreements

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, (UNFCCC) as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable.

By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed country parties to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. As agreed in Doha in 2012, the second commitment period began on 1 January 2013 and ended in 2020 (UNFCCC, 2017). The Doha Amendment to the Kyoto Protocol formally entered into force on December 31, 2020, exactly on the final day of the second commitment period it established.

The Paris Agreement (2016) builds upon the Convention and – for the first time – brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2.0°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

The Paris Agreement requires all Parties to put forward their best efforts through “nationally determined contributions” (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.

In 2018, Parties took stock of the collective efforts in relation to progress towards the goals set in the Paris Agreement to inform the preparation of NDCs. There will also be a global stocktake every five years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties.

As of September 2024, 195 Parties of the 197 Parties to the UNFCCC, including South Africa, had ratified the Paris Agreement. South Africa submitted its NDC to the UNFCCC on 25 September 2016 and an updated first NDC in September 2021. In July 2025, a draft of the second NDC was gazetted (Government Gazette (GG) 53092) for public comment, and in October 2025 a final second NDC was submitted to the UNFCCC.

On January 20, 2025, an executive order was signed by the United States President to withdraw the United States from the Paris Agreement.

2.2 South Africa's Low Emission Development Strategy 2050

Article 4 of the Paris Agreement sets out NDCs as the instrument countries must develop to present their part of the global effort to reach global peaking of greenhouse gas emissions as soon as possible on the basis of equity and in the context of sustainable development and efforts to eradicate poverty. To help ensure that the Parties national contributions can jointly achieve the collective goal, the Article further states that Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

In response to the Paris Agreement, South Africa prepared a Low Emission Development Strategy in February 2020, reiterating our country's commitment to achieving the Paris goals.

The strategy identifies 4 main sectors for GHG emission mitigation: energy (supply and demand), industry, agriculture/forestry/land use (AFOLU), and waste.

- Energy Supply
 - Driven by the Integrated Energy Plan and Integrated Resource Plan, focusing on diversifying the energy mix, increasing renewables, and planning for coal plant decommissioning.
 - Biofuels Industrial Strategy aims to introduce biofuels into the liquid fuel supply, with regulations for blending but limited implementation so far.
- Energy Demand
 - National Energy Efficiency Strategy sets targets for energy efficiency improvements across sectors.
 - Promotion of cleaner mobility through public transport strategies, Green Transport Strategy, and CO₂ taxes on vehicles.
- Industry

- Industrial Policy Action Plan supports green industry investment, resource efficiency, and cleaner production.
- Tax incentives encourage renewable energy, energy efficiency, and pollution control investments.
- AFOLU
 - Policies promote conservation agriculture, afforestation, agroforestry, and reducing emissions from deforestation and forest degradation (REDD+) initiatives to enhance carbon sinks and reduce emissions.
- Waste
 - National Environmental Management: Waste Act and National Waste Management Strategy promote waste reduction, recycling, and landfill diversion.

Other cross-cutting measures listed in the strategy include:

- Carbon Tax;
- Sectoral Emissions Targets;
- Carbon Budgets; and,
- Phasing Out Fossil Fuel Subsidies.

2.3 South African National Climate Change Response Policy

South Africa ratified the UNFCCC in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is a non-Annex I country, it implies no binding commitment to cap or reduce GHG emissions. South Africa later also ratified the Paris Agreement (as signed on 22 April 2016) which although not bound to commit to a cap or reduce GHG emissions, pledged to reduce emissions by 34% below Business-As-Usual (BAU) emissions by 2020 and 42% below BAU by 2025. The proposed 2030 target range represents a 28% reduction in GHG emissions commitment from the original 2015 NDC targets. However, these original goals were ambitious, and South Africa subsequently shifted from BAU-based targets for 2020 and 2025 in terms of the Cancun Agreement under the UNFCCC, to absolute GHG emissions targets under the Paris Agreement. This update demonstrates reducing the upper range of South Africa's targets by a more realistic 17% for 2025 and 28% for 2030, respectively.

The National Climate Change Response White Paper, passed by Cabinet in October 2011, stated that in responding to climate change, South Africa has two objectives: to manage the inevitable climate change impacts and to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system. The White Paper proposes mitigation actions, especially a departure from coal-intensive electricity generation, be implemented in the short- and medium-term to match the GHG trajectory range. Peak GHG emissions are expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions.

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone, and sulfur dioxide concentrations to levels in compliance with the National Ambient Air Quality Standards (NAAQS) by 2020. To achieve these objectives, the

Department of Forestry, Fisheries and the Environment (DFFE) established a national GHG emissions inventory that reports through the South African Atmospheric Quality Information System (SAAQIS).

The Climate Change Act (Act 22 of 2024) was assented to by the President of the Republic of South Africa on 23 July 2024 in Government Notice (GN) 5050 in GG 50966 of 23 July 2024. The President proclaimed its commencement under section 38 on 17 March 2025; however not all provisions are in force. The Act is aligned with international policies guidelines and South Africa's NDC and aim to reduce GHG emissions as primary driver to anthropogenic climate change. The aim of the Act is to achieve an effective climate change response through a long-term just transition to a low carbon economy that is climate resilient and allows for sustainable development of South Africa. When in force, the Act will:

- establish provincial and municipal forums on climate change which will be responsible for co-ordinating climate change response actions in each province.
- strengthen the establishment of the Presidential Climate Change Coordinating Commission. Although, the commission has already been established, its establishment only carries legal force after the Bill becomes an Act.
- establish a National Adaptation Strategy to guide South Africa's adaptation to the impacts of climate change and develop adaptation scenarios which anticipate the likely impacts over the short, medium, and long term.
- determine a national GHG emissions trajectory, which must be reviewed every five years, and which indicates an emissions reduction objective.
- put in place a 5-yearly sectoral emission targets for identified sectors and sub-sectors that must be aligned with the national GHG emissions trajectory and include quantitative and qualitative GHG emission reduction goals.
- bring into force the carbon budget allocation mechanism, which will be linked to the Carbon Tax Act, which will replace the current National Pollution Prevention Plan mechanism which is enforced under the National Environmental Management: Air Quality Act (NEM:AQA).

2.4 Nationally Determined Contribution

The first South African NDC submission was completed in 2016. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCCC. An update of the first NDC was published submitted to the UNFCCC on 27 September 2021¹ in preparation for the 26th Conference of the Parties (held in Glasgow, Scotland in November 2021). This document describes South Africa's NDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions with updated revisions to the adaptation goals and mitigation targets.

1

<https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/South%20Africa%20First/South%20Africa%20updated%20first%20NDC%20September%202021.pdf>

As part of the updated adaption portion the following goals have been assembled:

- Goal 1: Enhance climate change adaptation governance and legal frameworks.
- Goal 2: Develop an understanding of the impacts on South Africa of 1.5 and 2°C global warming and the underlying global emission pathways through geo-spatial mapping of the physical climate hazards, and adaptation needs in the context of strengthening the key sectors of the economy. This will provide the scientific basis for strengthening the national and provincial governments' readiness to respond to climate risk.
- Goal 3: Implementation of National Climate Change Adaptation Strategy adaptation interventions for the period 2021 to 2030, where priority sectors have been identified as biodiversity and ecosystems; water; health; energy; settlements (coastal, urban, rural); disaster risk reduction, transport infrastructure, mining, fisheries, forestry, and agriculture.
- Goal 4: Mobilise funding for adaptation implementation through multilateral funding mechanisms.
- Goal 5: Quantification and acknowledgement of the national adaptation and resilience efforts.

As part of the mitigation portion the following have been, or can be, implemented at National level:

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer projects as part of a Renewable Energy Independent Power Producer Procurement Programme. An additional 6 300 MW is being deliberated.
- A "Green Climate Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS).
- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be achieved through the use of energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar photovoltaic (PV); wind power; CCS; and advanced bioenergy.
- Updated targets based on revised 100-year global warming potential (GWP) factors (published in the Annex to decision 18/CMA.1 of the Intergovernmental Panel on Climate Change's (IPCC) 5th assessment report) (AR5) and based on exclusion of land sector emissions arising from natural disturbance. The first NDC mitigation targets, consistent with South Africa's fair share, are presented in Table 2-1.

Table 2-1: South Africa's first NDC mitigation targets

Year	Target	Corresponding period
2025	South Africa's annual GHG emissions will be in a range between 398 - 510 Mt CO ₂ e.	2021-2025
2030	South Africa's annual GHG emissions will be in a range between 350 - 420 Mt CO ₂ e.	2026-2030

The draft second South African NDC was gazetted in July 2025 (GG 53092) for public comment. This draft set out to update South Africa's climate change mitigation targets and adaptation goals for 2026-2030 and 2031-2035

period, in line with national development priorities and international obligations. The final second NDC (NDC2) was submitted to the UNFCCC in October 2025.

As part of the updated adaption portion the following goals have been assembled:

1. Goal 1: Adapt South Africa's water and sanitation systems to drying conditions and drought and flood intensification, as water underpins human, plant and animal health and all economic and livelihood activities.
2. Goal 2: Enhance disaster risk management, healthcare and sanitation provision, especially in informal settlements, to reduce impacts of flooding and heat stress on most vulnerable households.
3. Goal 3: Upgrade critical transport infrastructure (roads, rail, ports) to maintain functioning under increased rainfall intensity, heat stress, wind speeds and storm surges.
4. Goal 4: Enhance nutritious food access and affordability through support to agricultural and fisheries producers and distributors in adapting to warmer and windier conditions and changes in rainfall.
5. Goal 5: Enhance climate services, with early warning and impact information made accessible to a wide range of users, tailored to different operational, language, gender, age and disability needs.
6. Goal 6: Enhance ecosystem-based adaptation to heat and water stress, protecting South Africa's natural heritage, biodiversity and improving ecosystem functioning that under plans our cultural identity, food systems, human wellbeing and our tourism economy.
7. Goal 7: Capacitate all spheres of government to implement adaptation through enacting and enforcing all provisions of the Climate Change Act.
8. Goal 8: Enhanced efforts to build climate resilient human settlements and resilient infrastructure.

South Africa's updated mitigation target is presented in Table 2-2.

Table 2-2: South Africa's mitigation target in its second NDC

Period of implementation	Target
2031 – 2035	South Africa's annual GHG emissions will be in a range from 320 – 380 Mt CO ₂ e in 2035.

2.5 Greenhouse Gas Emissions Reporting

Regulations pertaining to GHG reporting using the National Atmospheric Emission Inventory System (NAEIS) were published on 3 April 2017 (GN 257 in GG 40762 and amendment – GNR 994 in Government Gazette 43712). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only. The three broad scopes for estimating GHG are:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

The South African Greenhouse Gas Emission Reporting System (SAGERS) monitoring and reporting system is used to collect GHG information in a standard format for comparison and analyses. The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP).

The DFFE is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the IPCC's default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Methodological guidelines for GHG emission estimation, which include country specific emission factors for fuels used in stationary and mobile combustion, have been issued (DFFE, 2022b).

Also, the Carbon Tax Act (Act 15 of 2019) includes details on the imposition of a tax on the carbon dioxide equivalent (CO₂e) of GHG emissions. Certain production processes indicated in Annexure A of the Declaration of Greenhouse Gases as Priority Pollutants (GN 710 in GG 40966, 21 July 2017) with GHG more than 0.1 Mt/year, measured as CO₂e, are required to submit a greenhouse gas mitigation plan to the Minister for approval.

The proposed project will be required to report CO₂e emissions.

2.6 GHG Inventories

2.6.1 National GHG Emissions Inventory

South Africa is a GHG contributor and is undertaking steps to mitigate and adapt to the changing climate. DFFE is categorised as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption and evaluation strategies (DFFE, 2022a). This includes the establishment and updating of the National GHG Inventory. The National Greenhouse Gas Improvement Programme (GHGIP) has been initiated; it includes sector specific targets to improve methodology and emission factors used for the different sectors as well as the availability of data.

The 2022 National GHG Inventory was prepared using the 2006 IPCC Guidelines (IPCC, 2006). According to the 9th National GHG Inventory Report (DFFE, 2025), the total GHG emissions in 2022 were estimated at approximately 478.3009 Mt CO₂e (excluding Land Use, Land Use Change and Forestry (LULUCF)). This was a 2.9% decrease from the 2000 total GHG emissions (excluding LULUCF). LULUCF is estimated to be a net carbon sink which reduces the 2022 GHG emissions to 435.1196 Mt CO₂e. The assessment (excluding LULUCF) showed the main sector contributing to GHG emissions in 2022 to be the energy sector, contributing 78% to the total GHG emissions.

2.6.2 GHG Emission Inventory for the Sector

The proposed project would be categorised in the energy category for both the global GHG inventory and for the national GHG inventory. According to the World Resources Institute (WRI) – Climate Analysis Indicators Tool,

(CAIT) Climate Data Explorer² (as accessed in April 2026 and using the Climate Watch data source) the 2023 global GHG emissions from the energy category were approximately 38 990.40 Mt CO₂e; 76.7% of the total GHG emissions (including Land-Use Change and Forestry (LUCF)). The South African energy sector contributed 406.99 Mt CO₂e, ~1.04% of the global emissions from the energy sector in 2023.

2.6.3 *Draft National Guideline for Consideration of Climate Change in Development Applications*

The DFFE published (on 25 June 2021) a notice under the NEMA requesting public comment on the *Draft National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisation, Atmospheric Emission Licences and Waste Management Licences*. On 24 October 2025, the DFFE published a revised draft for a second round of public comment in GN 6759 in GG 53574.

The Draft National Guideline has been developed to support the inclusion of climate change considerations into the EIA process, and to create a consistent approach for such incorporation, which will help proponents to assess:

- how a proposed development will likely exacerbate climate change;
- the impact of a development on features (natural and built) that are crucial for climate change adaptation and resilience; and,
- the sustainability of a development in the context of climate change projection.

The Guideline puts forward “a consistent approach in providing interested and affected parties (for example, proponents, Environmental Assessment Practitioners (EAPs) and specialists) with the minimum requirements to consider when undertaking a climate change assessment, which forms part of an application for environmental authorisation, an atmospheric emissions licence, and/or waste management licence”.

One of the impact requirements for a climate change assessment is an estimation of the GHG emissions, direct and indirect (including upstream GHG emissions) that will be released into the atmosphere annually throughout the impact related to the activity.

The comment period for amendments to the draft guideline has now closed but the final guideline has not yet been published. As far as possible the guideline has been followed in the preparation of this climate change impact assessment in support of environmental authorisation.

² <http://cait.wri.org/>

3 PHYSICAL RISKS OF CLIMATE CHANGE ON THE REGION

The discussions of physical risks of climate change discussed in this section are likely to be relevant to the project as well as to the communities surrounding the project, even if the project is not authorised.

3.1 Vulnerability

The Green Book (CSIR, 2025); was developed to be an online platform providing quantitative scientific evidence on the likely impacts that climate change and urbanisation will have on South Africa's cities and towns. A profile for each local municipality, including individual settlements and neighbourhoods, was built in terms the rates of socio-economic, economic, physical and environmental risks associated with urbanisation, population growth and climate change (Le Roux, et al., 2019). The risk profile was accessed for the Matjhabeng and Masilonyana Municipalities³.

The Matjhabeng Municipality socio-economic vulnerability score⁴ (out of 10) is 5.3 for 1996, reducing to 4.2 for 2011. The lower score in 2011 compared to 1996 indicates improvement of socio-economic factors. The Matjhabeng Municipality for socio-economic vulnerability ranks 4th out of 19 in the province and 81st out of 213 in the country. The Matjhabeng Municipality economic vulnerability score⁵ (out of 10) is 7.7 for 1996, increasing to 9.9 for 2011. The economic vulnerability ranks 19th out of 19 in the province and 211th out of 213 in the country. The physical vulnerabilities⁶ ranks 4th out of 19 in the province and 50th out of 213 in the country. The environmental vulnerability⁷ ranks 13th out of 19 in the province and 102nd out of 213 in the country.

The Masilonyana Municipality socio-economic vulnerability score (out of 10) is 6.7 for 1996, reducing to 5.8 for 2011. The lower score in 2011 compared to 1996 indicates improvement of socio-economic factors. The Masilonyana Municipality for socio-economic vulnerability ranks 15th out of 19 in the province and 141st out of 213 in the country. The Masilonyana Municipality economic vulnerability score (out of 10) is 7.4 for 1996, increasing to 8.7 for 2011. The economic vulnerability ranks 18th out of 19 in the province and 202nd out of 213 in the country. The physical vulnerabilities ranks 6th out of 19 in the province and 57th out of 213 in the country. The environmental vulnerability ranks 2nd out of 19 in the province and 31st out of 213 in the country.

3 <https://riskprofiles.greenbook.co.za/>

4 Defined as the vulnerability of households based on household composition; education and health; access to basic services; safety and security.

5 Defined as the susceptibility of the municipality to external shocks based on economic diversity; size of economy; labour force; gross domestic product (GDP) growth rate; and inequality.

6 Defined by the physical fabric of connectedness of the settlements within the municipalities and structural robustness.

7 This indicator represents the balance between preserving the natural environmental and the pressures of population growth, urbanisation, and economic development. The indicator is based on air quality, environmental governance and competition between ecology and the urban environment.

3.2 Climate

3.2.1 Baseline Climate

Climate change metrics focus on temperature; the number of very hot days (where temperatures exceed 35°C); and rainfall. The baseline (1961 to 1990) annual averages for these metrics were accessed for the area near the project site from the South Africa 'Green Book'⁸ (CSIR, 2025).

Baseline annual average temperature was 15.9°C (**Figure 3-1**) with three very hot days per year and seven heat wave days per year (**Figure 3-2**). Average annual rainfall (**Figure 3-1**) was 1 099 mm.

⁸ <https://greenbook.co.za/>

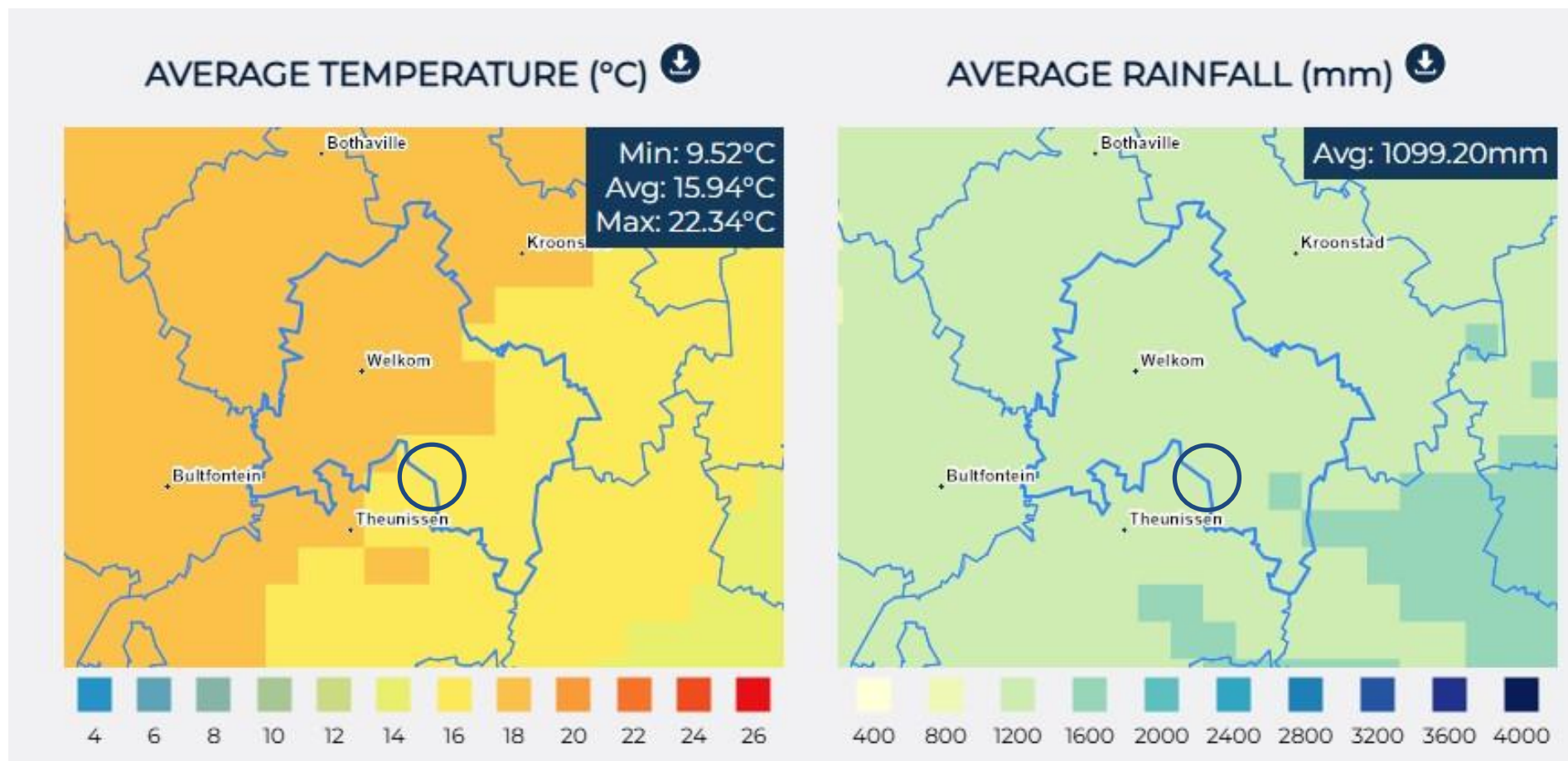


Figure 3-1: Baseline (1961 to 1990) annual average temperature and rainfall for the project area (CSIR, 2025) (dark blue marker indicates approximate location of the project)

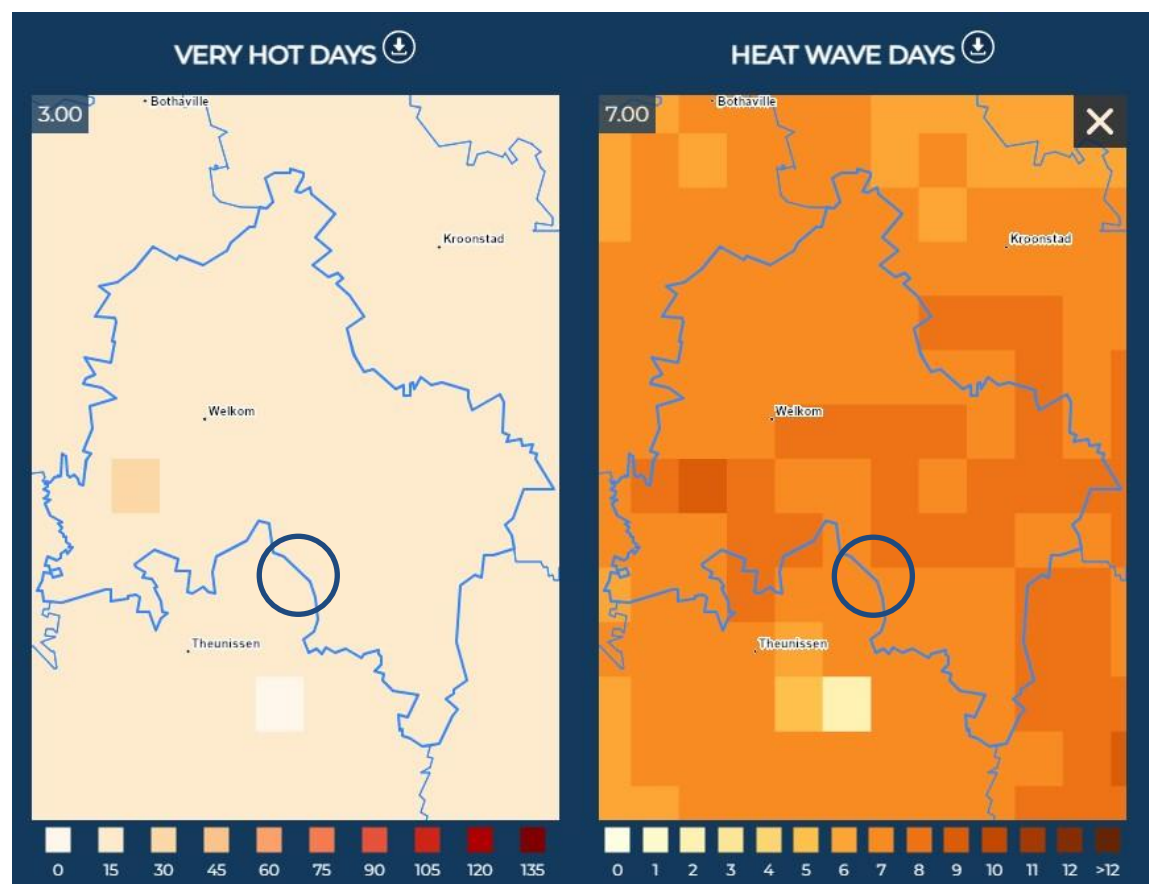


Figure 3-2: Baseline (1961 to 1990) number of very hot days (>35°C) and heat wave days¹ annually for the project area (CSIR, 2025) (dark blue marker indicates approximate location of the project)

¹ The annual heat-wave days map depicts the number of days (per 8x8 km grid point) where the maximum temperature exceeds the average maximum temperature of the warmest month of the year at that location by 5°C, for a period of at least three consecutive days.

Recent change in climatic conditions near the project site were accessed from MeteoBlue¹ a weather forecasting platform developed at the University of Basel, Switzerland and based on models of National Oceanic and Atmospheric Administration (NOAA) or National Centres for Environmental Prediction (NCEP). The data sets also include historical climate data tracking changes in climate by referencing ERA5, the fifth generation ECMWF (European Centre for Medium-Range Weather Forecasts) atmospheric reanalysis of the global climate, for the period between 1979 to 2024, with a spatial resolution of 30 km. Based on the study area, an increasing trend in the annual average temperatures has been observed with temperatures measuring 16.7°C in 1979 to 18.1°C in 2024 (**Figure 3-3** – top panel). The lower part the graph shows the so-called warming stripes. Each coloured stripe represents the average temperature for a year - blue for colder and red for warmer years.

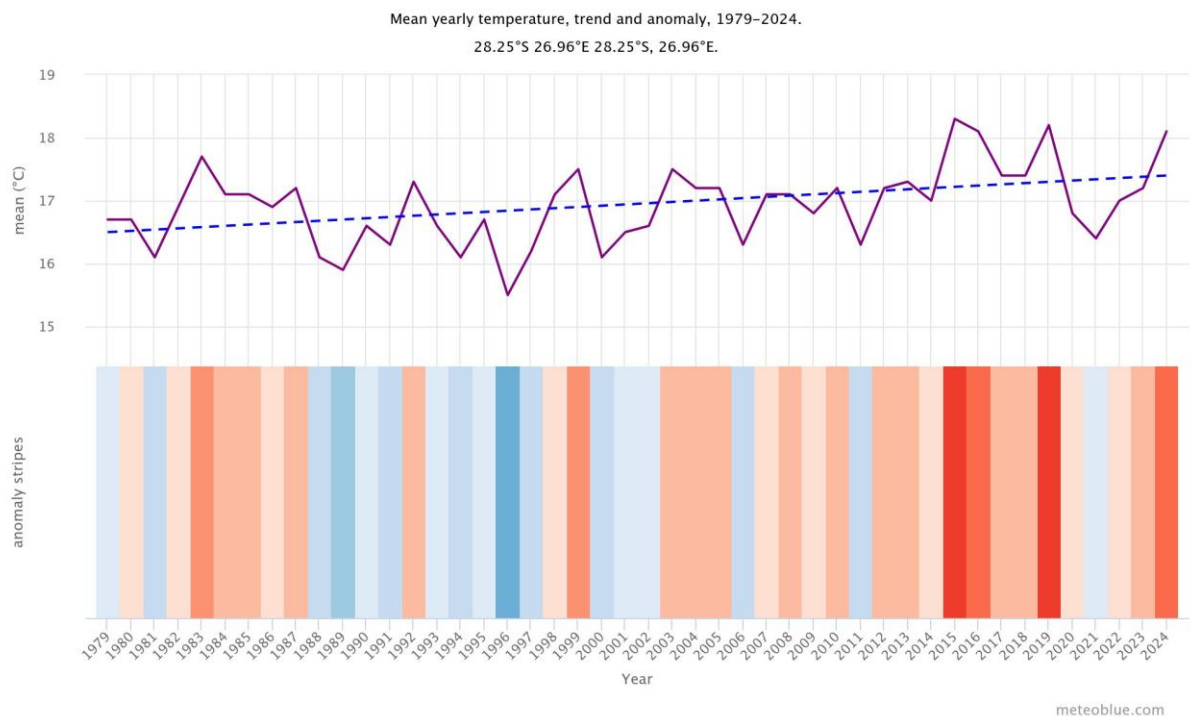


Figure 3-3: Annual average temperature (top panel) and temperature anomaly (lower panel) between 1979 and 2024 (Meteoblue, 2025)

The change in rainfall over the same period (1979 – 2024) displays a slight decreasing trend (**Figure 3-4**), where the difference from long-term average for each year in the data set is visualised by the stripes in the lower panel of Figure 3-4 (brown stripes indicate lower than average rainfall and green stripes above average rainfall).

¹ <https://www.meteoblue.com>

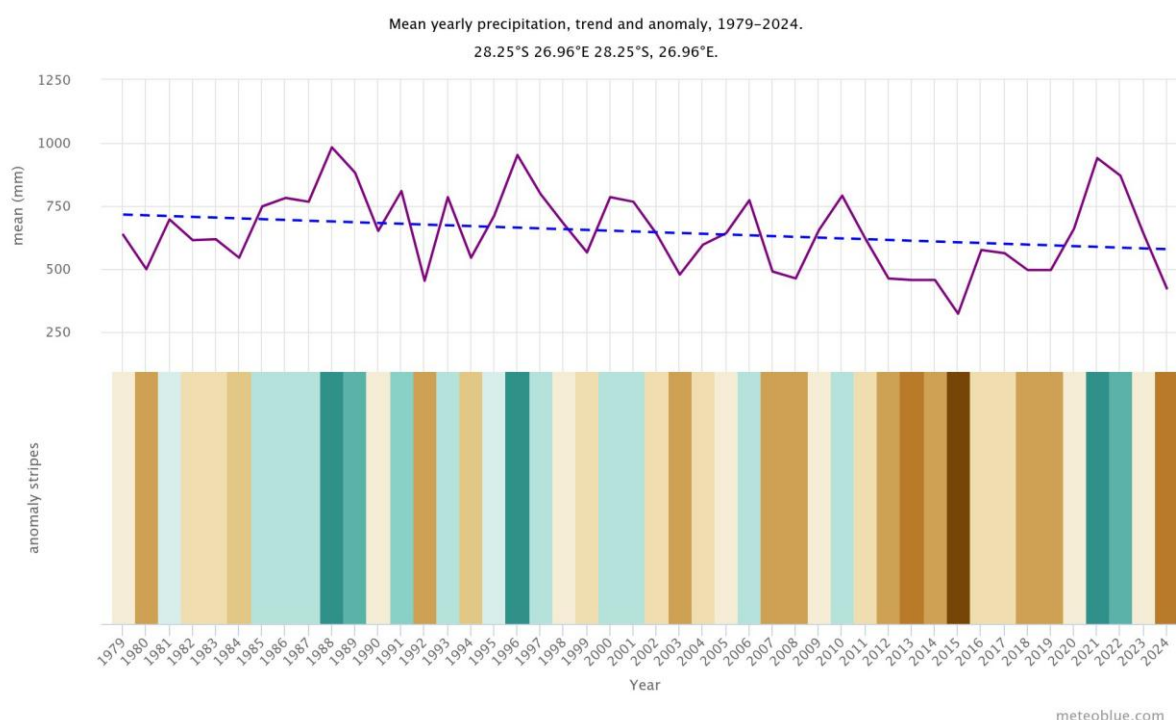


Figure 3-4: Annual average rainfall (top panel) and rainfall anomaly (lower panel) between 1979 and 2024 (Meteoblue, 2025)

3.2.2 Projected Future Climate

In 2017 the South African Weather Services (SAWS) published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections (SAWS, 2017). It must be noted that as with all atmospheric models, there is the possibility of inaccuracies in the results because of the model's physics and accuracy of input data. The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to $0.44^{\circ} \times 0.44^{\circ}$ - the finest resolution GCMs in the ensemble were run at resolutions of $1.4^{\circ} \times 1.4^{\circ}$ and $1.8^{\circ} \times 1.2^{\circ}$. Findings from downscaled climatic simulations using six GCMs, at an $8 \text{ km} \times 8 \text{ km}$ resolution over South Africa, for the time slab 2021 to 2050 were included in the Green Book (Engelbrecht, 2019).

In both the CCRA and the Green Book, two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions being sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions being implemented (after 2100 the concentration is expected to continue to increase).

3.2.2.1 RCP4.5 Trajectory

The Green Book projected temperature changes in the near future (up to 2050) indicate an average increase of 2.3°C (**Figure 3-5**, Engelbrecht, et al., 2019). The number of very hot days are expected to increase by 8.5 days per year (**Figure 3-6**). Between 2021 and 2050 the annual rainfall near the project site was projected to increase by 163 mm (**Figure 3-7**, Engelbrecht, et al., 2019), with extreme rainfall days potentially increasing by 2.2 days in the near future (**Figure 3-8**, Engelbrecht, et al., 2019).

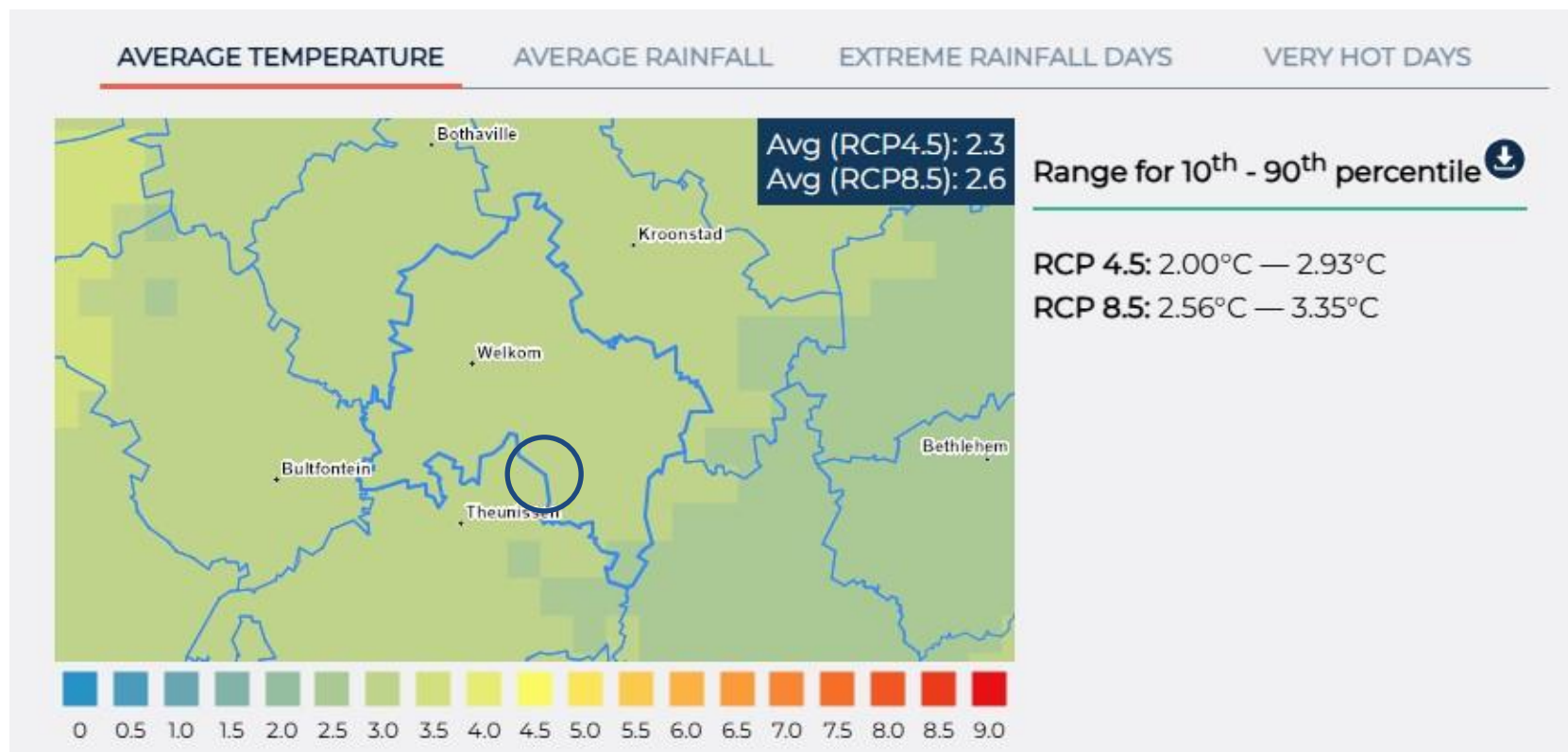


Figure 3-5: Projected change in annual average temperature for the near future (2021 – 2050) (dark blue marker indicates approximate location of the project)

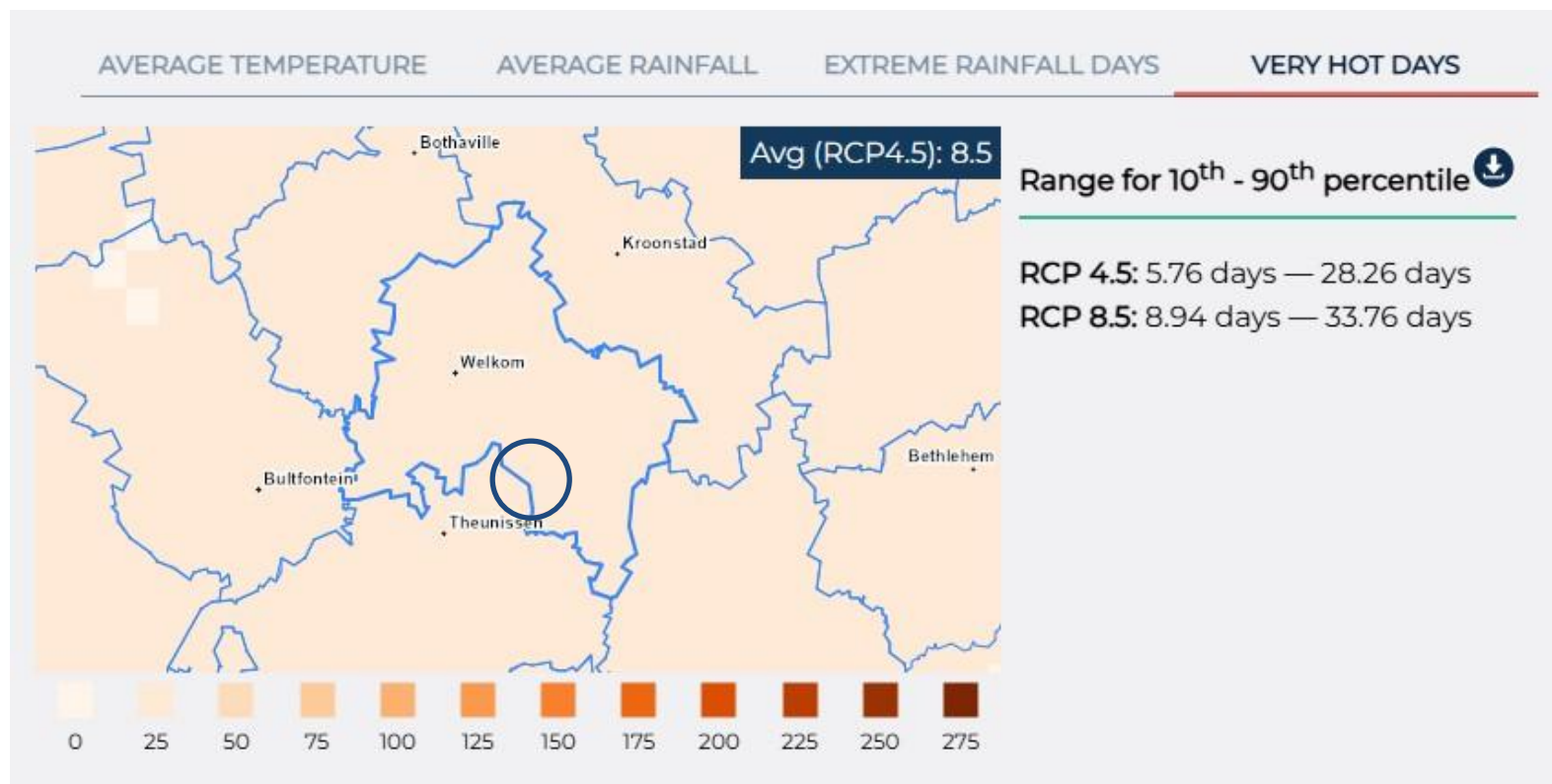


Figure 3-6: Projected change in annual average number of very hot days for the near future (2021 – 2050) (dark blue marker indicates approximate location of the project)

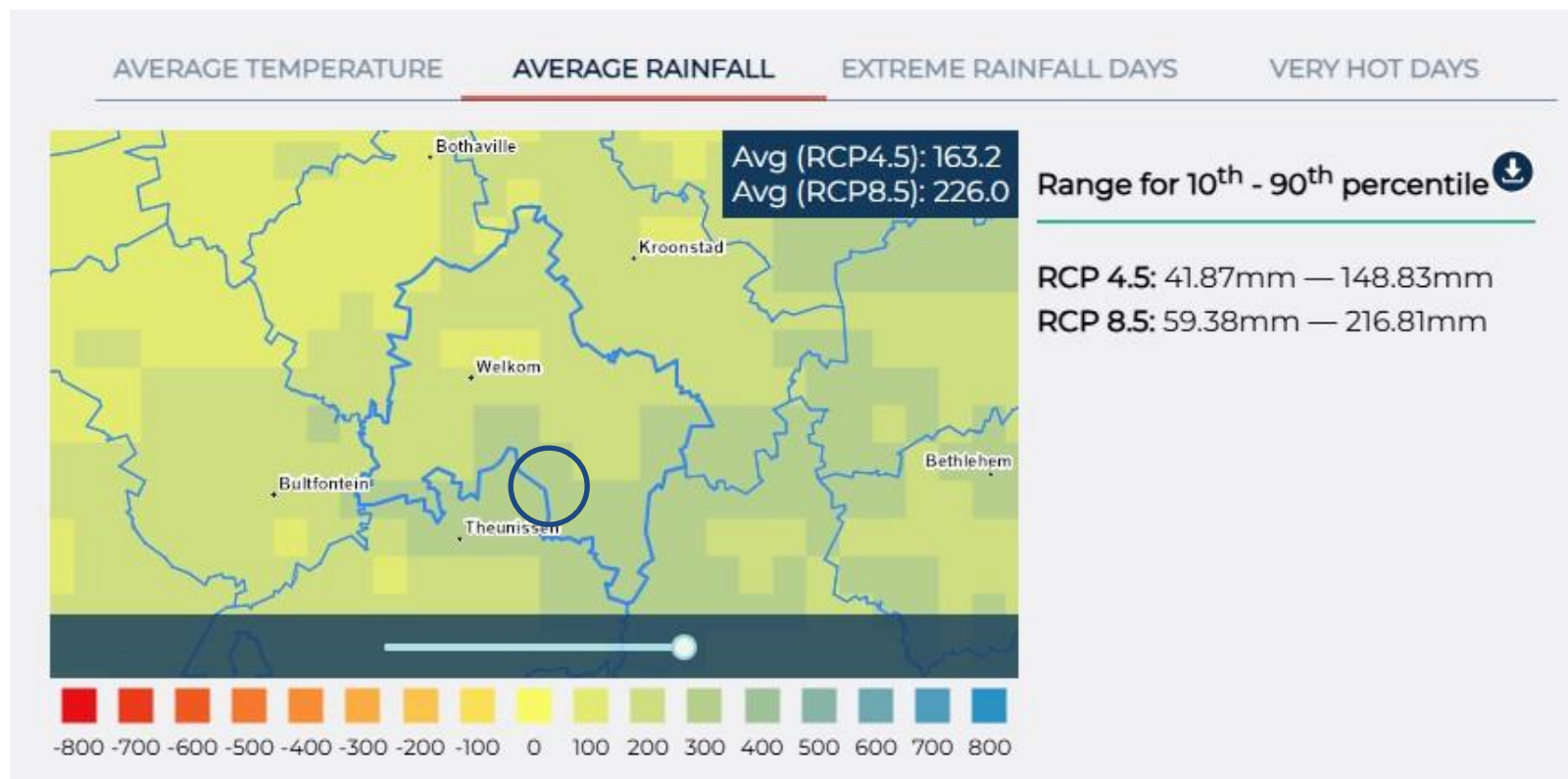


Figure 3-7: Projected change in annual average rainfall for the near future (2021 – 2050) (dark blue marker indicates approximate location of the project)

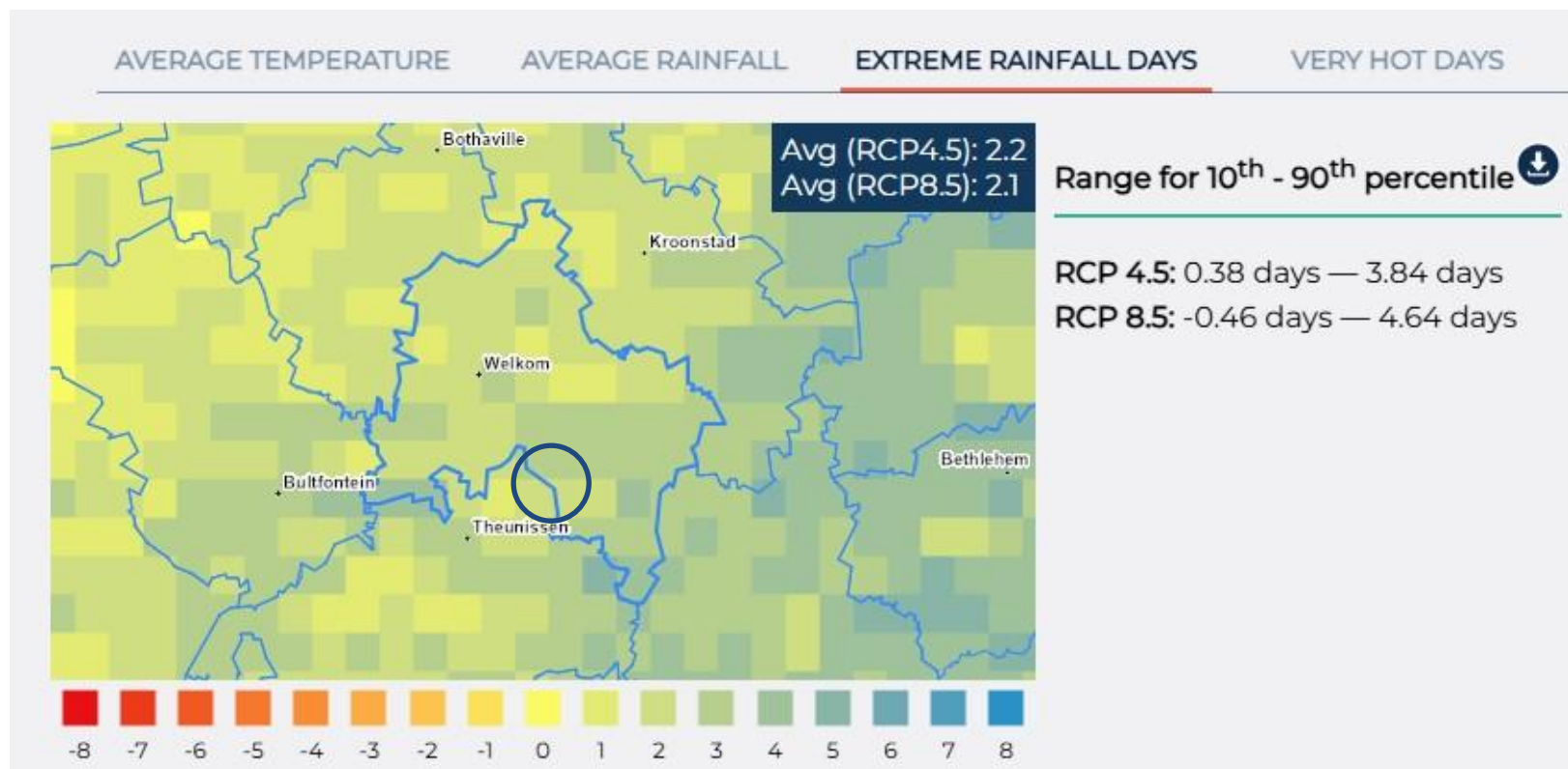


Figure 3-8: Projected change in annual average number of extreme rainfall days (>20 mm in <24 hours) for RCP4.5 trajectory (dark blue marker indicates approximate location of the project)

3.2.2.2 RCP8.5 Trajectory

The Green Book projected temperature changes in the near future (up to 2050) indicate an average increase of 2.6°C (**Figure 3-5**, Engelbrecht, et al., 2019). The number of very hot days are expected to increase to between 9 and 34 days per year. Between 2021 and 2050 the annual rainfall near the project site was projected to increase by 226 mm (**Figure 3-7**, Engelbrecht, et al., 2019), with extreme rainfall days potentially increasing by 2.1 days in the near future (**Figure 3-8**, Engelbrecht, et al., 2019).

3.2.2.3 IPCC's Sixth Assessment Report: Temperature and Rainfall Projections

The most recent IPCC data are from the Coupled Model Intercomparison Project (CMIP) which were derived from the sixth phase of the CMIPs (CMIP6) and supports the IPCC's Sixth Assessment Report (AR6) which was released on 9 August 2021 (Working Group I), 28 February 2022 (Working Group II and 4 April 2022 (Working Group III). Projection data is presented at a 1.0° x 1.0° (100 km x 100 km) resolution. The scenarios are the result of complex calculations that depend on how quickly humans curb greenhouse gas emissions, whilst also capturing socioeconomic changes in areas such as population, urban density, education, land use and wealth. For example, a rise in population is assumed to lead to higher demand for fossil fuels and water. Education can affect the rate of technology developments. Emissions increase when land is converted from forest to agricultural land. Each scenario is labelled to identify both the emissions level and the so-called Shared Socioeconomic Pathway, or SSP, used in those calculations. This first scenario is the only one that meets the Paris Agreement's goal of keeping global warming to around 1.5°C above preindustrial temperatures, with warming hitting 1.5°C but then dipping back down and stabilizing around 1.4°C by the end of the century. Projected changes are defined relative to a historical 20-year period (1995 to 2014).

The AR6 projections for the study area for the scenario RCP4.5 indicate an increase in annual average temperatures of 1.6°C for the period 2041 to 2060 and 2.3°C for the period 2081 to 2100. The projections for the RCP8.5 indicate an increase in annual average temperatures of 2.7°C for the period 2041 to 2060, to 5.3°C for the period 2081 to 2100 (IPPC, 2022). The AR5 projections, for comparison, estimate an increase in annual average temperatures (50th percentile) of 2.3°C for RCP4.5 and 2.6°C for RCP8.5 for the period 2021 to 2050.

The AR6 projections for rainfall in the study area for RCP4.5 indicate a decrease in annual rainfall of 5% for the period 2041 to 2060, to 6% for the period 2081 to 2100. The projections for RCP8.5 indicate a decrease in rainfall of 6% for the period 2041 to 2060, to 10% for the period 2081 to 2100 (IPPC, 2022).

It should be noted that the difference in precipitation projections between the various models (for e.g. Green Book and AR6) vary primarily by spatial resolution, geographic scope, forecast time horizon, and underlying physical or statistical physics.

3.3 Hazards

The Green Book risk profile includes an assessment of projected risk to the Matjhabeng and Masilonyana Municipalities in 2050, mostly based on the low mitigation RCP8.5 climate simulations, and highlights the following:

- Isolated pockets of moderate and high increased risk of wildfires within the municipalities, but not within the project area (**Figure 3-9**);
- Isolated pockets of very low risk of increased drought frequency within the municipalities and the Standardized Precipitation Index (SPI)¹ of -0.44 (**Figure 3-10**);
- Isolated pockets of high increased heat extremes within the municipalities (**Figure 3-11**); and,
- Areas of slight to moderate risk of increased extreme rainfall days within the project area (**Figure 3-12**).
- Isolated pockets of very low to moderate increase in exposure to urban flooding is expected for the municipalities (**Figure 3-12**).

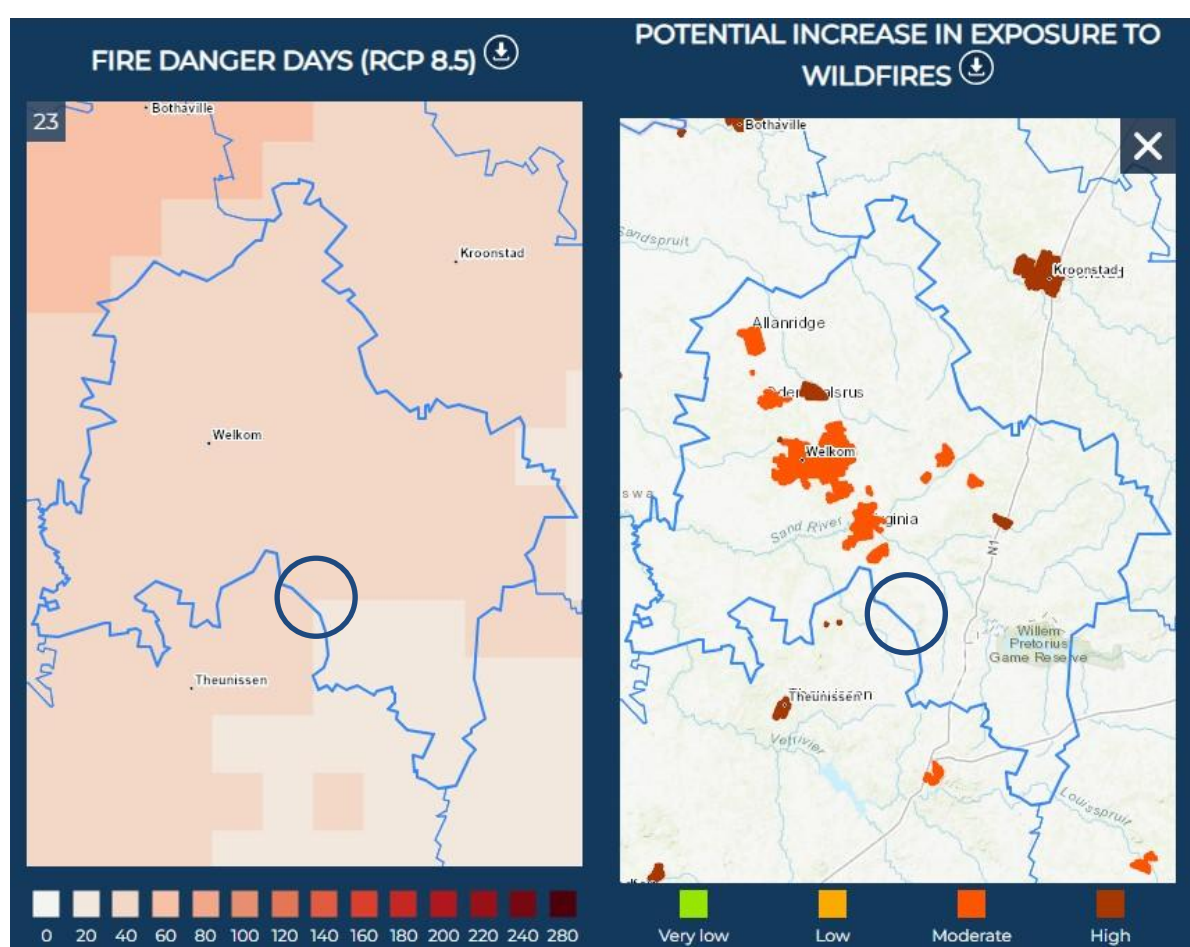


Figure 3-9: Risk of increased wildfires for the Matjhabeng and Masilonyana Municipalities in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

¹ The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought on a range of timescales. SPI index.

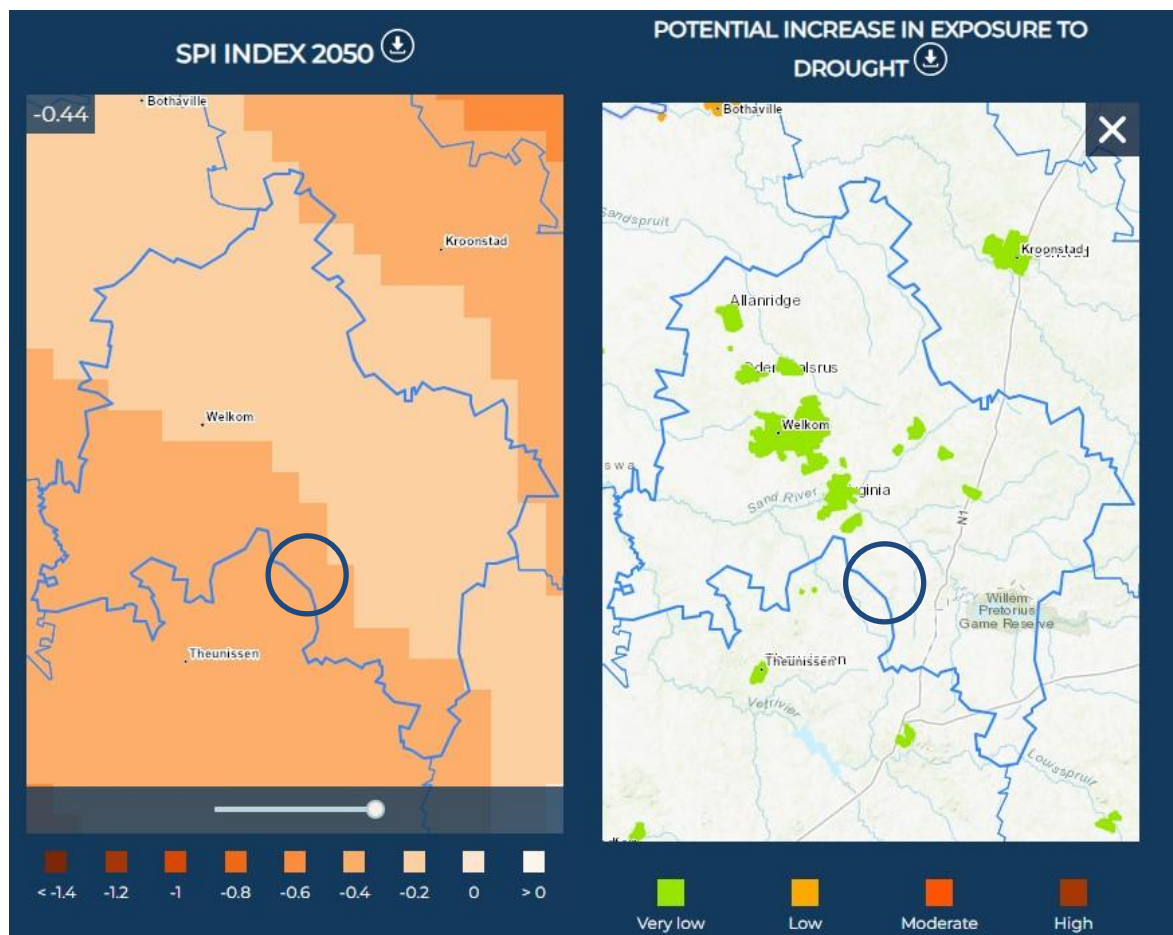


Figure 3-10: Risk of increased drought tendencies for the Matjhabeng and Masilonyana Municipalities in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

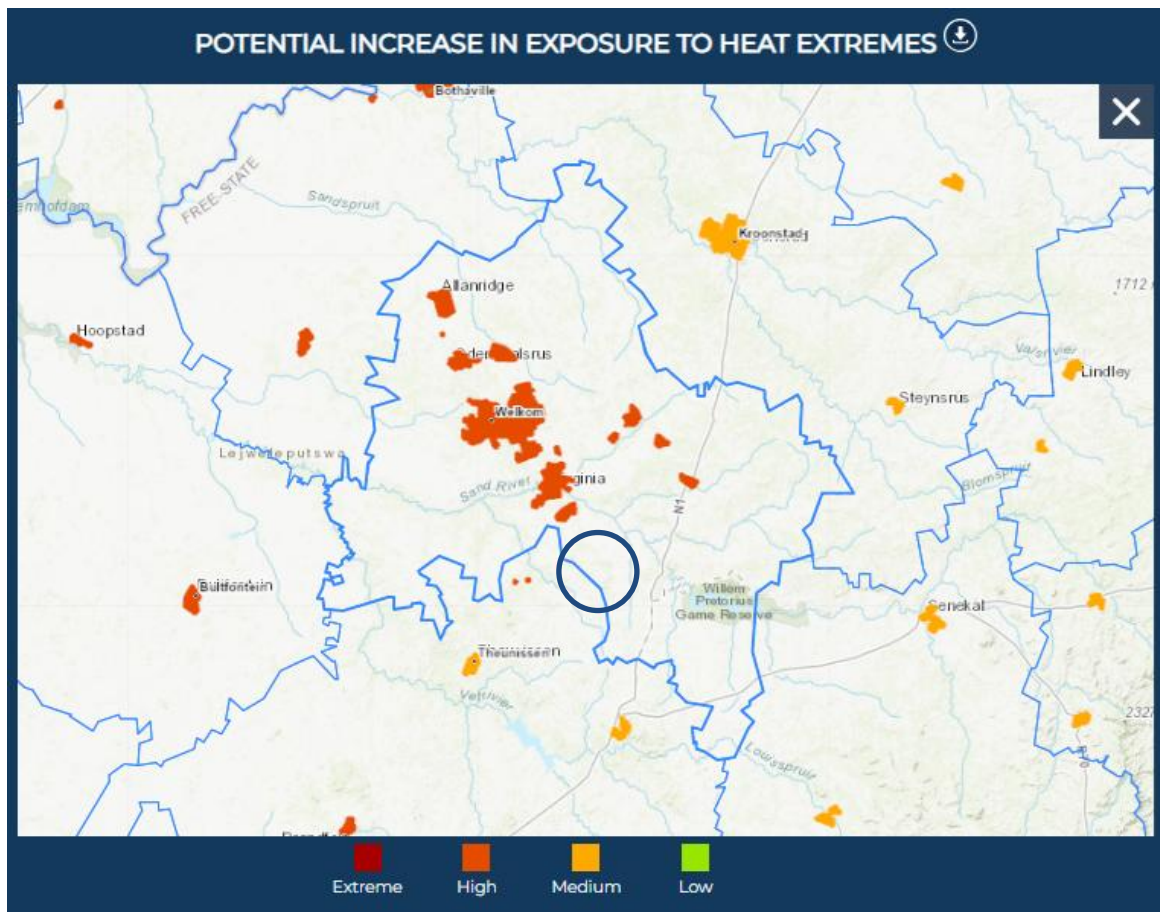


Figure 3-11: Risk of increased heat extremes for the Matjhabeng and Masilonyana Municipalities in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

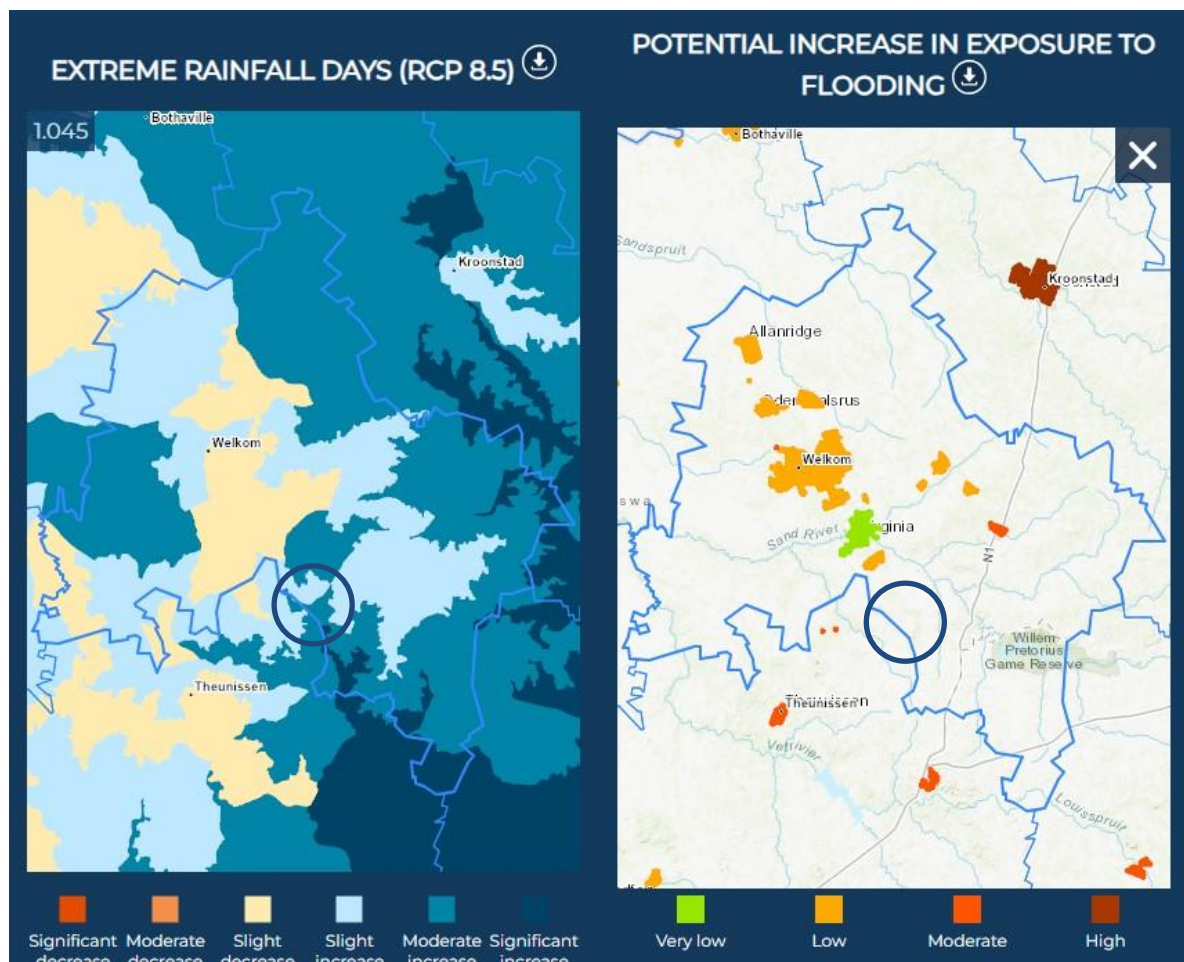


Figure 3-12: Risk of increased flooding for the Matjhabeng and Masilonyana Municipalities in 2050 based on RCP8.5 trajectory (dark blue marker indicates approximate location of the project)

In addition to the hazards identified in the Green Book, Hofste, *et al.*, (2019) currently rate the project area as arid and low water use (Figure 3-13) with a near normal water stress projection for the future (2050 based on a conservative low mitigation trajectory) (Figure 3-14).

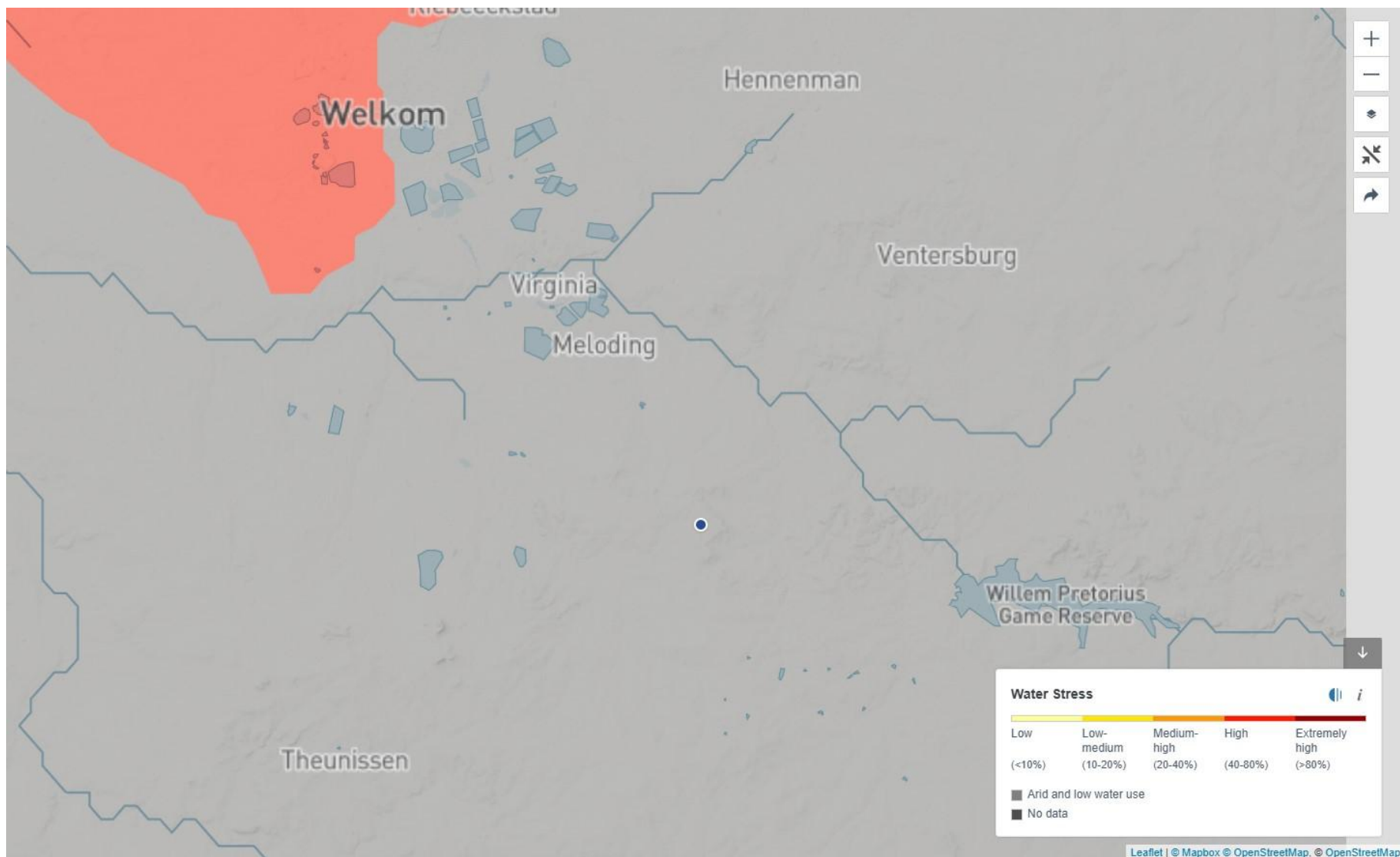


Figure 3-13: Current water stress for the project area (Hofste, et al., 2019) (blue dot indicates project location)

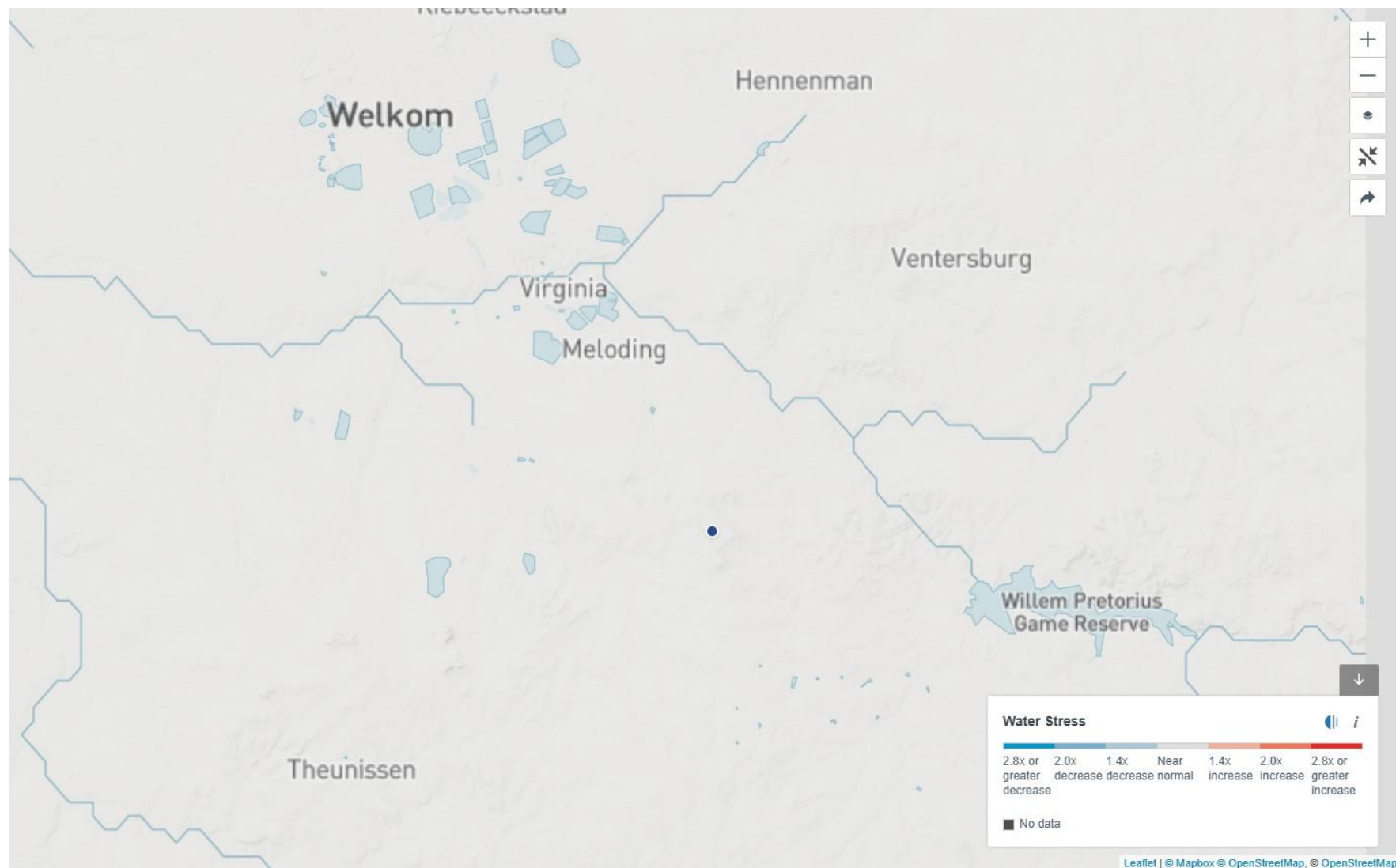


Figure 3-14: Projected (2050) water stress for the project area (Hofste, et al., 2019) (blue dot indicates project location)

3.4 Vegetation Disturbance

The potential vegetation types that will be disturbed over the lifetime of the proposed project include (South African National Biodiversity Institute, 2025):

- Bloemfontein Karroid Shrubland;
- Central Free State Grassland;
- Eastern Free State Clay Grassland;
- Highveld Alluvial Vegetation; and,
- Vaal-Vet Sandy Grassland.

3.5 Impact of Climate Change

To understand the impact that climate change might have on the major resources of the Matjhabeng and Masilonyana Municipalities, it is first necessary to provide an overview of the current situation, which has been provided for water, economy, and agriculture.

3.5.1 Water Supply

3.5.1.1 Current Resources

Figure 3-15 provides the current water supply vulnerability (i.e., demand versus supply) for the Matjhabeng Municipality (1.43) based on the data compiled for the Department of Water and Sanitation (DWS) All Town's Study (Cole, Bailey, Cullis, & New, 2017). The current water demand for the municipality is 207 l/p/d (litres per person per day) with supply of 144.5 l/p/d, with 100% sourced from surface water.

Figure 3-16 provides the current water supply vulnerability (i.e., demand versus supply) for the Masilonyana Municipality (1) based on the data compiled for the Department of Water and Sanitation (DWS) All Town's Study (Cole, Bailey, Cullis, & New, 2017). The current water demand for the municipality is 257 l/p/d (litres per person per day) with supply of 258 l/p/d, with 80% sourced from surface water and 20% from groundwater.

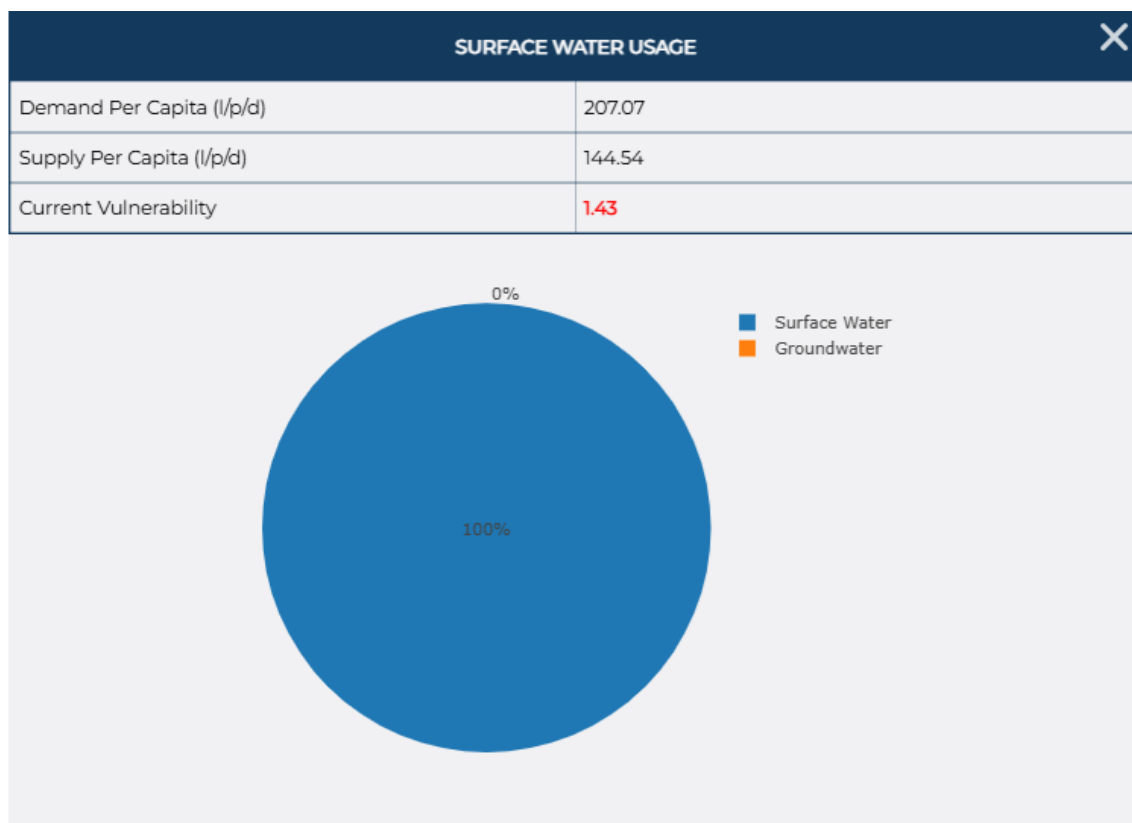


Figure 3-15: Current water availability for the Matjhabeng Municipality

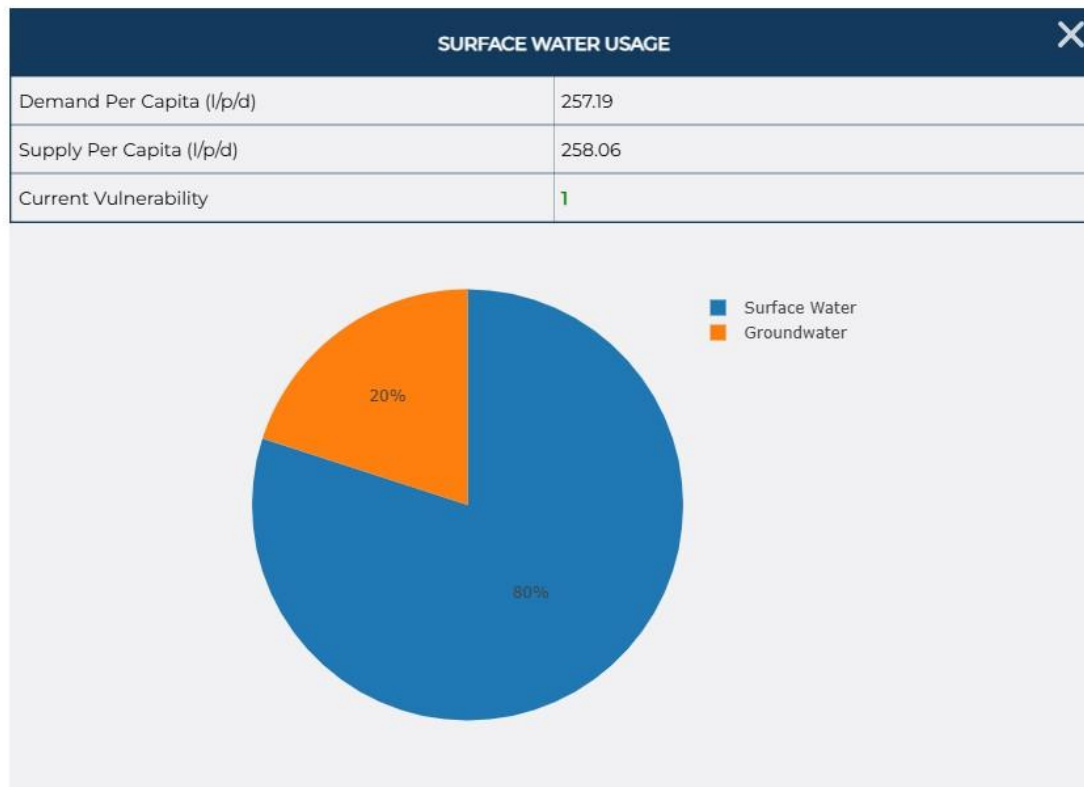
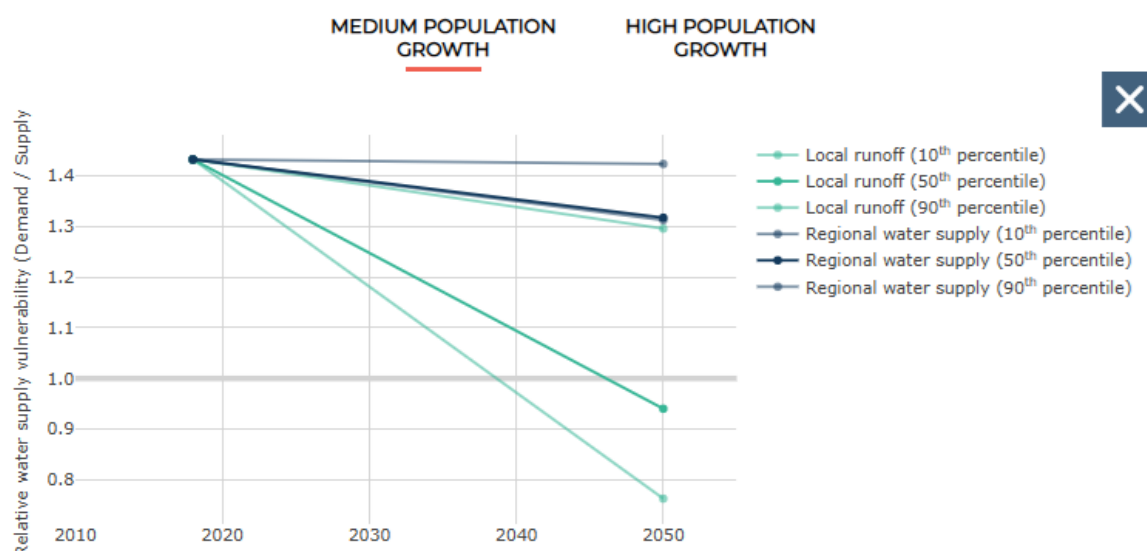


Figure 3-16: Current water availability for the Masilonyana Municipality

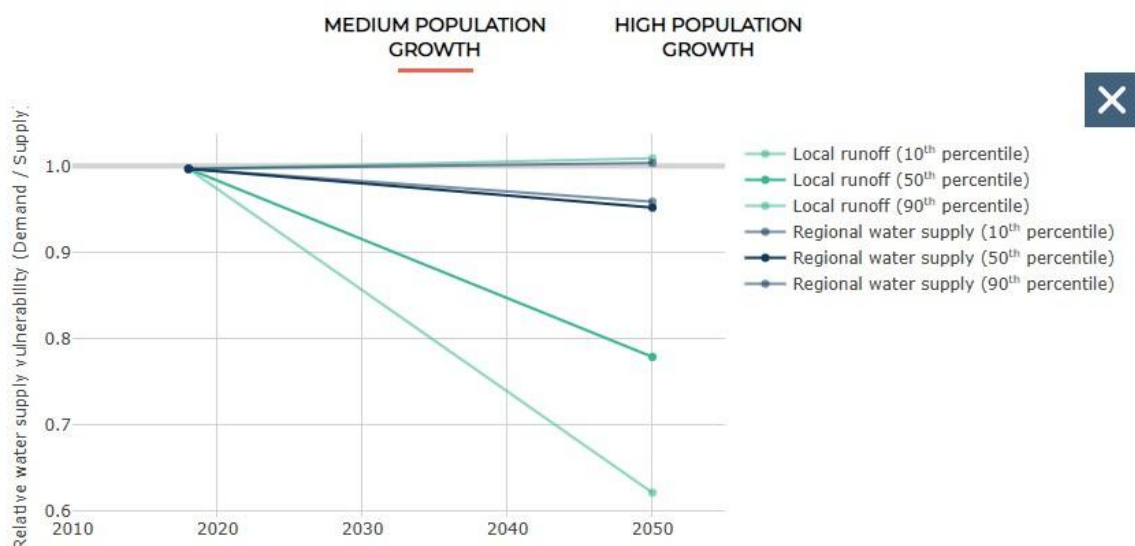
3.5.1.2 Impact on Resources

Figure 3-17 and **Figure 3-18** shows the estimated current and future water supply vulnerability (i.e., the ratio of demand to supply) based on: 1) a local water supply perspective incorporating changes to population growth coupled with exposure to climate risk (based on impacts on local runoff), and 2) a regional water supply perspective (based on impacts of regional water supply assuming supply is part of the integrated regional and national bulk water supply network). The mean annual precipitation for the Matjhabeng and Masilonyana municipalities is predicted to increase by 6.5% and 6.9% respectively for 2050 with a regional urban water supply increase of 11.9%.



VULNERABILITY CONTRIBUTION FACTORS			PERCENTAGE CHANGE
	Mean annual precipitation	▲	6.5%
	Mean annual evaporation	▲	8.02%
	Mean annual runoff	▲	56.82%
	Regional urban water supply	▲	11.91%
	Population growth	▼	-4.72%

Figure 3-17: Estimated current and future (2050) water supply vulnerability based on medium population growth for the Matjhabeng Municipal



VULNERABILITY CONTRIBUTION FACTORS			PERCENTAGE CHANGE
	Mean annual precipitation		6.92%
	Mean annual evaporation		8.03%
	Mean annual runoff		42.72%
	Regional urban water supply		11.91%
	Population growth		-1.95%

Figure 3-18: Estimated current and future (2050) water supply vulnerability based on medium population growth for the Masilonyana Municipal

3.5.2 Surface Water

3.5.2.1 Current Situation

The project location is within the Vaal Primary Catchment (**Figure 3-19**).

Figure 3-20 and **Figure 3-21** depicts the current annual and monthly surface water runoff, precipitation and evaporation for the Vaal Primary Catchment associated with the Matjhabeng and Masilonyana municipalities respectively. Precipitation and evaporation for the Matjhabeng Municipality is currently 533 mm/yr and 1 615 mm/yr respectively. Precipitation and evaporation for the Masilonyana Municipality is currently 525 mm/yr and 1 612 mm/yr respectively.

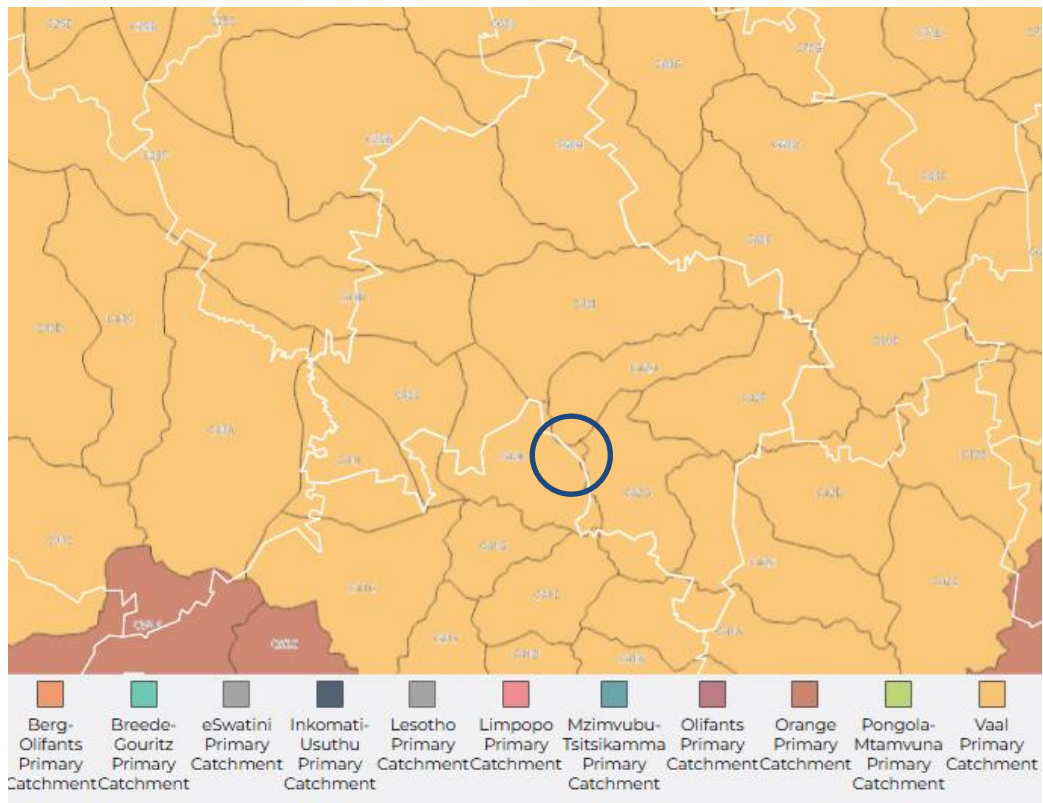


Figure 3-19: Quaternary catchment areas for the study area

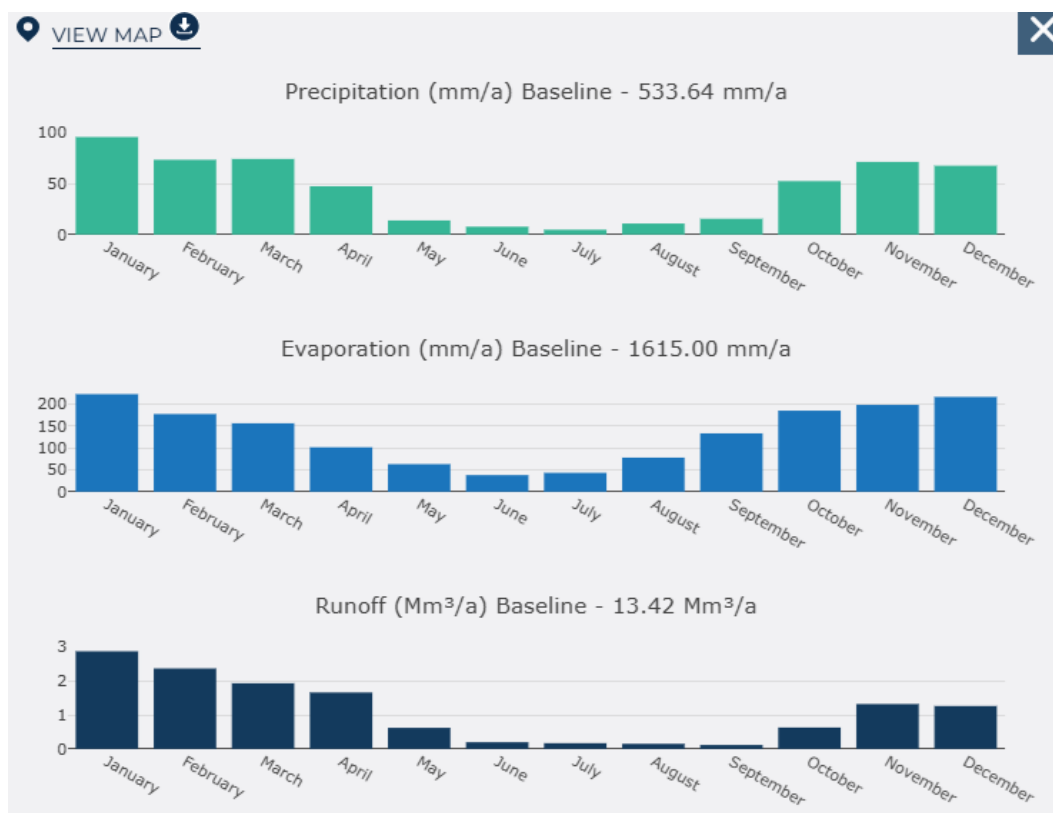


Figure 3-20: Current annual and monthly surface water runoff, precipitation and evaporation for the Matjhabeng Municipality which falls under the Vaal Primary Catchment

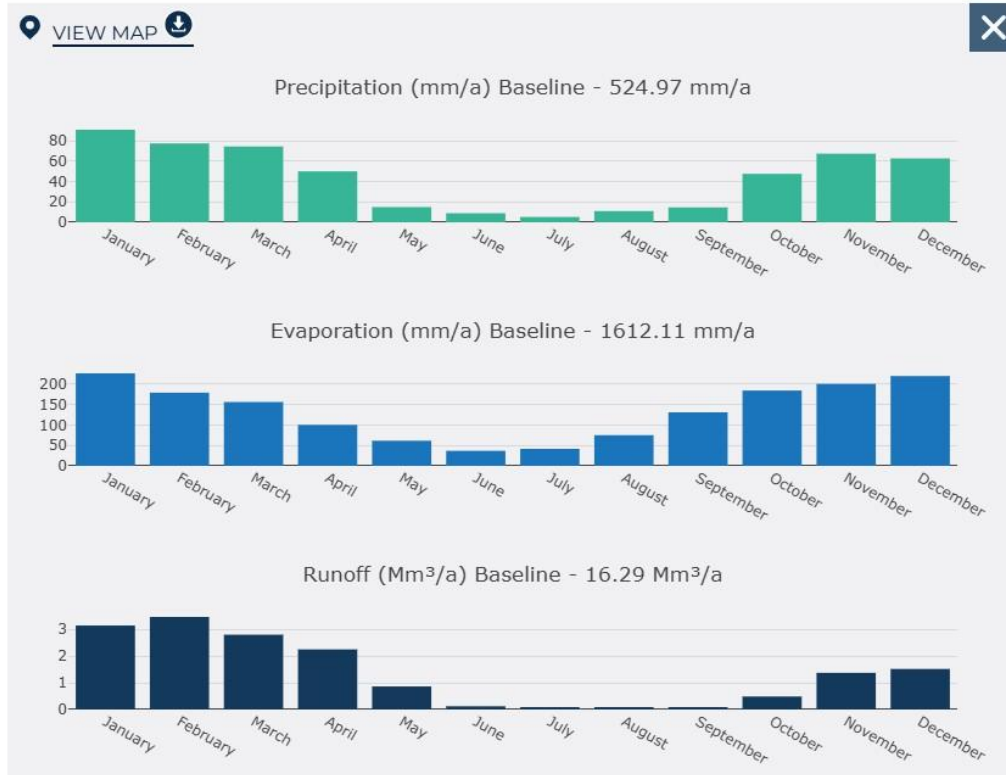


Figure 3-21: Current annual and monthly surface water runoff, precipitation and evaporation for the Masilonyana Municipality which falls under the Vaal Primary Catchment

3.5.2.2 Projected Impact

Figure 3-22 and **Figure 3-23** provides the projected monthly change for future (2050) evaporation, precipitation, and estimated runoff values for the Matjhabeng and Masilonyana municipalities respectively.

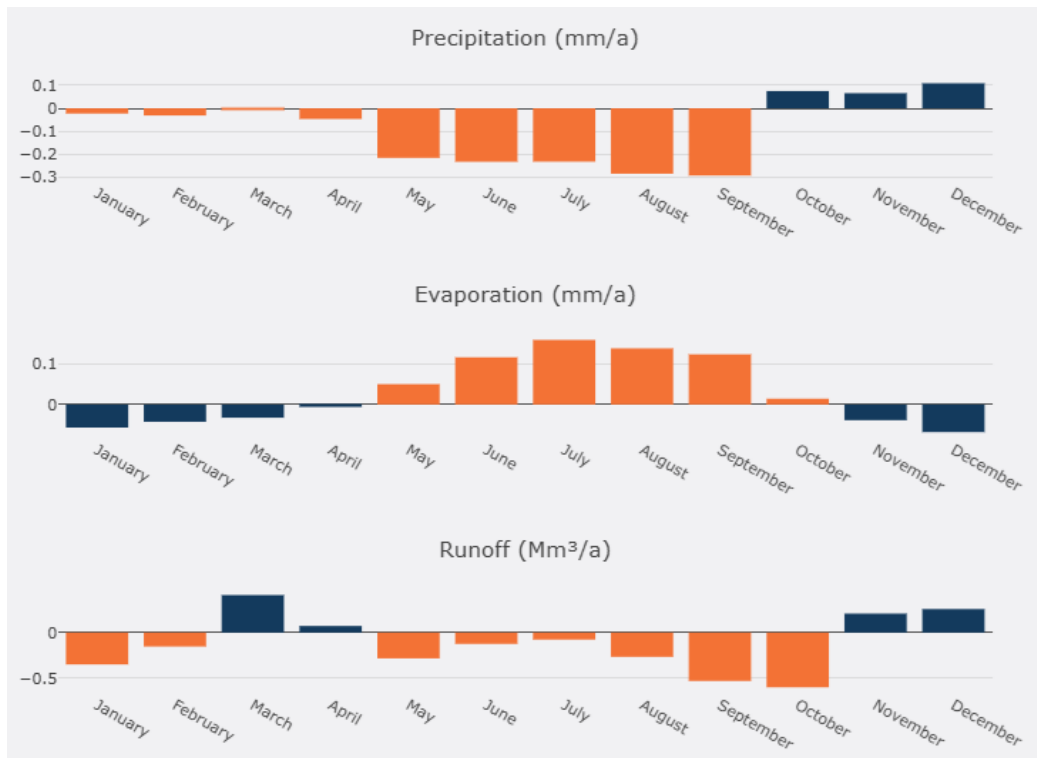


Figure 3-22: Projected monthly change to future (2050) evaporation, precipitation, and estimated runoff values for the Matjhabeng Municipality

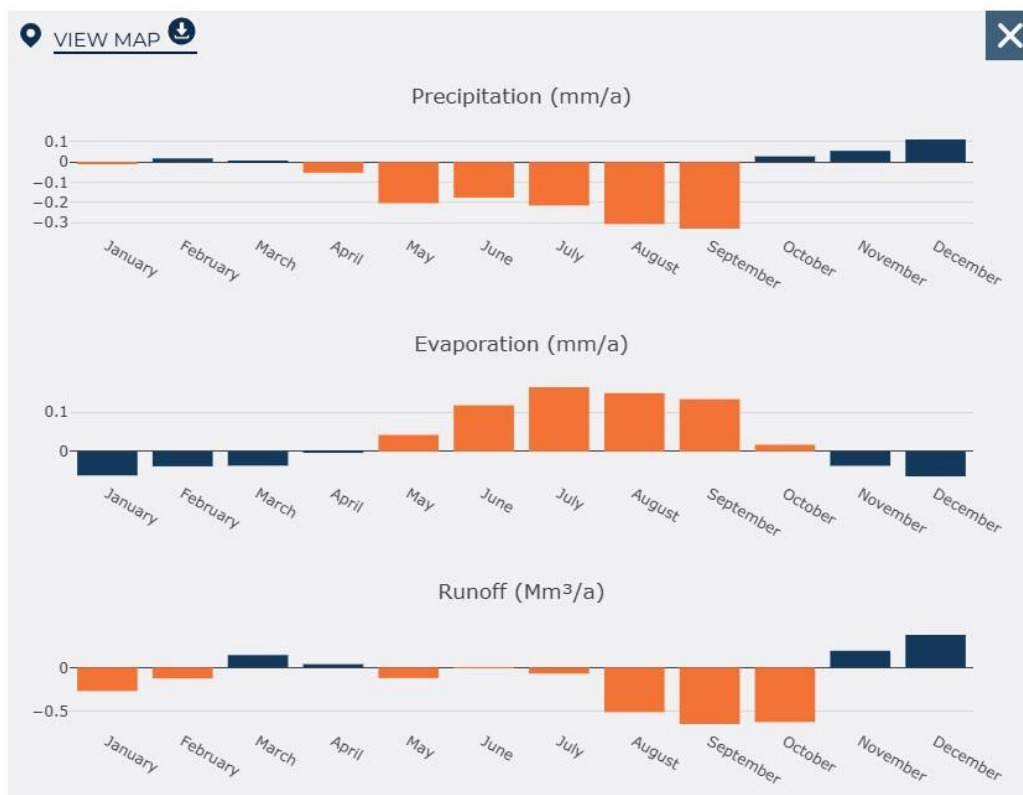


Figure 3-23: Projected monthly change to future (2050) evaporation, precipitation, and estimated runoff values for the Masilonyana Municipality

3.5.3 Ground Water

3.5.3.1 Current Situation

The groundwater recharge potential map indicates the occurrence and distribution of groundwater resources across the country, showing distinctive recharge potential zones. The groundwater dependency map indicates where settlements get their main water supply from, be it groundwater, surface water or a combination of both sources. Settlements that rely on groundwater, either entirely or partially, are deemed groundwater dependent. The residential settlements within the vicinity of the project area are surface water dependent.

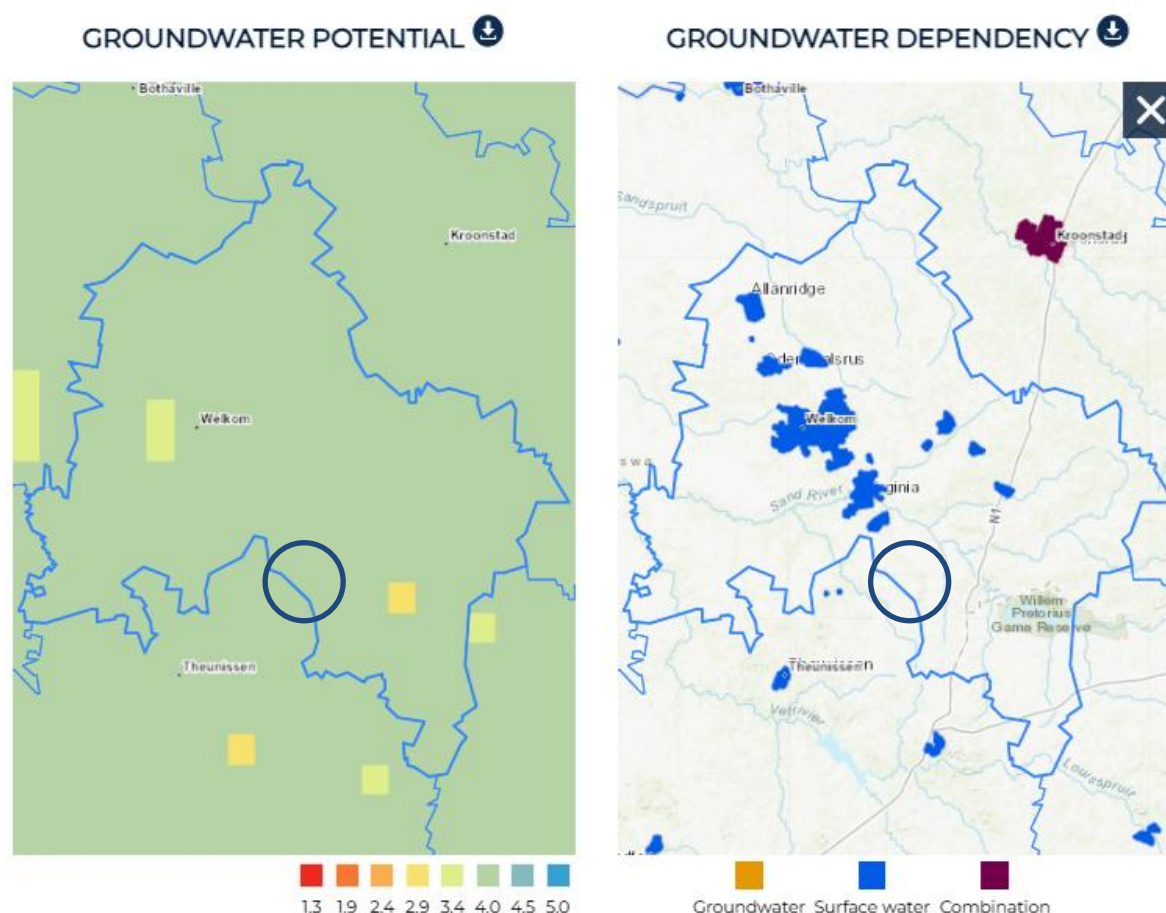


Figure 3-24: Groundwater potential and dependency for the Matjhabeng and Masilonyana Municipalities (dark blue marker indicates approximate location of the project)

3.5.3.2 Projected Impact

A groundwater depletion risk map was created to determine which of South Africa's groundwater dependent settlements may be most at risk to groundwater depletion based on decreasing groundwater aquifer recharge potential and significant increases in population growth pressure by 2050. The groundwater depletion risk map (**Figure 3-25**) is based on the settlement aquifer recharge potential of the 50th percentile RCP8.5 scenario, and the medium population growth scenario. Based on this information, and based on the fact that the nearest

residential areas are not groundwater dependent, there is no groundwater depletion risk within the areas closest to the study area.

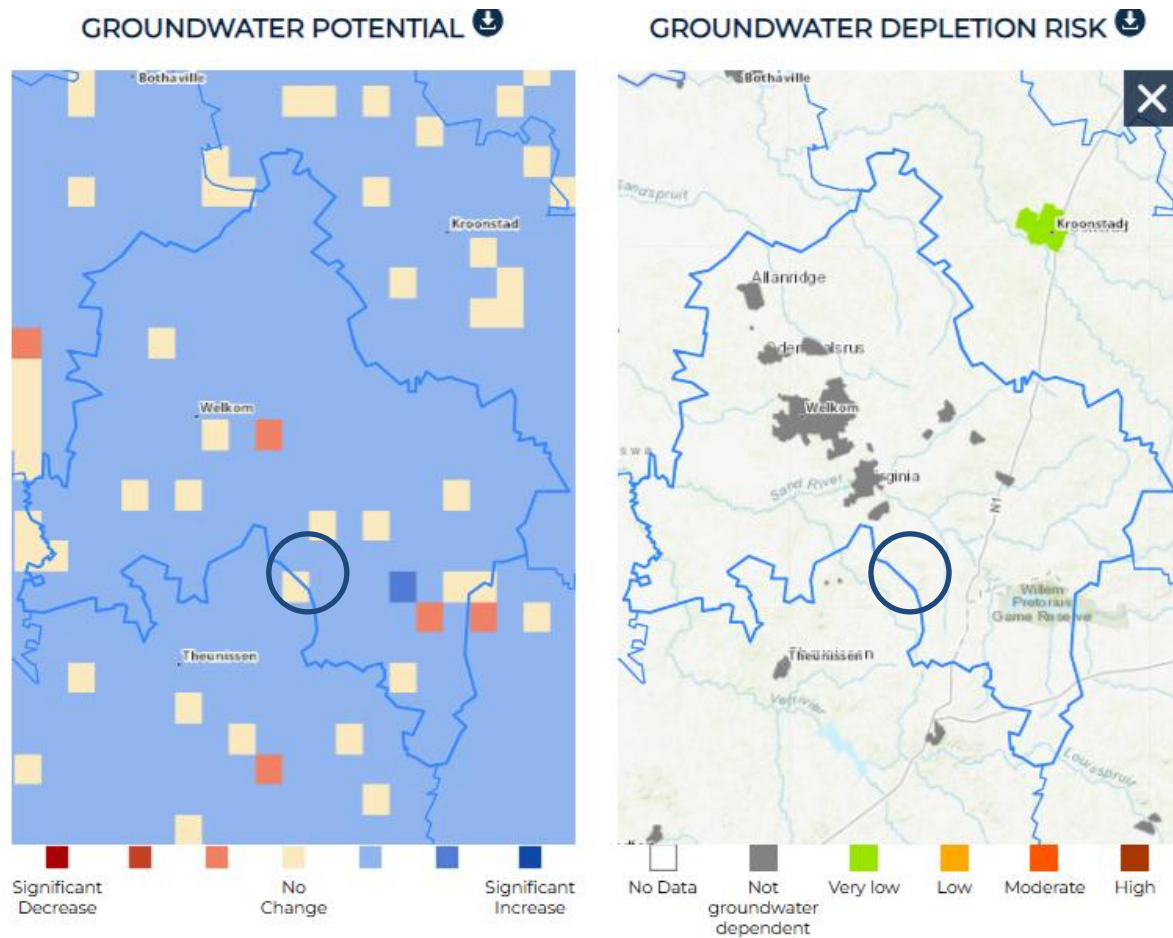


Figure 3-25: Groundwater potential and depletion for 2050 for the Matjhabeng and Masilonyana Municipalities (dark blue marker indicates approximate location of the project)

3.5.4 Economy

Figure 3-26 and **Figure 3-27** shows the contribution that the different economic sectors make to the total Gross Value Added (GVA)¹³ of the Matjhabeng Municipality and the Masilonyana Municipality respectively as well as its national GVA rank (total GVA contribution to the national GVA). The Matjhabeng Municipality ranks 15th in the national GVA rank with mining and quarrying activities making up the highest economic sector to the total GVA at 41.1%. The Masilonyana Municipality ranks 128th in the national GVA rank with mining and quarrying activities making up the highest economic sector to the total GVA at 38.6%.

¹³ Gross value added (GVA) is an economic productivity metric that measures the contribution of a corporate subsidiary, company, or municipality to an economy, producer, sector, or region.

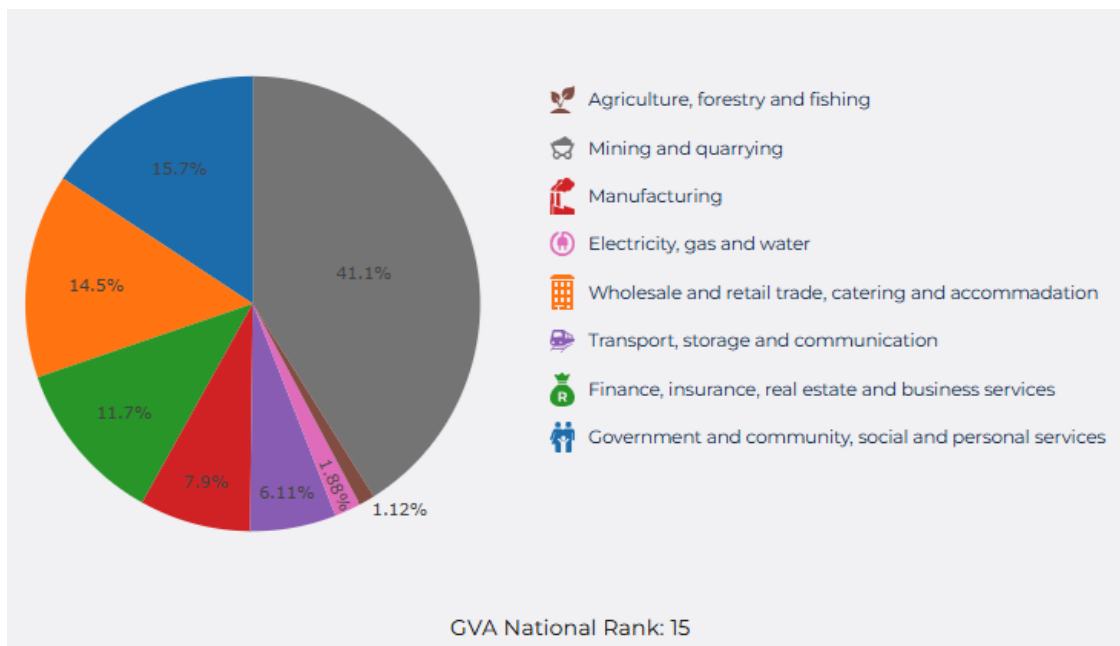


Figure 3-26: The contribution that the different economic sectors make to the total GVA of the Matjhabeng Municipality

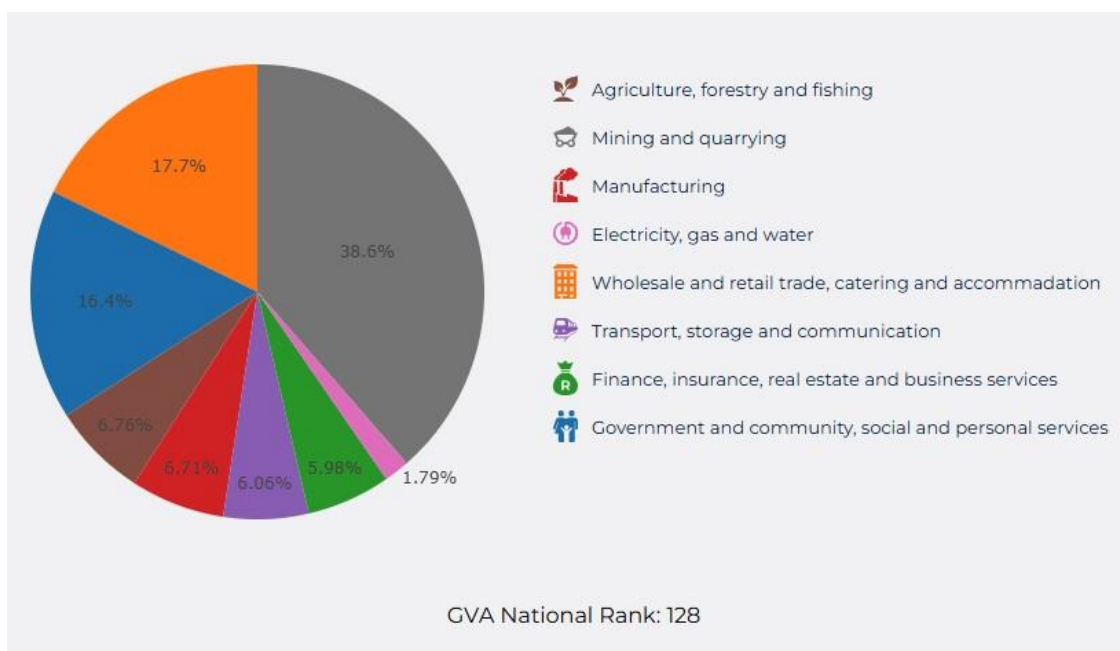


Figure 3-27: The contribution that the different economic sectors make to the total GVA of the Masilonyana Municipality

Table 3-1 and **Table 3-2** summarises the forecasted economic gains or losses for the Matjhabeng Municipality and Masilonyana Municipality respectively, under both the RCP4.5 and RCP8.5 scenarios, for each of the contributing economic sectors.

Table 3-1: Forecasted economic gains or losses for the Matjhabeng Municipality for the RCP4.5 and RCP8.5 scenarios

RCP 4.5 Impacts			RCP 8.5 Impacts		
Average	0.92%	▲	Average	-0.05%	▼
Agriculture Sector	1.23%	▲	Agriculture Sector	-0.64%	▼
Forestry Sector	1.73%	▲	Forestry Sector	-0.91%	▼
Fishing Sector	1.24%	▲	Fishing Sector	-0.65%	▼
Mining Sector	-0.1%	▼	Mining Sector	-0.03%	▼
Manufacturing Sector	-0.54%	▼	Manufacturing Sector	0.76%	▲
Electricity & Gas Sector	4.78%	▲	Electricity & Gas Sector	1.29%	▲
Water Sector	-1.54%	▼	Water Sector	-0.42%	▼
Service Sector	0.57%	▲	Service Sector	0.17%	▲

Table 3-2: Forecasted economic gains or losses for the Masilonyana Municipality for the RCP4.5 and RCP8.5 scenarios

RCP 4.5 Impacts			RCP 8.5 Impacts		
Average	-3.97%	▼	Average	-4.6%	▼
Agriculture Sector	-7.21%	▼	Agriculture Sector	-8.45%	▼
Forestry Sector	-16.56%	▼	Forestry Sector	-19.4%	▼
Fishing Sector	0%	-	Fishing Sector	0%	-
Mining Sector	0.28%	▲	Mining Sector	0.33%	▲
Manufacturing Sector	2.91%	▲	Manufacturing Sector	3.85%	▲
Electricity & Gas Sector	-13.61%	▼	Electricity & Gas Sector	-15.95%	▼
Water Sector	4.07%	▲	Water Sector	4.77%	▲
Service Sector	-1.67%	▼	Service Sector	-1.95%	▼

3.5.5 Agriculture, Forestry and Fisheries

The main agricultural commodities for the Matjhabeng Municipality are maize, beef cattle and milk and cream (**Table 3-3**). Agriculture, Forestry and Fishing (AFF) sector contributes 1.12% to Matjhabeng Municipality GVA production and 4.28% to Matjhabeng total employment. The total AFF GVA production of Matjhabeng Municipality contributes 0.5% to the national AFF GVA (**Table 3-3**).

The main agricultural commodities for the Masilonyana Municipality are maize and beef cattle (**Table 3-4**). Agriculture, Forestry and Fishing (AFF) sector contributes 6.8% to Masilonyana Municipality GVA production and 21.1% to Masilonyana total employment. The total AFF GVA production of Masilonyana Municipality contributes 0.25% of the national AFF GVA (**Table 3-4**).

Table 3-3: Economic contribution of main commodities for Matjhabeng Municipality

MAIN COMMODITIES		
 MAIZE FOR GRAIN	 BEEF CATTLE	 MILK AND CREAM
AFF contributes 1.12% to Matjhabeng GVA production	AFF contributes 4.28% to Matjhabeng total employment	The total AFF GVA production of Matjhabeng Municipality contributes 0.51% to the national AFF GVA, ranking them as the 62nd biggest contributor

Table 3-4: Economic contribution of main commodities for Masilonyana Municipality

MAIN COMMODITIES		
 BEEF CATTLE	 MAIZE FOR GRAIN	
AFF contributes 6.76% to Masilonyana GVA production	AFF contributes 21.14% to Masilonyana total employment	The total AFF GVA production of Masilonyana Municipality contributes 0.25% to the national AFF GVA, ranking them as the 118th biggest contributor

For the Matjhabeng Municipality, the main agricultural commodities for 2050 are maize, beef cattle and milk and cream (under an RCP8.5 low-mitigation scenario) (**Table 3-5**). The climate for the municipality is expected to be hotter and wetter with slightly more extreme rainfall events. There is the potential increase in maize yield for the near future. However, towards 2050, heat stress can negatively impact on production. The hot moist conditions will result in increased spread of disease and parasites, and the heat stress will result in reduced growth and reproduction performance for beef cattle and milk yield and milk quality.

For the Masilonyana Municipality, the main agricultural commodities for 2050 are maize and beef cattle (under an RCP8.5 low-mitigation scenario) (**Table 3-6**). The climate for the municipality is expected to be hotter and wetter with more extreme rainfall events. There is the potential increase in maize yield for the near future. However, crop suitability may decline over time as temperatures start to exceed critical crop thresholds. The hot moist conditions will result in increased spread of disease and parasites, and the heat stress will result in reduced growth and reproduction performance for beef cattle.

Table 3-5: Projected economic contribution of main commodities for Matjhabeng Municipality

MAIN COMMODITIES		
 MAIZE FOR GRAIN	 BEEF CATTLE	 MILK AND CREAM
CLIMATE IMPACT		
Change in climate expected: Hotter and wetter with more extreme rainfall events.		
Potential increase in maize yield for near future. However, towards 2050, heat stress can negatively impact on production.	Increased water availability. Hot and moist conditions cause increased spread of disease and parasites. Reduced growth & reproduction performance due to heat stress.	Hot and moist conditions cause increased spread of disease and parasites. Potential increase in heat stress which could negatively affect conception rates, milk yield and milk quality.

Table 3-6: Projected economic contribution of main commodities for Masilonyana Municipality

MAIN COMMODITIES	
 BEEF CATTLE	 MAIZE FOR GRAIN
CLIMATE IMPACT	
Change in climate expected: Hotter and wetter with more extreme rainfall events.	
Increased water availability. Hot and moist conditions cause increased spread of disease and parasites. Reduced growth & reproduction performance due to heat stress.	Potential increase in maize yield for near future. However, towards 2050, heat stress can negatively impact on production.

3.5.6 Other Resources

The impacts of climate change on other resources are summarised in **Table 3-7**.

Table 3-7: The impacts of climate change on other resources

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Transport and Mobility	• Increased rate of infrastructure deterioration leading to pavement failure including cracking, rutting, potholes, flushing, and stripping. • Increased stress on bridges, particularly expansion joints, through thermal expansion and increased movement. • Corrosion of steel reinforcing in concrete structures due to increase in surface salt levels in some locations. • Increased infrastructure maintenance cost for road repair and reconstruction work, causing traffic delays and emergency service response delays. • Increased frequency and intensity of wildfires leading to more road closures. • Increased vehicle accidents, due to low pavement adhesion, leading to higher rates of transport-related fatalities.	• Reduced water resources available for construction and maintenance. • Reduced production of some agricultural produce leading to changes in freight flows in the network.	• Increased rate of infrastructure deterioration, especially in areas with poor infrastructure maintenance history. • Temporary and permanent flooding of road, rail, port and airport infrastructure. • Structural integrity of roads, bridges and tunnels could be compromised by higher soil moisture levels. • Potential destruction of bridges and culverts. • Erosion of embankments and road bases leading to undermining of roads or railways. • Increased risk of landslides, slope failures, road washouts and closures. • Undermining of bridge structures (scouring). • Closure of roadways and tunnels leading to traffic delays. • Transportation system disruptions, impacts to traffic signalling and low water crossings. • Increased weather-related accidents.	• Increased drag on vehicles resulting in increased fuel consumption. • Increased safety risk for pedestrians and cyclists due to flying objects or being uncontrollably dragged by winds, additionally leading to reduced trip making by pedestrians and cyclists.	(Mokonyama & Van Wyk, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Solid Waste	• Increased risk of combustion at open waste disposal sites and illegal dumps and increase in explosion risk associated with methane gas. • Increased rate of decay of putrescible waste resulting in increased odour, breeding of flies, and attracting of vermin. • Increased health and safety concern regarding heat stroke to staff collecting waste. • Increased risk of landfill site instability and failure due to changes in consumption patterns with increased waste creation (i.e., glass, plastic and paper cups).		• Increased risk of flooding due to pressure on stormwater and leachate management systems at landfills. • Increased demand for capacity to cope with large volumes of waste generated by flood events. • Increase in soil saturation causing decreased stability of slopes and landfills linings (if clay or soil based) at waste management facilities. • Inundation of waste releasing contaminants to waterways, pathways and low elevation zones. • Potential loss of value and degradation of paper and cardboard for recycling due to increased moisture content. • Increased flooding causing the risk of localised disruption of waste collection rounds. • Flooding in areas with untreated, dumped waste causing the risk of groundwater contamination. • Increased flooding causing the risk of litter entering the storm water systems.	• Possible increase in nuisance due to waste dispersed by high winds leading to increased health effects associated with particulate matter (air pollution).	(Oelofse, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Stormwater	• Potential risk of undermining the temperature regime of temperature-sensitive stormwater ponds and receiving waters, resulting in a decrease in water quality. • Increased corrosion in stormwater drains due to a combination of higher temperatures, increased strengths, longer retention times, and stranding of solids.	• Increased shrinking soils increasing the potential for cracking, increased infiltration and exfiltration of water mains and sewers, which in turn exacerbates treatment and groundwater or storm water contamination.	• Increased risk of flooding due to pressure on stormwater systems. • Increased risk of litter entering the stormwater systems. • Increased risk of damage and failure of stormwater systems due to overloading during floods and intense rainfall events. • Failure of stormwater treatment devices during high flow events leading to by-pass and / or flushing of contaminated water. • High wet-weather hydraulic loads and bottlenecks in stormwater and networks due to inflow and sewer infiltration, leading to local inundation and overflows of untreated wastewater. • Increased rainfall causes soil erosion thus damaging underground stormwater systems. • Increased surface and stream erosion causing deposition of sediments in receiving environments. • Stream morphology for undeveloped, developing and fully developed urban areas, may change, hence affecting existing outfall structures and potential stormwater pond locations.	• Increased wind speed and intensity causing changes in rainfall over complex topography including increasing upwind of hills and ranges.	(Dunker & Van Wyk, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Sanitation	Increased heat waves, accompanied by dry weather, can exacerbate already stressed water supply systems leading to competition between sectors for water services, affecting sanitation.	- Decrease in water supply for sanitation through decrease in available water to flush sewage systems adequately. - Declining annual rainfall threatening the viability of water-borne sanitation systems, and the capacity of surface water to dilute, attenuate and remove pollution. - Sewers are structurally vulnerable to drying, hence shrinking soils increase the potential for cracking, increased infiltration, and exfiltration, which in turn exacerbates treatment and groundwater or storm water contamination. - Increased corrosion in sewers due to a combination of higher temperatures, increased strengths, longer retention times, and stranding of solids.	- Increased wet-weather hydraulic loads and bottleneck in stormwater and sanitary sewer networks due to inflow and sewer infiltration, causing local inundation and overflows of untreated wastewater. - Increased rainfall and heavy rainfall events increasing the washing of faecal matter into water sources due to flooding of wastewater treatment works. - Increased risk of flooding resulting in both infrastructure damage and contamination of surface and groundwater supplies. - Increased groundwater levels due to flooding, putting risk on sewage treatment plants (which are often positioned on low-lying ground as sewerage systems rely on gravity). - Increased vulnerability of sewerage pipe systems due to their size and complexity, and their exposure to multiple flood damage threats from source, through treatment, to delivery. - Increased vulnerability of pit toilets (widely used in rural areas) due to flooding, causing serious environmental contamination. - Increase in groundwater recharge and groundwater levels causing flooding of subsurface infrastructure such as pit toilets or septic tanks.		(Duncker, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Information and Communication Technology	• Increased weathering and deterioration of infrastructure resulting in increased maintenance and repair costs. • Heat stress causing structural damage to infrastructure. • Increased energy demands during heatwaves resulting in power outages which can impact on delivery of telecommunications services. • Increases in temperature and higher frequency, duration, and intensity of heat waves increasing the risk of overheating in data centres, exchanges, and base stations, which can result in increased failure rates of equipment. • Increased mean temperature increasing operating temperature of network equipment which may cause malfunctions if it surpasses design limits.	• Decreased precipitation leading to land subsidence and heave, reducing the stability of telecommunications infrastructure above and below ground (foundations and tower structures).	• Increased risk of flooding of low-lying infrastructure, access holes and underground facilities. • Increases in storm frequency or intensity increasing the risk of damage to aboveground transmission infrastructure and impacting on telecommunications service delivery. • Increases in storm frequency leading to more lightning strikes, consequently damaging transmitters, and overhead cables, causing power outages. • Increased cost of insurance for infrastructure in areas with repeated incidents of flooding, as well as withdrawal of risk coverage in vulnerable areas by private insurers. • Road closures due to flooding thus inhibiting service and/or restoration efforts. • Rising sea levels and corresponding increases in storm surges, increasing the risk of saline corrosion of coastal telecommunications infrastructure, and leading to erosion or inundation of coastal and underground infrastructure.	• Increased risk of storm surges impacting on coastal infrastructure. • Increased storm intensity and frequency impacting on electricity and telecommunications infrastructure.	(Naidoo, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Health	• More exposure to high temperatures causing increased health risks including heat strokes. • Heat waves increase threat of cardiovascular, kidney, and respiratory disorders. • Increase in fire danger days causing increased loss of life and damage to health infrastructure. • Wildfire smoke significantly reducing air quality, both locally and in areas downwind of fires. Smoke exposure increases respiratory and cardiovascular hospitalizations; emergency department visits; medication dispensations for asthma, bronchitis, chest pain, chronic obstructive pulmonary disease, and respiratory infections; and medical visits for lung illnesses. • Increased emissions in biogenic volatile organic compounds from vegetation causing increases in air pollution. • Increase in evaporative emissions from cars contributing to exposure to, and health impacts from, air pollution. • Increase in distribution of vector-borne diseases in warmer areas. • Increased water temperatures leading to an increase in algal blooms which can likely lead to increases in food- and waterborne	• Decreased soil moisture potentially creating more wind-blown dust which has negative impacts on air quality. • Increase in water-borne diseases and diarrhoeal diseases due to inadequate water availability. • Decreased precipitation causing changes in salinity of water, resulting in an increase in algal blooms which can likely lead to increases in food- and waterborne exposures. • Increase in stagnant air, decreasing air quality.	• Wetter climate combined with increased temperatures may have negative health impacts as many diarrhoeal diseases vary seasonally, typically peaking during the rainy season. • Extreme rainfall and higher temperatures increasing the prevalence of fungi and mould indoors, with increased associated health concerns. • Increased flooding increasing the risk of drinking and wastewater treatment facilities being flooded, meaning that diarrhoeal diseases can be transmitted as wastewater systems overflow or drinking water treatment systems are breached. • Increase in natural disasters (e.g., floods) creating a conducive environment for the occurrence of mental health problems.	• Increase in wind-blown dust combined with low humidity causing increased cases of meningitis (Davis, 2014).	(Garland, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
	exposures. • Increased temperatures combined with fewer clouds (e.g., from increased subsidence that is projected for parts of South Africa) causing increased exposure to Information and Communication Technology which will have negative impacts on health. • Increased temperatures increasing the reaction between certain pollutants and sunlight and heat, resulting in more severe hazardous smog events.				

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Energy	• Increased heat causing expansion of overhead cables, and cable sag. Sagging below a certain level result in a reduction in the amount of electricity transmitted. • Increased heat stress on electricity transmission networks (overhead cables). • Increase in heat island effect increasing energy demand for cooling, leading to grid stress. • Increased threat of wildfires causing widespread damage to infrastructure and causing disruptions to service provision.		• Increase in flooding causing damage to electricity transmission and distribution infrastructure, poles, lines and sub-stations. • Increase in frequency and cost of maintenance of concrete structures due to frequent and intense rainfall, flooding, or sea level rise. • Increased repair events increasing stress put on service crews and resulting in delays to power restoration.	• Winds causing damage to energy supply infrastructure as winds cause overhead lines to sag, reducing electricity transmission. • Extreme winds causing poles and trees to fall, causing further damage to energy supply infrastructure such as overhead lines.	(Thambiran & van Wyk, 2018)
Ecosystem Services	• Increased risks of water shortages increasing demand for irrigation of gardens and agriculture. • Increased evapotranspiration rates with rising temperatures, reducing the water available in reservoirs and water available for reliant ecosystems. • Increase in temperature leading to water loss via evapotranspiration resulting in decreased water quality and loss of wetlands. • Loss or degradation of indigenous species, including threatened species or ecosystems. • Increased threat from invasive species as competition for water increases. • Dieback or death of susceptible	• Decreased amounts of rainfall reaching ecosystems as settlements use rainwater harvesting techniques for increased household use. • Increased reliance on irrigation and greater demand for water to maintain public open space and gardens. • Reduced planting and pollination leading to greater risk of erosion and soil loss. • Increasing temperatures together with increased intensity of drought will potentially increase the occurrence of algal blooms in reservoirs and dams which are damaging to ecosystem functioning and water services. • Drought and decreased rainfall	• Rainfall in shorter and more violent spells making recharging groundwater difficult. • Increase in intensity of rainfall and flooding leading to increased surface runoff, resulting in increased soil erosion, soil loss and degradation. • Increased rainfall and floods resulting in waterlogged soils which increase the likelihood of crop failure. • Increasingly saturated soils leading to more standing water (ponding) which can result in more insect (pest) activity and their potential to carry diseases. • Increased wave energy and run-up (sea level rise and more storms)	• Evapotranspiration rates increase with wind speed, reducing the water available in reservoirs and water available for reliant ecosystems. • Increased rate of fire spread and spotting (the ignition of fires ahead of the main fire front) of fires. • Potential damage to or uprooting of vegetation including trees, which can also damage infrastructure. • Potential wind damage to crops, reducing yield and quality (e.g., sandblasting and fruit fall). • Increased windblown materials (e.g., dust, litter) increasing the need for maintenance and city cleaning. • Degradation of natural coastal defence structures and increased	(Pieterse & Crankshaw, 2018)

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
	plants (e.g., street trees) and animals (e.g., fish). • Reduced availability of water and increased evapotranspiration resulting in reductions in harvested area (cropping area), yield (ton/ha) and quality. • Warmer winters resulting in reduced period of dormancy (rest period) in deciduous fruit crops, decreasing the production and quality of associated food products. • Warmer climate resulting in shifts in the growing season and life cycles of various plants, including crops, resulting in pests and diseases having a greater destructive impact as well as a shift in climatically suitable areas for specific crops. • Increased humidity levels resulting in higher rates of microbial growth in fresh produce, reducing their expiry time. • Increased heat stress on crops changes the micro-nutrients of crops products, decreasing the nutrient density and quality of food. • Increased water temperature leading to increased growth of aquatic weeds which increases breeding of disease vectors and reduces water oxygen levels. • Milder winters and reduced frost increase the duration of the	causing wetland habitat loss. • Locally specific changes in humidity levels will have impacts on local vegetation. • Increased threat to watershed and aquifer recharge areas, affecting vegetation. • Reduced soil moisture availability increasing moisture stress leading to dieback and death of plants and the loss or degradation of indigenous communities, including threatened species or ecosystems. • Increased moisture stress leading to decline in crop yield and quality, and reduced fodder quantity and quality for livestock. • Drying up of aquatic systems, perennial systems will become seasonal and seasonal systems will die off and be replaced by terrestrial plants. • Increased spread of drought-adapted alien invasive plant species.	causing degradation of natural coastal defence structures.	damage to hard coastal infrastructure.	

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
	growing season, increasing the survival rate of insects and diseases. • Increased sea surface temperatures (SST) causing shifts in the spatial distribution of fish species. • Increased SST and ocean acidification decreases marine phytoplankton growth and synthesis of omega-3 polyunsaturated fatty acids (PUFA's), affecting the oceanic food chain and consequent ecosystems. • Increased heat stress and higher humidity levels potentially resulting in the exceedance of the temperature humidity index in livestock, causing reduced immunity, fertility, productivity and even mortality of livestock.				

Parameter	Results of Climate Change				Reference
	Increase in temperature and heat stress	Drought and decrease in rainfall	Increase in rainfall and inland flooding	Increased wind speed	
Culture and Heritage	• Increased temperature having significant impacts on the comfort levels of built heritage resources, resulting in the building no longer being fit-for-purpose. • Increased demand for additional heating and cooling resulting in the installation of heating, ventilation, and air-conditioning systems with potential negative consequences on the heritage value. • Increased heat stress potentially impacting on the materials and structural integrity of heritage resources. • Migration of several plant species due to changing climate patterns, posing a threat to the conservation of biodiversity hotspots, and potentially altering heritage places. • Increase in veld and forest fires raising the threat of fire to all heritage resources, natural and built, as well as posing health risks to heritage resource dwellers from exposure to smoke and ash pollution.	• Decreased rainfall impacting negatively on ground moisture levels and thus the geological conditions of sensitive heritage resources. Drying out clays, for example, will shrink and potentially undermine founding conditions.	• Increased rainfall in areas with clay soils resulting in swelling which poses a threat to the structural integrity of heritage resources. • Increased floods and changes in precipitation resulting in increasing vulnerability of archaeological evidence buried underground due to changing stratigraphic integrity of the soils. • Increased threat to materials and structural integrity of heritage resources exposed to higher humidity/ precipitation levels.		(van Wyk, 2018)

4 GHG INVENTORY

4.1 Approach and Methodology

This assessment has been undertaken in accordance with the principles of:

- ISO 14064-1:2006 Greenhouse gases – Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.
- Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol) (World Business Council for Sustainable Development and World Resources Institute, 2015).
- IPCC Fifth Assessment Report (2014).

These guidelines are considered representative of good practice GHG accounting internationally and are applicable to the project.

The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (WRI & WBCSD, 2004), provides two approaches. This includes the assessment of GHGs based on: (1) the organisational boundaries and (2) operational boundaries. For the calculation of GHG footprint for the project, the operational boundary approach was selected.

4.1.1 Organisational Boundaries

For corporate reporting, two distinct approaches can be used to consolidate GHG emissions: the equity share and the control approaches. Companies shall account for, and report, their consolidated GHG data according to either the equity share or control approach as presented below.

In setting organizational boundaries, a company selects an approach for consolidating GHG emissions and then consistently applies the selected approach to define those businesses and operations that constitute the company for the purpose of accounting and reporting GHG emissions. If the reporting company wholly owns all its operations, its organizational boundary will be the same whichever approach is used. For companies with joint operations, the organizational boundary and the resulting emissions may differ depending on the approach used. In both wholly owned and joint operations, the choice of approach may change how emissions are categorized when operational boundaries are set.

4.1.2 Operational Boundaries

To help delineate direct and indirect emission sources, improve transparency, and provide utility for different types of organizations and different types of climate policies and business goals, three “scopes” (Scope 1, Scope 2, and Scope 3) are defined for GHG accounting and reporting purposes (**Figure 4-1**).

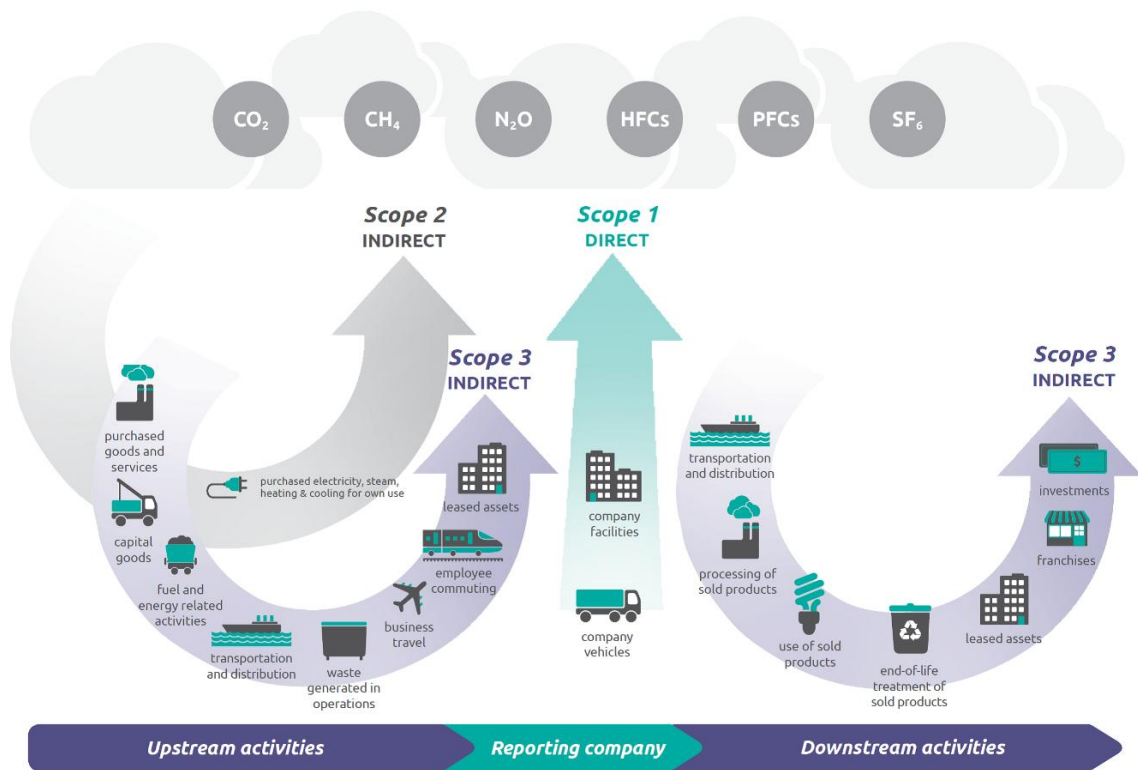


Figure 4-1: Overview of scopes and emissions

4.1.2.1 Scope 1: Direct GHG Emissions

Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled vehicles, etc.; and/or emissions from chemical production in owned or controlled process equipment.

4.1.2.2 Scope 2: Electricity - Indirect GHG Emissions

Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.

4.1.2.3 Scope 3: Other Indirect GHG Emissions

Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are extraction and production of purchased materials; transportation of purchased materials and product; and use of sold products.

4.2 Greenhouse Gases and Global Warming Potential

The GHGs considered in this assessment and the corresponding global warming potential (GWP) for each GHG are listed in **Table 4-1**. GWP is a metric used to quantify and communicate the relative contributions of different substances to climate change over a given time horizon. GWP accounts for the radiative efficiencies of various gases and their lifetimes in the atmosphere, allowing for the impacts of individual gases on global climate change to be compared relative to those for the reference gas carbon dioxide. The GWPs from the IPCC Third Assessment report were used in this assessment. These are reflective of radiative forcing over a 100-year time horizon. There are more recent GWP values available (i.e. the IPCC Sixth Assessment report). **However, the Methodological Guidelines for Quantification of Greenhouse Gas Emissions (DFFE, 2022) published by the Department of Forestry, Fisheries and Environment stipulate the older GWP values (from the Third Assessment report) to be used.** The GWP values from the IPCC Sixth Assessment report and the calculated GHG emissions using these GWPs is given Appendix C.

Table 4-1: Greenhouse gasses and 100-year global warming potentials

Greenhouse Gas	Global Warming Potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	23
Nitrous oxide (N ₂ O)	296

4.3 Assessment Boundary

The following GHG emissions have been considered:

- Emissions during project exploration activities (Scope 1);
- Fuel consumption during project exploration activities (Scope 1);
- Emissions during project production activities (Scope 1);
- Fuel consumption during project production activities (Scope 1);
- Electricity consumption during project exploration activities (Scope 2); and,
- Downstream and upstream project activities (Scope 3).

4.4 Project Activities

The 2019 refinement to the 2006 IPCC guidelines for National GHG Inventories, provides key segments in Natural Gas Systems (**Figure 4-2**). The proposed D3 Energy Production Right Application (the project) entails exploration and production activities. The term fugitive emissions is broadly applied here to mean all emissions from gas systems except contributions from fuel combustion. Fugitive emissions include vented emissions, leak emissions, and flaring emissions. Natural gas systems comprise all infrastructure required to produce, collect, process or refine and deliver natural gas and petroleum products to market, and includes abandoned gas wells. The system begins during the exploration process, which includes all fugitive emissions associated with activities such as prospecting and/or exploratory drilling, well testing, field development and well development, and ends at the consumer (IPCC, 2019).

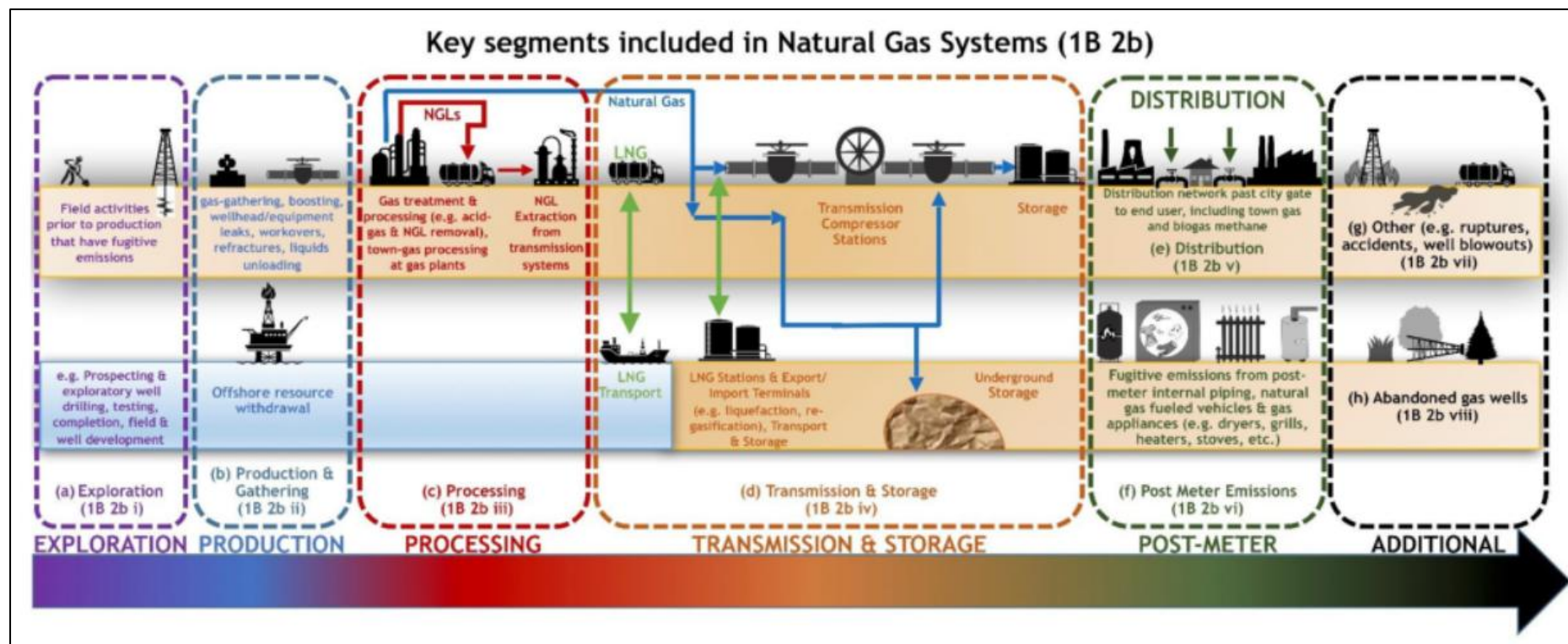


Figure 4-2: The natural gas system (IPCC, 2019)

4.5 Source Data and Assumptions

The information provided for the assessment is summarised in **Table 4-2**. It should be noted that no electricity from the grid will be used during the exploration and production activities. GHG emission from Scope 2 will therefore be zero.

Table 4-2: Greenhouse gas assessment source data provided for the project

Project	Value	Unit	Note / Comment
Duration of the project	30	years	Exploration and production stages
Scope 1			
Number of wells drilled	11	wells/year	Maximum per year (ranges from 0-11)
Number of active wells	43	wells/year	Maximum per year (ranges from 22-43)
Gas produced	32	million m ³ /year	Maximum per year (ranges from 16-32)
Gas combusted for power	900	m ³ /hour	Assume 8760 hours per year, at 0.8 kg/m ³ , therefore 6 307.2 tonnes/year.
Diesel used (stationary combustion)	5 000	litres/year	
Diesel used (mobile combustion)	60 000	litres/year	
Scope 3			
Raw materials	24 940	tonnes	Steel and casing (5 800 + 19 140)
	24 940	tonnes	Concrete
	8 120	Tonnes	HDPE
Distance travelled by materials to site (by ship)	23 000	km	Assuming casing shipped from China 11 500 km one-way
Distance travelled by materials to site (by truck)	80	km	Assuming steel trucked from 40 km one-way
	1 100	km	Assuming casing trucked 1 100 km return trip
	640	km	Assuming HDPE trucked from 320 km one-way
	80	km	Assuming concrete trucked from 40 km one-
Water requirement	2	m ³ /day	Assume 365 days/year, therefore 730 m ³ /year
Industrial Waste	10	tonnes/year	
Municipal Solid Waste	160	tonnes/year	
Business travel by air (domestic)	17 536	passenger.km	Assume 8 return flights Cape Town to Bloemfontein and 4 return flights Johannesburg to Bloemfontein
Business travel by air (international)	132 000	passenger.km	Assume 6 return flights Johannesburg to Australia
Employee commuting (bus)	467 200	passenger.km	Assume 40 km round trip, 32 passengers, 1 bus per day
Employee commuting (car)	58 400	km	Assume 40 km round trip, 4 cars per day
Distance travelled by materials from site (by truck)	1 533 000	km	CNG 300 km round trip, 14 trucks per day
	438 000	km	Helium 600 km round trip, 2 trucks per day
Natural gas sold	2.7	TJ/day	Assume 365 days/year, 48 TJ/Gg, therefore 20 531 tonnes/year

4.6 Emission Factors

The emission factors used for the assessment is provided in **Table 4-3** and were mainly sourced from the:

- South African Methodological Guidelines for Quantification of Greenhouse Gas Emissions gazetted by the Department of Forestry, Fisheries and Environment, No. 47257(2598) (DFFE, 2022b).
- The 2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019). The IPCC emission factors used are aggregates of venting, flaring, and leak emissions.
- The United Kingdom (UK) Department for Energy Security and Net Zero (DESNZ) GHG emission factors (DESNZ, 2025).

Table 4-3: Emission factors used in the assessment

Emission factors	Value	Unit	Reference document
Scope 1 - Direct Emissions			
Process related activities ⁽¹⁾			
Gas exploration	4.72	t CO ₂ per onshore conventional well drilled	IPCC, 2019
Gas exploration	5.78	t CH ₄ per onshore conventional well drilled	IPCC, 2019
Gas exploration	0.00003	t N ₂ O per onshore conventional well drilled	IPCC, 2019
Gas production	2.51	t CO ₂ per onshore active gas wells	IPCC, 2019
Gas production	7.07	t CH ₄ per onshore active gas wells	IPCC, 2019
Gas production	0.00004	t N ₂ O per onshore active gas wells	IPCC, 2019
Gas production (gathering)	2.51	t CO ₂ per million m ³ gas produced	IPCC, 2019
Gas production (gathering)	7.07	t CH ₄ per million m ³ gas produced	IPCC, 2019
Gas production (gathering)	0.00004	t N ₂ O per million m ³ gas produced	IPCC, 2019
Gas processing	0.11	t CO ₂ per million m ³ gas produced	IPCC, 2019
Gas processing	1.7	t CH ₄ per million m ³ gas produced	IPCC, 2019
Gas processing	0.000001	t N ₂ O per million m ³ gas produced	IPCC, 2019
Abandoned wells	0.012	t CH ₄ per million m ³ gas produced	IPCC, 2019
Fuel related activities			
diesel - stationary combustion	74 638	kg CO ₂ per TJ	DFFE, 2022
diesel - stationary combustion	3	kg CH ₄ per TJ	DFFE, 2022
diesel - stationary combustion	0.6	kg N ₂ O per TJ	DFFE, 2022
diesel - mobile combustion	74 638	kg CO ₂ per TJ	DFFE, 2022
diesel - mobile combustion	3.9	kg CH ₄ per TJ	DFFE, 2022
diesel - mobile combustion	3.9	kg N ₂ O per TJ	DFFE, 2022
natural gas - stationary combustion	56 100	kg CO ₂ per TJ	DFFE, 2022
natural gas - stationary combustion	1	kg CH ₄ per TJ	DFFE, 2022
natural gas - stationary combustion	0.1	kg N ₂ O per TJ	DFFE, 2022
Scope 3 - Indirect Emissions			
Purchased Goods and Services			
Water supply	0.1913	kg CO ₂ e per m ³	DESNZ, 2025
Water treatment	0.17088	kg CO ₂ e per m ³	DESNZ, 2025
Steel	3824.09335	kg CO ₂ e per tonne	DESNZ, 2025

Emission factors	Value	Unit	Reference document
HDPE	3095.15524	kg CO ₂ e per tonne	DESNZ, 2025
Concrete	118.79306	kg CO ₂ e per tonne	DESNZ, 2025
Upstream Transportation and Distribution			
HGV (average laden) - diesel	0.10163	kg CO ₂ e per tonne.km	DESNZ, 2025
Container ship (8000+ TEU)	0.01266	kg CO ₂ e per tonne.km	DESNZ, 2025
Waste generated			
Household residual waste	497.24244	kg CO ₂ e per tonne landfilled	DESNZ, 2025
Commercial and industrial waste	520.5327	kg CO ₂ e per tonne landfilled	DESNZ, 2025
Business Travel (Air)			
Domestic flights (with RF)	0.22928	kg CO ₂ e per passenger.km	DESNZ, 2025
International flights (with RF)	0.31656	kg CO ₂ e per passenger.km	DESNZ, 2025
Employee commuting			
Dual purpose 4x4 - Diesel	0.16272	kg CO ₂ e per km	DESNZ, 2025
Bus - Diesel	0.17304	kg CO ₂ e per km	DESNZ, 2025
Downstream Transportation and Distribution			
HGV - CNG	0.745	kg CO ₂ e per km	Climatiq
Use of sold Products			
CNG - mobile combustion	56 100	kg CO ₂ per TJ gas sold	DFFE, 2022
CNG - mobile combustion	92	kg N ₂ O per TJ gas sold	DFFE, 2022
CNG - mobile combustion	3	kg CH ₄ per TJ gas sold	DFFE, 2022
Conversion factors			
Diesel calorific value	0.043	TJ/tonne	IPCC, 2019
Diesel calorific value	35.5	MJ/l	DFFE, 2022
Diesel - density	0.8255	kg/l	DFFE, 2022
Nat gas calorific value	0.048	TJ/tonne	IPCC, 2019
Nat gas calorific value	38.1	MJ/m ³	DFFE, 2022
Nat gas density	0.8	kg/m ³	

(1) The IPCC emission factors used are aggregates of venting, flaring, and leak emissions.

4.7 Emissions

The GHG emissions estimated due to the project activities is provided in **Table 4-4**. There are no Scope 2 emissions as no electricity from the grid will be used during exploration and production activities. A duration of 30 years was assumed for the total GHG emissions. Total emissions for the 30-year period are based on variable gas produced, wells drilled and active wells per year.

Scope 1 and Scope 3 GHG emissions for the project are 809 057 tCO₂e and 1 930 635 tCO₂e respectively over the 30-year life of the project (29 221 tCO₂e and 191 915 tCO₂e per annum respectively).

For comparison, international reporting considers a small facility as producing 10 000 tCO₂e per annum, medium at 25 000 tCO₂e per annum and large at 100 000 tCO₂e per annum (for Scope 1 and 2 emissions). This project would thus be considered a medium facility (29 221 tCO₂e per annum for Scope 1 and 2 emissions).

Table 4-4: GHG emissions estimated for the project

Source	t CO ₂ e per year			
	Scope 1	Scope 2	Scope 3	Total
GHG released due to exploration ⁽¹⁾	1 514			1 514
GHG released due to production ⁽²⁾	7 101			7 101
GHG released due to gathering	2 345			2 345
GHG released due to processing ⁽³⁾	1 207			1 207
GHG released due to abandoned wells	12			12
Natural gas (stationary combustion)	16 867			16 867
Diesel (stationary combustion)	13			13
Diesel (mobile combustion)	162			162
Purchased goods and services ⁽⁴⁾			123 469	123 469
Fuel and energy related activities			40	40
Upstream transportation ⁽⁴⁾			8 491	8 491
Waste			85	85
Business travel			46	46
Employee commuting			70	70
Downstream transportation			1 468	1 468
Use of sold natural gas			58 247	58 247
Total t CO₂e per year	29 221	-	191 915	221 137
Total t CO₂e for period (30 years)	809 057	-	1 930 635	2 739 692

(2) Exploration emissions are split into leaks, venting and flaring as follows: 0, 1 448 and 67 tpa.

(3) Production emissions are split into leaks, venting and flaring as follows: 773, 6 257 and 71 tpa.

(4) Processing emissions are split into leaks, venting and flaring as follows: 60, 1 143 and 3 tpa.

(5) Purchasing of raw materials for well construction and transport of these materials was assumed to only take place initially and not for the life of the project

Emissions using the GWP values (20 and 100 years) from the IPCC Sixth Assessment report (given in more detail in Appendix C) amount to 32 772 t CO₂e per year and 60 293 t CO₂e per year. Even with the more conservative GWP factors, this project would still be considered a medium facility.

The project activities will also result in non-methane volatile organic compounds (NMVOCs) (**Table 4-5**) which are included in the assessment as they can produce increases in tropospheric ozone concentrations, increasing radiative forcing (warming of the atmosphere).

Table 4-5: NMVOC emissions estimated for the project

Pollutant	Source	Value	Units
NMVOC	Emissions released from the well during exploration	10	tpa
NMVOC	Emissions released from the well during production	73	tpa
NMVOC	Emissions released from the well during gathering	24	tpa
NMVOC	Emissions released from the well during processing	4	tpa

Pollutant	Source	Value	Units
NM VOC	Total emissions released	2 806	tonnes for production period (30 years)

4.7.1 Catastrophic Events

Emissions provided above are generally considered routine operational and predictable upset emissions (like venting and flaring). Besides these emissions there is also a low probability of severe acute events such as well blowouts and pipeline explosions.

If a well blows out or a pipeline ruptures without catching fire, massive volumes of raw natural gas are vented directly into the atmosphere. This gas is primarily CH₄. If the blowout or rupture ignites, the CH₄ is combusted. The main release would then be CO₂. The statistical probability of a well blowout during drilling operations typically ranges from roughly 1 in 3 200 to 1 in 10 000 wells. The overall statistical probability of a high-pressure natural gas transmission pipeline suffering a full-scale rupture is very low, typically ranging from about 0.2 to 0.4 incidents per 1,000 kilometres annually.

Assuming a flow rate per well of 85 m³/hr, at a density of 0.78 kg/m³, a mass rate of gas of 66.3 kg/hr would be released. At a CH₄ fraction of 86.5%, 57 kg/hr of CH₄ released or 4 731 kg/hr CO₂e (using a GWP of 82.5, AR6 at 20 year). This is assuming the gas does not ignite. Assuming a worst-case scenario for "duration to control" of 30 to 45 days (reflecting the time required to mobilize a capping stack or begin drilling a relief well in a remote area), the anticipated release could be up to 5 110 tonne CO₂e.

Should the gas ignite, approximately 98 % of the CH₄ would combust to form CO₂, and 2% would remain as CH₄ (249 kg/hr CO₂e), and the anticipated release could be up to 270 tonne CO₂e.

Assuming a flow rate of 3 600 m³/hr in the pipeline, at a density of 0.78 kg/m³, a mass rate of gas of 2 808 kg/hr would be released should pipeline rupture. At a CH₄ fraction of 86.5%, 2 429 kg/hr of CH₄ released or 200 386 kg/hr CO₂e (using a GWP of 82.5, AR6 at 20 year). This is assuming the gas does not ignite. Assuming the volume of gas that escapes during the operator detection and valve closure lag time is 10 to 30 minutes, the anticipated release could be up to 100 tonne CO₂e.

4.7.2 Cumulative Emissions

Other gas exploration and production activities in the Free State Province include Tetra4 (production) as well as Rhino Oil and Gas (Exploration).

The production and exploration right areas are shown in **Figure 4-3**.

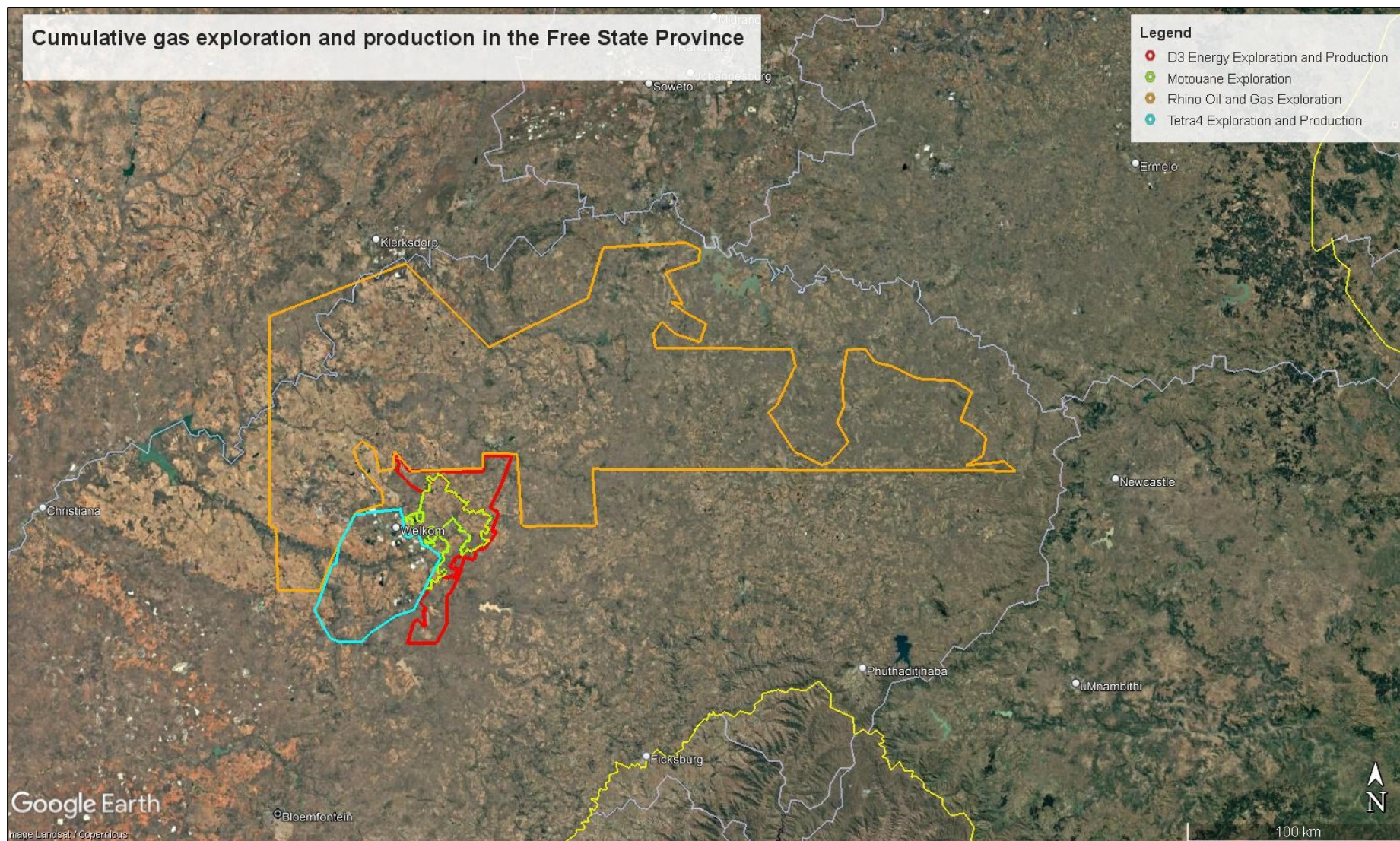


Figure 4-3: Cumulative gas exploration and production in the Free State Province

Table 4-6: Emissions estimated for the cumulative projects in the area

Company	Type of right	Scope 1 CO ₂ e emissions (tpa)	Number of wells	Gas processed or produced/year (million m ³)
D3 Energy	Exploration and production	29 221	43	32
Tetra4	Exploration and production	163 748	300	204
Motouane ER386	Exploration	2 360	3	NA
Rhino Oil and Gas ER377	Exploration	unknown	20	NA
Rhino Oil and Gas ER378	Exploration	1 860	20	NA
Total		197 189		

4.8 The Project's GHG Impact

4.8.1 Impact on the National Remaining Carbon Budget

According to the second NDC (Section 2.3), the South African remaining carbon budget is in the range of 320 – 380 Mt CO₂e by 2035. Using the lower end of the range for 2035, the project (Scope 1) would contribute approximately 0.009% of the remaining carbon budget per year and represent a contribution of 0.006% to the 2022 National GHG inventory total. Based on the more conservative AR6 for 20-year GWP, the project (Scope 1) would contribute approximately 0.019% of the remaining carbon budget per year and represent a contribution of 0.013% to the 2022 National GHG inventory total. While corporations use the Greenhouse Gas Protocol (GHG Protocol) to track Scopes 1, 2, and 3, NDCs operate strictly on a geographic, production-based accounting framework. Scope 3 emissions are excluded from National Targets to prevent massive global double-counting.

4.8.2 Alignment with National Policy

Most of the South African GHG policy is in early phases of implementation where GHG emissions have been reported to DFFE since 31 March 2018 and the Carbon Tax Act came into effect on the 23 May 2019. The project will be required to align to GHG reporting with national policy.

4.9 Cumulative GHG Impact for the area

4.9.1 Impact on the National Remaining Carbon Budget

Cumulative projects in the area would contribute approximately 0.06% of the remaining carbon budget per year and represent a contribution of 0.04% to the 2022 National GHG inventory total.

5 IMPACT SIGNIFICANCE RATING

5.1 Potential Impact Description

Gaseous pollutants released from the exploration, production, processing and use of natural gas is the main source of GHGs from the project. The release of GHG includes mainly CO₂, CH₄ and N₂O. GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour H₂O, CO₂, N₂O, CH₄ and O₃ are the primary GHG in the Earth's atmosphere. The effect of climate change is related to changing atmospheric GHG concentrations, increased temperatures, changing weather patterns and sea level rise (indirect negative impact).

5.2 Impact Significance

The calculated CO₂e emissions from the project operations for Scope 1 is summarised in Section 4.7, estimating a total of 809 057t CO₂e over a 30-year period (29 221t CO₂e per annum).

The calculated CO₂e emissions from the project operations in the area (cumulative) for Scope 1 is summarised in Section 4.9, estimating a total of 197 189t CO₂e per annum.

The project Scope 1 emissions due to the project would contribute approximately 0.009% of the remaining carbon budget per year for 2035 and represent a contribution of 0.006% to the 2022 National GHG inventory total.

The draft *National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations* (in GN 6759 in GG 53574) provides a Climate Change Significance Rating Framework for assessments (summarised in Appendix D) (DFFE, 2025). This framework was used for the evaluation of significance for the project (**Table 5-1**).

The climate change significance rating was as follows:

- Climate change manifestations on the project: **low**;
- Impact of the project on climate change adaptation or resilience: **moderate**;
- Impact of project on GHG emissions: **moderate**;
- Impact of cumulative projects on GHG emissions: **high**.

The climate change significance rating for catastrophic events is difficult to assess as the likelihood of the impact occurring is low and the duration is unknown. Assuming a well blowout takes place and a worst-case scenario for "duration to control" of is 45 days, and the gas does not ignite, the anticipated release could be up to 5 110 tonne CO₂e. This falls in the LOW intensity range (< 10000 tpa CO₂e) and the overall impact significance is likely LOW.

Table 5-1: Climate Change significance rating for the project

Climate Change Impacts or Risks	Impact of Climate Change Manifestations on the Project	Impact of the Project on Climate Change Adaptation or Resilience	Impact of Project on Greenhouse Gas Emissions
Impact or Risk	Increased heat extremes may result in occupational health and operational risks on the project. These risks are driven by higher ambient temperatures which can lead to heat-related illnesses (i.e. heatstroke and exhaustion) in workers and reduced labour productivity.	The impact of the project on the resources is limited to some clearing of land for the exploration and production areas.	The project would release GHG emissions into the atmosphere during the exploration and production activities.
IMPACT CRITERIA			
1. Nature	Negative Direct	Negative Direct	Negative Indirect
2. Duration	Permanent	Permanent	Permanent
3. Extent	Localised	Localised	Global
4. Probability	Unlikely	Probable	Probable
5. Irreplaceability	Limited	Limited	VERY HIGH due to irreversibility of elevated GHG concentrations in the atmosphere.
6 Reversibility and mitigation potential	Easy	Moderate	Reversibility VERY DIFFICULT due to irreversibility of elevated GHG concentrations in the atmosphere.
7. Severity (intensity)	Slight	Moderate	MODERATE - more than 10 000 tCO ₂ e per year.
8. Significance	Low (-)	Moderate (-)	Moderate (-)
9. Residual risk	Low (-)	Moderate (-)	Moderate (-)

Table 5-2: Climate Change significance rating for the cumulative projects in the area

Climate Change Impacts or Risks	Impact of Climate Change Manifestations on the Project	Impact of the Project on Climate Change Adaptation or Resilience	Impact of Project on Greenhouse Gas Emissions
Impact or Risk	Increased heat extremes may result in occupational health and operational risks on the project. These risks are driven by higher ambient temperatures which can lead to heat-related illnesses (i.e. heatstroke and exhaustion) in workers and reduced labour productivity.	The impact of the project on the resources is limited to some clearing of land for the exploration and production areas.	The projects would release GHG emissions into the atmosphere during the exploration and production activities.
IMPACT CRITERIA			
1. Nature	Negative Direct	Negative Direct	Negative Indirect
2. Duration	Permanent	Permanent	Permanent
3. Extent	Localised	Localised	Global
4. Probability	Unlikely	Probable	Probable
5. Irreplaceability	Limited	Limited	VERY HIGH due to irreversibility of elevated GHG concentrations in the atmosphere.
6 Reversibility and mitigation potential	Easy	Moderate	Reversibility VERY DIFFICULT due to irreversibility of elevated GHG concentrations in the atmosphere.
7. Severity (intensity)	Slight	Moderate	HIGH - more than 100 000 tCO ₂ e per year.
8. Significance	Low (-)	Moderate (-)	High (-)
9. Residual risk	Low (-)	Moderate (-)	High (-)

6 CLIMATE RISK, ADAPTATION AND MITIGATION

6.1 Adaptation Action Plans

6.1.1 Matjhabeng Local Municipality Adaptation Action Plan

As of 2024–2025, the Matjhabeng Local Municipality does not have a formal Climate Change Adaptation Plan in place. The municipality is, however, integrating climate risks into its Integrated Development Plan (IDP) to address infrastructure vulnerabilities, such as drought and flood risks.

Key Climate Adaptation Focus Areas (via IDP and Planning):

- **Infrastructure Resilience:** The municipality aims to enhance service delivery infrastructure against extreme weather.
- **Integrated Planning:** The Draft Review Integrated Development Plan 2025/2026 calls for understanding regional vulnerabilities.
- **Disaster Management:** The 2025/2026 IDP Review, Budget and Performance Management highlights the need for adapting to climate change impacts.

6.1.2 Masilonyana Local Municipality Adaptation Action Plan

Masilonyana Local Municipality relies primarily on the Lejweleputswa District Municipality's Climate Change Risk Profile and their own IDP to guide climate adaptation. Rather than a standalone document, local climate adaptation action is integrated directly into municipal budgets and service delivery mandates.

Key Adaptation Areas & Strategies:

- **Water Security & Infrastructure:** Upgrading aging water networks and wastewater systems in towns like Theunissen and Winburg. Adaptation focuses on improving groundwater recharge and reducing water loss during droughts.
- **Waste Management:** Partnerships with national departments provide compactor trucks and clean-up campaigns to reduce illegal dumping and manage waste levels.
- **Energy Transition:** The development of the 100MW Sonvanger Solar Power Plant near Theunissen helps mitigate greenhouse gas emissions while stabilizing the regional power supply.
- **Disaster & Risk Management:** Focuses on mitigating the impacts of severe weather events, soil erosion, and rural poverty by building climate-resilient infrastructure.

6.2 Physical Risks of Climate Change to the Project's Operations

With the increase in heat extremes, there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both these have the potential to negatively affect employee performance and productivity along with process efficiency.

From a process point of view, elevated ambient temperatures (up to 45°C) may slightly increase evaporative fuel losses from vehicles and increase temperature related wear on equipment.

6.3 Transitional Risks and Opportunities of Climate Change on the Project's Operations

The Taskforce for Climate-related Financial Disclosures (TCFD) advocates the disclosure of the financial risks associated with climate change impacts on organisations (TCFD, 2020). These include physical risks resulting in large-scale financial losses caused by storms, droughts, wildfires, and other extreme events (as identified in Section 3). The Taskforce also advocates the quantification of transitional risks associated with the adjustment to low carbon economies, such as the rapid loss in the value of assets due to policy changes or consumer preference; and financial risks to the economy through elevated credit spreads, greater precautionary saving and rapid pricing readjustment (TCFD, 2020). Along with risks, the Taskforce encourages organisations to identify possible opportunities that could build resilience in economies shifting due to climate change.

Although assessment of the full financial risk is out of the scope of the work, potential transitional risks and opportunities applicable to the project are tabulated below (**Table 6-1** as summarised from TCFD, 2017).

Table 6-1: Examples of climate-related risks and opportunities and the potential financial impacts (TCFD, 2017)

Type	Climate Related Risk / Opportunity	Potential financial impact	Comments
Risks	Policy and Legal		
	- Increased pricing of GHG emissions	- Increased operating costs (for example higher compliance cost, increased insurance premiums)	Carbon tax act proposed 2% increase in baseline carbon tax rate until 2022 and thereafter annual inflation-based increases
	- Enhanced emissions reporting obligations	- Write-offs, asset impairment, and early retirement of existing assets due to policy changes	South African Greenhouse Gas Emission Reporting System (SAGERS)
	- Mandates on and regulation of existing products and services	- Increased costs and / or reduced demand for products and services resulting from fines and judgements.	Country commitment to decarbonise energy supplies by 2050 could influence energy demand. Exceedances of emission standards could result in fines and litigation.
	- Exposure to litigation		
	Technology		
	- Substitution of existing products and services with lower emission options	- Write-offs and early retirement of existing assets - Reduced demand for products and services	Country commitment to decarbonise energy supplies by 2050 could influence product demand.
	- Costs to transition to lower emissions technology	- Capital investments in technology development - Costs to adopt / deploy new practises and processes	
	Market		
	- Changing customer behaviour	- Reduced demand for goods and services due to shift in consumer preferences	
	Reputation		

Type	Climate Related Risk / Opportunity	Potential financial impact	Comments
	- Increased stakeholder concern or negative stakeholder feedback	- Reduction in capital availability	
Opportunities	Resource efficiency		
	- Use of more efficient modes of transport	- Reduced operating costs (through efficient gains and cost reductions)	
	Products and services		
	- Shifts in consumer preferences	- Better competitive position to reflect shifting consumer preferences, resulting in increased revenues	
	Markets		
	- Access to new markets	- Increased revenue through access to new and emerging markets (for example partnerships with governments)	
	- Use of public-sector incentives		

6.4 Project Adaptation and Mitigation Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention. Mitigation measures are typically the focus of the energy, transport and industry sectors (Thambiran & Naidoo, 2017). Adaptation measures focus on the minimising the impact of climate change, especially on vulnerable communities and sectors. Inclusion of the climate change adaptation in business strategic implementation plans is one of the outcomes defined in the Draft National Climate Change Adaptation Strategy (Government Gazette No.42466:644, May 2019).

The project will need to take increased heat extremes into consideration when developing mitigation and adaptation measures for the project.

6.4.1 General Adaptation

The following general adaptations can be considered:

- Continually improving risk management systems and onsite employee training specifically for extreme weather events, such as extreme heat.
- Implementing a health and safety plan for work practices to manage heat stress and temperature extremes for workers. This could consider the following measures:
 - Rotation of staff on hot days,
 - Wearing of protective safety or reflective clothing when exposed to the sun or being outdoors to reflect radiant heat from the ground or infrastructure,
 - Heat-related incidences should also be reported as part of the facilities health and safety reporting, to have such records for future heat related stress,
 - Provision of work-rest procedure – frequent breaks and short work periods.

6.4.2 Technology/Sector-Specific Mitigation

Sector-specific climate change mitigation in gas exploration is focused on mitigating methane emissions due to their high global warming. Key strategies include the following:

1. Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard (part of the World Bank Group's Global Gas Flaring Reduction Public-Private Partnership (GGFR program) should be adopted when considering flaring and venting options for onshore activities. The standard provides guidance on how to eliminate or achieve reductions in the flaring and venting of natural gas. Continuous venting of associated gas is not considered current good practice and should be avoided. The associated gas stream should be routed to an efficient flare system, although continuous flaring of gas should be avoided if feasible alternatives are available. Before flaring is adopted, feasible alternatives for the use of the gas should be evaluated to the maximum extent possible and integrated into production design.
2. Alternative options may include gas utilization for on-site energy needs, export of the gas to a neighboring facility or to market, gas injection for reservoir pressure maintenance, enhanced recovery using gas lift, or gas for instrumentation. An assessment of alternatives should be adequately documented and recorded. If none of the alternative options are currently feasible, then measures to minimize flare volumes should be evaluated and flaring should be considered as an interim solution, with the elimination of continuous production associated gas flaring as the preferred goal.
3. Robust Leak Detection and Repair (LDAR) Programs:
 - Advanced LDAR programs can include visual checks, utilising infrared cameras (optical gas imaging), drones, satellites, and sensors to detect, locate, and quantify methane leaks from wells.
 - Leading practices recommend frequent (quarterly or even continuous) inspection, particularly for high-emitting components.
 - Upon detection, leaks must be repaired promptly to minimise fugitive emissions.
4. Reducing methane releases during well testing
5. Proper capping and abandonment
 - To prevent leaks from abandoned or inactive wells, wells must be plugged following modern, robust standards, rather than simply sealed with a basic cap.
 - Regular monitoring of capped wells is necessary to identify and remediate leakage from degraded cement or casing, which is a major source of methane seepage.

7 FINDINGS

Project specific information together with local and internationally published emission factors were used to calculate Scope 1 (direct), Scope 2 (indirect) and Scope 3 (indirect) GHG emissions for the project. Locally published literature was referenced, to understand the projected changes to climate for the area.

Based on information provided, the project is likely to result in an estimated total GHG emissions as follows:

- Scope 1 direct emissions:
 - 809 057 t CO₂e over a 30-year period
 - 29 221 t CO₂e per annum
- Scope 2 indirect emissions:
 - None
- Scope 3 indirect emissions:
 - 1 930 635 t CO₂e over a 30-year period
 - 191 915 t CO₂e per annum

The GHG emissions from the project was calculated to represent 0.009% of the remaining South African annual budget for 2035. The contribution to the South African annual budget will also progressively increase throughout the life of the project as the country's NDCs decrease.

The impact of the project on climate change was assessed to have a **moderate** negative risk rating for GHG emissions.

The calculated CO₂e emissions from the project operations in the area (cumulative) for Scope 1 is estimated at a total of 197 189t CO₂e per annum.

Cumulative projects in the area would contribute approximately 0.06% of the remaining carbon budget per year and represent a contribution of 0.04% to the 2022 National GHG inventory total.

The impact of the cumulative projects on climate change was assessed to have a **high** negative risk rating for GHG emissions.

The CCA identified no climate-related reasons that would preclude consideration to obtaining Environmental Authorisation (EA). The assessment does not say there is no climate impact. It recognises the contribution while assessing whether the requested EA can be considered. However, as climate change results in a multidisciplinary impact (including, but not limited to, socio-economic, fauna and flora, ground and surface water, air quality), the CCA cannot be evaluated in isolation. Other disciplinary specialist impact assessments as well as cumulative impacts thus need to be taken into consideration to understand the full impact of the project.

In the event that this project is allocated a carbon budget, it will need to provide a greenhouse gas mitigation plan. The project will also be required to report CO₂e emissions annually via the SAGERS.

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APPENDIX A – CURRICULUM VITAE OF ASSESSMENT AUTHOR

CURRICULUM VITAE

GILLIAN PETZER

CURRICULUM VITAE

Name	Gillian Petzer (née Möhle)
Date of Birth	1 December 1975
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Principal Consultant and Project Manager
Profession	Chemical Engineer employed as an Air Quality and Climate Change Impact Assessment Consultant
Years with Firm	20+ years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- South African Institute of Chemical Engineers, 2003 to present
- Institution of Chemical Engineers (IChemE) - Membership number 99964317
- National Association for Clean Air (NACA), 2003 to present
- Professional Engineer – Registration number 20170315

EXPERIENCE

Gillian has over twenty years of experience in air quality impact assessment and management and ten years in greenhouse gas quantification and climate change impact assessments. She is an employee of Airshed Planning Professionals (Pty) Ltd and is involved in the compilation of emission inventories, air pollution mitigation and management, and air pollution and climate change impact work.

A list of projects completed in various sectors is given below.

Air Quality Management

- Richards Bay Air Quality Management Plan
- Tshwane Air Quality Management Plan
- Dust Management Plan for various mines

Mining Sector

Lusthof Colliery, South Deep Mine, Kangra, MacWest, Sishen Iron Ore Mine, Kolomela Mine, SA Chrome, Esaase Gold Project (Ghana), Mampon Gold Mine (Ghana), Navachab (Namibia), Skorpion Zinc mine (Namibia), Debswana Diamond Mines (Botswana). Quarries: Afrisam Pietermaritzburg, AMT operations (Rustenburg and Wonderstone).

Industrial Sector

Various Brickworks, Middelburg Ferrochrome, Impala Platinum (Springs), Delta EMD Project, PetroSA, Alfluorco Aluminium Fluoride Project, PPC, Rand Carbide, Vanchem, BCL incinerator, AEL, Namakwa Sands Plant, Liquid Natural Gas Refinery (Equatorial Guinea), Phalaborwa Mining Company, Asphalt plants, Ceramic facilities, Arcelor Mittal.

Energy Sector

Walvis Bay Power Station Project (Namibia), various small power stations (Eritrea, Nigeria, Mauritania, Kenya), Matimba Power Station, Mossel Bay OCGT Power Station, Sese Power Station (Botswana), Geothermal Power Station (Kenya), Kusile Power Station.

Waste Disposal and Treatment Sector

Rosslyn and Chloorkop Waste Disposal Sites, Organic waste disposal site.

Transport and Logistics Sector

Kolomela Iron Ore Railway Line, Guinea Port and Railway Project (Guinea), Grindrod Coal Terminal, VALE Port Project (Mozambique), various fuel depots.

Greenhouse Gas Emissions Inventories and Climate Change Impact Assessments

Van Eck Power Station (Namibia), Sheberghan Gas Fields (Afghanistan), Cabinda Refinery (Angola), Oil and gas offshore exploration (West Coast of SA), review of coal and gold mines climate change impact assessments.

Ambient Air Quality and Noise Sampling

- Gravimetric Particulate Matter (PM) and dustfall sampling
- Passive diffusive gaseous pollutant sampling

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM, TANKS
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

- BEng: (Chemical Engineering), 2002, University of Pretoria

RECENT COURSES COMPLETED AND CONFERENCES ATTENDED

- Conference: IUAPPA (October 2013), Attended
- Course: Climate change and carbon management. Presented by Environmental & Sustainability Solutions (July 2014)
- Conference NACA (October 2016), Attended
- Conference NACA (October 2017), Attended
- Process Vessel and Tank Design Course (May 2019)
- Multi-Variable Problems and Solutions Course (May 2020)
- Knowledge Management, Communication and Report Writing Course (June 2020)
- Materials Design Course (June 2020)
- Excel for Engineers and Other Built Environment Professionals (August 2022)
- IAIA Impact Assessment and Climate Change Symposium (September 2022), Attended and presented a climate change impact assessment
- IAIA Impact Assessment Conference (August 2023), Attended
- Conference NACA (October 2024), Attended

COURSES PRESENTED

- National Environmental Management: Air Quality Act and its Implementation (course arranged by the North-West University - NWU)

COUNTRIES OF WORK EXPERIENCE

South Africa, Namibia, Botswana, Ghana, Eritrea, Mauritania, Mozambique, Kenya, Guinea, Equatorial Guinea, Nigeria, Angola and Afghanistan.

LANGUAGES

Language	Proficiency
English	Native language
Afrikaans	Full professional proficiency

REFERENCES

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Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.



13/03/2025

APPENDIX B – DECLARATION OF INDEPENDENCE

Project Details

Project Name	Change Change Assessment for the D3 Energy Production Right Application (PR16), Free State Province
Applicant	
Competent Authority	

Specialist Details

Specialist Company	Airshed Planning Professionals			
Specialist Name	Gillian Petzer			
Contact details	Tel	011 805 1940	Cell	083 4793412
	E-mail	gillian@airshed.co.za		
	Postal Address	Postnet Suite 006, Private Bag X2, Raslouw, 0109		
	Physical Address	62 Constantia Road, Mnandi AH, Centurion, 0157		

General Declaration

By signing this form, I hereby declare that:

- I act as an independent specialist in this application.
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant.
- I declare that there are no circumstances that may compromise my objectivity in performing such work.
- I have expertise in conducting undertaking the specialist work as required, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations, and all other applicable legislation.
- I have not, and will not engage in, conflicting interest in the undertaking of the activity.
- I understand to disclose to the applicant and competent authority all material information in my possession that reasonably has or may have the potential of influencing- any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority.
- I have taken into account, to the extent possible, the matters referred to in Regulation 18 when preparing the report, plan or document.
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.
- All the particulars furnished by me this form are true and correct.
- I will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations.

- I am aware of what constitutes an offence in terms of Regulation 48 and that a person convicted of an offence in terms of Regulation 48(1) is liable to the penalties as contemplated in Section 49B of the Act.

Disclosure of Vested Interest

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remunerative for work performed in terms of the Regulations.

Undertaking Under Oath/Affirmation

By signing this form, I swear under oath/affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signatures

Specialist					
Name	Gillian Petzer	Signature		Date	19/06/2026
Commissioner of Oaths					
Name		Signature		Date	
Commissioner of Oaths Official Stamp					

APPENDIX C – CALCULATED GHG EMISSIONS USING THE IPCC SIXTH ASSESSMENT REPORT GLOBAL WARMING POTENTIALS

The IPCC Sixth Assessment report (AR6) 100-year GWP is provided in **Table C-1**. The estimated GHG emissions due to project is provided in **Table C-2**. The quantified GHG emissions using the AR6 100-year GWP increase by approximately 12% compared to the calculated emissions (32 772 tCO₂e per year for Scope 1) using the AR3 GWP (Section 4.7). It should be noted that certain emission factors were already given as CO₂e and therefore stay the same as Section 4.7 (especially for scope 3 categories). The UK DESNZ emission factors made use of the AR5 GWP.

Table C-1: Greenhouse gasses and 100-year AR6 global warming potentials

Greenhouse Gas	Global Warming Potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄) – fossil	29.8
Nitrous oxide (N ₂ O)	273

Table C-2: GHG emissions estimated for the project assuming 100-year AR6 global warming potentials

Source	t CO ₂ e per year			
	Scope 1	Scope 2	Scope 3	Total
GHG released due to exploration	1 947			1 947
GHG released due to production	9 168			9 168
GHG released due to gathering	3 035			3 035
GHG released due to processing	1 563			1 563
GHG released due to abandoned wells	15			15
Natural gas (stationary combustion)	16 868			16 868
Diesel (stationary combustion)	13			13
Diesel (mobile combustion)	161			161
Purchased goods and services ⁽¹⁾			123 469	123 469
Fuel and energy related activities			40	40
Upstream transportation ⁽¹⁾			8 491	8 491
Waste			85	85
Business travel			46	46
Employee commuting			70	70
Downstream transportation			1 468	1 468
Use of sold natural gas			58 796	58 796
Total t CO₂e per year	32 772	-	192 464	225 236
Total t CO₂e for period (30 years)	896 092	-	1 947 091	2 843 183

(1) Purchasing of raw materials for well construction and transport of these materials was assumed to only take place initially and not for the life of the project

In the AR6, the GWP for methane from fossil fuels has been estimated as 29.8 (with an uncertainty of ± 11) over 100-years. However, methane has an atmospheric lifetime of approximately 12 years, which is much shorter than 100 years. The GWP in this case has been estimated to be 82.5 (with an uncertainty of ± 25.8) over 20 years. The CO₂ from the oxidation of methane is formed at the end of a methane molecule's atmospheric lifetime, which, on average, is 12 years. Therefore, to derive the GWP over a 100-year period, the IPCC effectively integrates the radiative forcing effect of this CO₂ over, on average, approximately 88 years of the 100-year time horizon. Furthermore, the IPCC assumes that at the end of its atmospheric lifetime, 25% of the methane is not oxidized to CO₂ but rather is converted to formaldehyde and removed from the atmosphere through deposition on soils and water bodies. Therefore, it is assumed that only 75% of the carbon in methane becomes atmospheric CO₂ through oxidation and 25% as formaldehyde.

Assuming a 20-year global warming potential AR6 GWP is provided in **Table C-3**. The estimated GHG emissions due to project assuming the AR6 20-year GWP is provided in **Table C-4**. The quantified GHG emissions using the AR6 20-year GWP is approximately double than the calculated emissions (60 293 tCO₂e per year for Scope 1), using the AR3 100-year GWP (Section 4.7).

Table C-3: Greenhouse gasses and 20-year global warming potentials

Greenhouse Gas	Global Warming Potential
Carbon dioxide (CO ₂)	1
Methane (CH ₄) – fossil	82.5
Nitrous oxide (N ₂ O)	273

Table C-4: GHG emissions estimated for the project assuming 20-year AR6 global warming potentials

Source	t CO ₂ e per year			
	Scope 1	Scope 2	Scope 3	Total
GHG released due to exploration	5 297			1 947
GHG released due to production	25 189			9 168
GHG released due to gathering	8 384			3 035
GHG released due to processing	4 321			1 563
GHG released due to abandoned wells	43			15
Natural gas (stationary combustion)	16 884			16 868
Diesel (stationary combustion)	13			13
Diesel (mobile combustion)	162			161
Purchased goods and services ⁽¹⁾			123 469	123 469
Fuel and energy related activities			40	40
Upstream transportation ⁽¹⁾			8 491	8 491
Waste			85	85
Business travel			46	46
Employee commuting			70	70
Downstream transportation			1 468	1 468
Use of sold natural gas			63 574	58 796
Total t CO₂e per year	60 293	-	197 242	257 535
Total t CO₂e for period (30 years)	1 570 828	-	2 090 434	3 661 262

(1) Purchasing of raw materials for well construction and transport of these materials was assumed to only take place initially and not for the life of the project

Referencing the international reporting which considers a medium facility as producing more than 25 000 tCO₂e and less than 100 000 tCO₂e per annum (Scope 1 and Scope 2), the project, assuming AR3 100-year GWP (29 221 tCO₂e per annum) is considered a medium facility. The project, assuming the AR6 100-year GWP (32 772 tCO₂e per annum) and AR6 20-year GWP (60 293 tCO₂e per annum) remains classified as a medium facility. A summary of the GHG emissions and the significance of the potential impacts using AR3 and AR6 GWP is provided in **Table C-5**. The various GWP used, therefore, does not change the significance rating of the project. The contribution of project GHG emissions to NDC2 for 2035 and National GHG total emissions is less than 1% assuming AR3 and AR6 GWP.

Table C-5: Summary of GHG emissions estimated for the project assuming AR3 and AR6 global warming potentials and the significance of the impacts

Global warming potentials used in the emission quantification	t CO ₂ e per year (Scope 1 and Scope 2)	Classification of facility based on international reporting	Significance in terms of severity of GHG emissions (Scope 1 and Scope 2) ^(a)	Contribution to NDC for 2035 (assuming lower end of range provided in the NDC)	Contribution to 2022 National GHG total emissions
AR3 100-year GWP	29 221	Medium facility	MODERATE	0.009%	0.006%
AR6 100-year GWP	32 772	Medium facility	MODERATE	0.010%	0.007%
AR6 20-year GWP	60 293	Medium facility	MODERATE	0.019%	0.013%

(a) Based on the Climate Change Significance Rating Framework that classifies the severity of GHG emissions for facilities of more than 10 000 tCO₂e per year as MODERATE.

APPENDIX D – CLIMATE CHANGE SIGNIFICANCE RATING FRAMEWORK

The following framework is proposed with respect to climate change risks associated with the following main climate change impact categories:

- Impact of climate change manifestations on the project;
- Impact of the project on climate change adaptation or resilience;
- Impact of the project on GHG emissions.

Table D-1 provides the overall climate change significance rating framework that aligns with the requirements of Appendix 3 of the EIA Regulations for the environmental impact assessment process, particularly paragraph 3(1)(h)(V-VI).

Table D-2 provides a more detailed criteria for the ranking of impact severity.

Table D-3 provides a more detailed criteria for ranking of impact severity (intensity).

Table D-4 provides a more detailed description of significance rating.

Table D-1: Climate change impact significance rating framework

Climate Change Impacts or Risks	Impact of Climate Change Manifestations on the Project	Impact of the Project on Climate Change Adaptation or Resilience	Impact of Project on Greenhouse Gas Emissions
Examples of Impact or Risk	Increased rainfall may expose the project to a higher risk of flooding and damage to infrastructure.	The project may damage coastal dune systems thus compromising the natural coastal defence and increasing vulnerability to tidal surges.	The project may require the consumption of significant quantities of fossil fuels resulting in a significant increase in GHG emissions into the atmosphere.
	Increased sea-level rise and tidal surges may expose infrastructure to damage.	The project could result in the loss of a water resource thus increasing vulnerability to expected drought conditions.	The project may be a renewable energy project that avoids or reduces the burning of fossil fuels thus reducing GHG emissions into the atmosphere.
IMPACT CRITERIA			
1. Nature - the nature of an impact is classified as negative or positive, also whether an impact is Direct or Indirect.	Positive or negative Direct or Indirect	Positive or negative Direct or Indirect	Positive or negative Indirect

Climate Change Impacts or Risks	Impact of Climate Change Manifestations on the Project	Impact of the Project on Climate Change Adaptation or Resilience	Impact of Project on Greenhouse Gas Emissions
2. Duration - the length of time the impact is expected to last, from short-term to long-term or permanent or how often the impact occurs, such as frequency to storm and flooding events.	Table D-2	Table D-2	Probably permanent
3. Extent Spatial Extent - the geographical area effected by the impact, ranging from local to global. Extent of Impact - the scale of the impact on the receiving environment, such as changes in temperature, rainfall patterns, or sea levels.	Local	Local, study area, municipality or regional	Global
4. Probability - the likelihood of the impact occurring ranging from low to high probability.	Table D-2	Table D-2	PROBABLE based on calculations.
5. Irreplaceability - the extent to which the impact will cause irreplaceable loss of resources.	Table D-2	Table D-2	Probably VERY HIGH due to irreversibility of elevated GHG concentrations in the atmosphere.
6 Reversibility and mitigation potential - the extent to which the impacted environment or system can be mitigated to reduce or avoid the impact through various measures and return to its previous state after the impact occurs. The degree of difficulty of implementing measures to reverse and/or mitigate the various impacts including the practical feasibility, the cost and the potential effectiveness of the measure(s).	Table D-2	Table D-2	Reversibility probably VERY HIGH negative due to irreversibility of elevated GHG concentrations in the atmosphere. Table D-2

Climate Change Impacts or Risks	Impact of Climate Change Manifestations on the Project	Impact of the Project on Climate Change Adaptation or Resilience	Impact of Project on Greenhouse Gas Emissions
7. Severity (intensity) The severity or intensity of the impact on the environment or socio-economic systems. This could include the degree of temperature change, the intensity of storms, or the severity of droughts, or levels of project GHG emissions.	Table D-3	Table D-3	VERY HIGH - > 1 000 000 tCO ₂ e per year. HIGH - > 100 000 tCO ₂ e per year. MODERATE - > 10 000 tCO ₂ e per year. LOW - < 10 000 tCO ₂ e per year.
8. Significance - The significance of an impact is often determined by combining the rating for above criteria. For example, a high-impact event with a high probability, global extent, long duration, and irreversible effects would be considered highly significant.	Table D-4	Table D-4	Table D-4
9. Residual risk - The residual risk is a measure of the remaining environmental or social risk after mitigation measures or controls have been implemented. Residual risk is the risk "left-over" after mitigation measures or controls have been applied.	Table D-4	Table D-4	Table D-4

Table D-2: Ranking of evaluation criteria

Effect	Duration	
	Short term	Less than 2 years
	Medium term	Between 2-10 years
	Long term	Between 10-25 years
	Permanent	Over 25 years or resulting in a permanent and lasting loss
	Extent	
	Localised	Impacts affect a small area of a few hectares in extent. Often only a portion of the project area.
	Study area	The proposed site and its immediate surroundings.
	Municipal	Impacts affect the Local Municipality, or any towns within the municipality.
	Regional	Impacts affect the wider area or the Province as a whole.
	National	Impacts affect the entire country.

	International/Global	Impacts affect other countries or have a global influence.
	Probability	
	Definite	More than 90% sure of a particular fact or impact. Should have substantial supportive data.
	Probable	Over 70% sure of a particular fact, or of the likelihood of the impact occurring.
	Possible	Only over 40% sure of a particular fact, or of the likelihood of the impact occurring.
	Unsure/Unlikely	Less than 40% sure of a particular fact, or of the likelihood of the impact occurring.
Irreplaceable loss of resources	Irreplaceable loss of resources	
	Limited	Loss or impact on replaceable or regenerable resources. Restoration is simple and effective.
	Moderate	Resources are degraded or lost, with replacement possible but difficult, costly, or time-consuming.
	High	Major loss of significant resources or ecosystems that are largely irreplaceable. Restoration is technically possible but not guaranteed.
	Very High	Permanent loss of unique and irreplaceable resources with no visible replacement or restoration pathway.
Mitigation potential	Impact reversibility and mitigation potential	
	Easy	The impact can be easily, effectively and cost effectively mitigated/ reversed.
	Moderate	The impact can be effectively mitigated/ reversed without much difficulty or cost.
	Difficult	The impact could be mitigated/ reversed but there will be some difficulty in ensuring effectiveness and/ or implementation, and significant costs.
	Very difficult	The impact could be mitigated/ reversed but it would be very difficult to ensure effectiveness, technically very challenging and financially very costly.
Severity (intensity) Table D-3	Severity (intensity)	
	Slight	Slight impacts or benefits on the affected system(s) or party(ies)
	Moderate	Moderate impacts or benefits on the affected system(s) or party(ies)
	Severe / beneficial	Severe or intense impacts or benefits on the affected system(s) or party(ies)
	Very severe / very beneficial	Very severe or very intense impacts on or very high benefits to the affected system(s) or party(ies)
Residual Risk	Residual Risk	
	Low	There is a low risk that additional environmental and social (E&S) impacts will arise after mitigation measures have been effectively implemented.
	Moderate	There is a moderate risk that additional E&S impacts will arise after mitigation measures have been effectively implemented.
	High	There is a high risk that additional E&S impacts will arise after mitigation measures have been effectively implemented but not sufficient enough to stop the project from proceeding.
	Very High	There is a very high risk that additional E&S impacts will arise after mitigation measures have been effectively implemented and proceeding with the project should be seriously questioned.

Table D-3: Impacts severity (intensity) rating

Impact severity <i>(The severity of negative impacts, or how beneficial positive impacts would be on an affected system or affected party)</i>	
Very severe	Very beneficial
An irreversible and permanent change to the affected system(s) or party(ies) which cannot be mitigated. For example, the permanent loss of forested land with very high carbon content.	A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit. For example, the substantial improvement in energy efficiency.
Severe	Beneficial
Long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming, or some combination of these. For example, the clearing of forest vegetation with high carbon content.	Long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these. For example, an increase in energy efficiency.
Moderately severe	Moderately beneficial
Medium to long term impacts on the affected system(s) or party(ies), which could be mitigated. For example, constructing a road where there was vegetation with a low conservation value or low carbon content.	Medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way. For example, a 'slight' improvement in energy efficiency.
Slight	Slightly beneficial
Medium- or short-term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary. For example, a temporary loss of vegetation and carbon content.	A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.
No effect	Don't know / Can't know
The system(s) or party(ies) is not affected by the proposed development.	In certain cases, it may not be possible to determine the severity of an impact.

Table D-4: Description of issues level significance ratings

Significance rate	Description	Colour code
Negative		
Low	The climate related impacts on this issue are acceptable and mitigation, while desirable, is not essential. The impacts on the issue by themselves are insufficient, even in combination with other low impacts, to prevent the development being approved. Impacts on this particular issue will result in negative medium to short term effects on the social and/ or natural environment.	Low (-)
Moderate	The climate related impacts on this issue are important and require mitigation. The impacts on the issue are, by themselves, insufficient to prevent the implementation of the project, but could in conjunction with other issues with moderate impacts, prevent its implementation. Impacts on this particular issue usually result in a negative medium to long-term effect on the social and / or natural environment.	Moderate (-)
High	The climate change related impacts on this issue are serious, and if not mitigated, they may prevent the implementation of the project. Impacts on this particular issue would be considered by society as constituting a significant and usually a long-term change to the natural and/ or social environment.	High (-)

Significance rate	Description	Colour code
Very high	The climate change related impacts on this issue are very serious, and probably cannot be mitigated, and may represent a "fatal flaw" to the implementation of the project. Impacts on this particular issue would be considered by society as constituting a very severe and usually permanent or very long-term changes to the natural and/ or social environment.	Very high (-)
Positive		
Low	A short to medium term and negligible climate change related benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these.	Low (+)
Moderate	A medium to long term climate change related benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving this in this way. For example, a 'slight' improvement in energy efficiency.	Moderate (+)
High	A long-term impact and substantial climate change related benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive to time consuming, or some combination of these. For example, a material increase in energy efficiency.	High (+)
Very high	Impacts on this particular climate change related issue would be considered by society as constituting highly beneficial and usually a long-term positive change to the natural and/ or social environment. For example, the establishment and formal proclamation of a nature reserve with a high carbon content.	Very high (+)