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ENGINEERING SOLUTIONS
Environmental and Engineering Consultants

ECOPARTNERS

CLIMATE CHANGE IMPACT ASSESSMENT

TONKMETER WASTE RESOURCE FACILITY

September 2026

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PO Box 1369 Bromhof 2154

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	Name	**Signature**	**Date**
Author	**Mike Brugman** *Senior Air Quality Specialist*		19 October 2026
First Document Reviewer	**Jessica Burger** *(PhD)* *Atmospheric Scientist*		19 October 2026
Second Document Reviewer	**Brenton Faulds** *(MSc)* *Operations Manager*		19 October 2026
Document Authorisation	**Clive Wray** *(Pr. Eng.)* *Director*		19 October 2026

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DECLARATION

PROJECT TITLE

Tonkmeter Waste Resource Facility, Climate Change Impact Assessment.

Specialist	Rayten Engineering Solutions (Pty) Ltd
Contact Person	Clive Wray
Postal address	PO Box 1369, Bromhof 2154
Postal code	2154
Telephone	011 792 0880
E-mail	info@rayten.co.za
Professional affiliation(s) (if any)	As per below

Name of Practitioner: Rayten Engineering (Pty) Ltd
Name of Registration Body: Engineering Council of South Africa (ECSA)
Professional Registration No: 20090334 – Clive Wray

Declaration of accuracy of information provided:

Climate Change Impact Assessment report:

I, Clive Wray, declare that – general declaration

I am independent of the applicant;
I have the necessary expertise to conduct the assessments required for the report; and
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 will disclose to the applicant and the relevant authorities 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.
The information provided in this Climate Change Impact Assessment report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an authority is a criminal offence in terms of the NEMA EIA Regulations 2014 specialist declaration (Reg. 48).



Signature of the specialist:

Rayten Engineering Solutions (Pty) Ltd

Name of company (if applicable):

Date: 19 October 2026

EXECUTIVE SUMMARY

Rayten Engineering Solutions (Pty) Ltd was appointed by EcoPartners (Pty) Ltd to compile a Climate Change Impact Assessment (CCIA) report for Tonkmeter (Pty) Ltd, for the Tonkmeter Waste Resource Facility (hereafter referred to as the "Tonkmeter WRF"). The facility is located on Portions 222, 223 and 224 of the Farm Rietfontein 128IR, within the Ekurhuleni Metropolitan Municipality, Springs, Gauteng. The Tonkmeter WRF is an existing and operational waste disposal and resource recovery facility. The original licence for the facility was approved in 2019, the first landfill cell was constructed in 2024, and the facility became operational for the landfilling of general municipal waste in 2025. The recovery and recycling centre also became operational in 2025.

The facility has applied to amend of their Integrated Environmental Authorisation, with the current scope understood to include the proposed increase in height of Area E to 25m. Areas D and F will remain operational as part of the broader facility but are not proposed to be increased in height under the current application. For the purposes of the greenhouse gas inventory compiled for the current CCIA, emissions were assessed at facility level, as the waste disposal scenarios apply to the Tonkmeter WRF as a whole rather than to Area E only. The scope of work for this CCIA is to assess the impact of the facility on climate change, through calculation of the project's potential greenhouse gas (GHG) emissions inventory, as well as the impact of climate change on the facility, through assessing the project's vulnerability to physical climate risk identified for the region.

At present, Draft National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licences and Waste Management Licences (Government Notice 6759, Government Gazette No. 53574, October 2025). This guideline, however, remains in draft form at the time of writing this report and has not yet been formally enacted as a binding regulation. This report has therefore been compiled with consideration of Appendix 6 of the NEMA EIA Regulations, as well as applicable climate change, GHG reporting and emissions quantification guidance

GHG Emissions

The GHG inventory included Scope 1 emissions from landfill methane generation and operational diesel combustion, as well as Scope 2 emissions from purchased grid electricity. Scope 3 emissions were excluded due to limited activity data and because these emissions fall outside the direct operational boundary of the facility. Construction-phase emissions were also excluded, as the timing, frequency and associated activity data for future landfill cell construction were not sufficiently defined at the time of the assessment.

The following activities are expected to be the key sources of GHG emissions for the facility:

- Fugitive methane emissions from the disposal and decomposition of landfilled waste;
- Diesel combustion from operational mobile equipment and generator use; and
- Purchased grid electricity used for offices, the weighbridge and leachate aeration.

Two waste disposal scenarios were assessed. Scenario 1 assumes an average disposal rate of 7 500 tonnes/month, with an estimated facility life of 87 years under the no-go case and 126 years under the go-ahead case. Scenario 2 assumes an average disposal rate of 15 000 tonnes/month, with an estimated facility life of 44 years under the no-go case and 63 years under the go-ahead case. The

proposed Area E application therefore extends the estimated operating life of the facility by approximately 39 years under Scenario 1 and 19 years under Scenario 2.

The incremental GHG emissions attributable to the proposed application can be summarised as follows:

Scenario	Waste Disposal Rate	Additional Operating Life	Unmitigated Incremental Emissions	Mitigated Incremental Emissions
Scenario 1	7 500 tonnes/month	39 years	1 211 005 tCO_2e	308 547 tCO_2e
Scenario 2	15 000 tonnes/month	19 years	1 091 358 tCO_2e	278 163 tCO_2e

**Note: The above emissions are inclusive of diesel and grid electricity emissions.*

Fugitive landfill methane is the dominant emission source, contributing approximately 99.4% of the incremental unmitigated GHG footprint under both scenarios. Diesel combustion represents a comparatively small secondary source, while purchased grid electricity contributes less than 1%.

For the mitigated assessment, landfill gas collection and flaring were modelled from approximately 2030, using an assumed methane collection efficiency of 75%. Implementation of these measures reduces the incremental GHG footprint by approximately 74.5% under both scenarios.

When compared against South Africa's estimated share of the Remaining Carbon Budget (RCB), the incremental emissions are classified as High prior to mitigation and Medium following mitigation under both scenarios.

Scenario	Case	Incremental GHG Emissions (tCO_2e)	GHG Emissions ($GtCO_2e$)	Contribution to 1.5°C RCB (%)	Contribution to 2°C RCB (%)	Impact Rating
Scenario 1	Unmitigated	1 211 004.91	0.001211005	0.12253	0.01517	**High**
	Mitigated	308 546.67	0.000308547	0.03122	0.00387	**Medium**
Scenario 2	Unmitigated	1 091 357.91	0.001091358	0.11043	0.01367	**High**
	Mitigated	278 163.13	0.000278163	0.02815	0.00348	**Medium**

**Note: The above emissions are inclusive of diesel and grid electricity emissions.*

In terms of the environmental significance assessment, the climate change impact of the proposed height increase is rated **High Negative** prior to mitigation and decreases to **Medium Negative** following implementation of landfill gas collection and flaring. Landfill gas management therefore represents the most important mitigation opportunity for reducing the climate change impact associated with the additional landfill capacity.

Mitigation measures are available and should focus on landfill gas monitoring and future gas capture, flaring or utilisation where feasible, organic waste diversion through chipping or composting, efficient diesel use, reduced generator reliance, continued use of solar PV and improved operational data management. It is recommended that a GHG inventory be calculated on an annual basis and that this

form part of the facility's Environmental Management Programme (EMPr) reporting requirements and environmental authorisation compliance framework.

Landfilling of biodegradable waste inherently generates methane, but the quantity released depends strongly on how the facility is managed. Modelled landfill methane emissions for a poorly managed facility receiving the same waste would be approximately 40% higher than for the well-managed facility assessed here, and continued operation in accordance with the approved operating and engineering design therefore forms part of the facility's emissions control, alongside the proposed landfill gas collection and flaring.

Using various risk tools, physical climate and natural hazards that could affect the project were also identified and ranked. The Ekurhuleni Metropolitan Municipality, where the facility is located, is vulnerable to hazards including wildfires, water scarcity, earthquakes, extreme heat and urban flooding. The highest adjusted risks for the facility are wildfires and water scarcity. Adaptation measures should therefore be implemented to improve site resilience, including wildfire preparedness, water scarcity planning, stormwater and drainage maintenance, emergency response planning, infrastructure inspections, heat-stress management and contingency planning for operational disruptions.

Alternative site layouts are not expected to materially change the outcome of the CCIA, as the calculated GHG emissions are primarily driven by waste quantity, waste composition, landfill management practices, methane recovery assumptions, diesel use and purchased electricity consumption. The no-go alternative would mean that the proposed height increase for Area E is not authorised; however, as the facility is already operational, the no-go alternative would not result in zero GHG emissions.

No fatal flaws have been identified from a climate change perspective. The proposed application may therefore proceed from a climate change perspective, provided that the recommended mitigation, monitoring and adaptation measures are implemented. However, approval of the proposed height increase should not rely solely on the assessment of climate change impacts.

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LIST OF ABBREVIATIONS

ADT	Articulated Dump Truck
AFOLU	Agriculture, Forestry and Other Land Use
CCIA	Climate Change Impact Assessment
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CSIR	Council for Scientific and Industrial Research
DFFE	Department of Forestry, Fisheries and the Environment
DOC	Degradable Organic Carbon
DOC_f	Fraction of Degradable Organic Carbon Dissimilated
EAP	Environmental Assessment Practitioner
ECSA	Engineering Council of South Africa
EIA	Environmental Impact Assessment
EMM	Ekurhuleni Metropolitan Municipality
EMPr	Environmental Management Programme
FOD	First Order Decay
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gas
GLB+	General Waste, Large Landfill, Significant Leachate Generation (landfill classification)
GN	Government Notice
GWIS	Gauteng Waste Information System
GWP	Global Warming Potential
I&APs	Interested and Affected Parties
IEA	Integrated Environmental Authorisation
IFRS	International Financial Reporting Standards
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LULUCF	Land Use, Land-Use Change and Forestry
MCF	Methane Correction Factor
MM5	Fifth-Generation Penn State/NCAR Mesoscale Model
N_2O	Nitrous Oxide
NCV	Net Calorific Value
NDC	Nationally Determined Contribution
NEM:AQA	National Environmental Management: Air Quality Act
NEMA	National Environmental Management Act
OX	Oxidation Factor
PCRA	Physical Climate Risk Assessment
PV	Photovoltaic
RCB	Remaining Carbon Budget
RCP	Representative Concentration Pathway
SANS	South African National Standard
SARS	South African Revenue Service
TCFD	Task Force on Climate-related Financial Disclosures
TLB	Tractor-Loader-Backhoe
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
WRF	Waste Resource Facility
WRI	World Resources Institute

LIST OF UNITS

°C	Degrees Celsius
Gg	Gigagram
Gt / $GtCO_2$	Gigatonne / Gigatonnes of Carbon Dioxide
kg	Kilogram
kWh / MWh	Kilowatt-hour / Megawatt-hour
L	Litre
m / m^3	Metre / Cubic metre
MJ / TJ	Megajoule / Terajoule
mm	Millimetre
Mt	Megatonne
tCO_2e	Tonnes of Carbon Dioxide Equivalent

1. INTRODUCTION

Rayten Engineering Solutions (Pty) Ltd (hereafter referred to as “Rayten”) was appointed by EcoPartners (Pty) Ltd to compile a Climate Change Impact Assessment (CCIA) report for Tonkmeter (Pty) Ltd for the Tonkmeter Waste Resource Facility (hereafter referred to as the “Tonkmeter WRF”).

Tonkmeter is the owner and operator of the WRF, which comprises a landfill and associated resource recovery facility. The site is located on Portions 222, 223 and 224 of the Farm Rietfontein 128IR, within the Ekurhuleni Metropolitan Municipality, Springs, Gauteng. Tonkmeter is the holder of the Integrated Environmental Authorisation (IEA) for the facility, which is licensed as a GLB+/Class B landfill in terms of the National Environmental Management: Waste Act, 2008 (Act 59 of 2008).

The original licence for the facility was approved in 2019. The first landfill cell was constructed in 2024, and the facility became operational for the landfilling of general municipal waste in January 2025. The recovery and recycling centre also became operational in 2025.

Tonkmeter is applying to amend the IEA to increase the permitted height of Area E to 25 m, thereby increasing the available landfill capacity and extending the operating life of the WRF. Areas D and F will remain operational as part of the broader facility but are not proposed to be increased in height under the current application.

Based on updated information provided by the client, the proposed Area E height increase is expected to extend the operating life of the whole facility. At an average waste disposal rate of 7 500 tonnes/month, the estimated operating life increases from approximately 87 years without the height increase to approximately 126 years with the height increase. At 15 000 tonnes/month, the estimated operating life increases from approximately 44 years to approximately 63 years. The proposed application for the height increase therefore results in approximately 39 and 19 additional years of facility operation under Scenario 1 and Scenario 2, respectively.

No additional construction is required specifically to achieve the proposed vertical height increase. Additional landfill cells will, however, continue to be constructed within the authorised facility footprint as required during the operational life of the site. Construction phase emissions have been excluded from the current GHG assessment where the timing, duration and associated activity data for future cell construction are not sufficiently defined.

Landfill operations have the potential to contribute to climate change primarily through the generation and release of methane (CH_4) from the anaerobic decomposition of biodegradable waste. Additional Greenhouse Gas (GHG) emission sources include diesel combustion from operational mobile equipment and generators and indirect emissions associated with purchased grid electricity. A landfill gas collection and flaring system is proposed as a future methane mitigation measure and will be considered in the assessment subject to the available design and operational information.

The purpose of this CCIA is to assess the potential impact of the proposed Area E height increase on climate change through the quantification of GHG emissions, as well as to assess the potential impact of climate-related hazards on the WRF and its operations. The CCIA has

been prepared to support the environmental assessment process and to identify appropriate mitigation and adaptation measures for consideration in facility planning, operational management and environmental authorisation requirements.

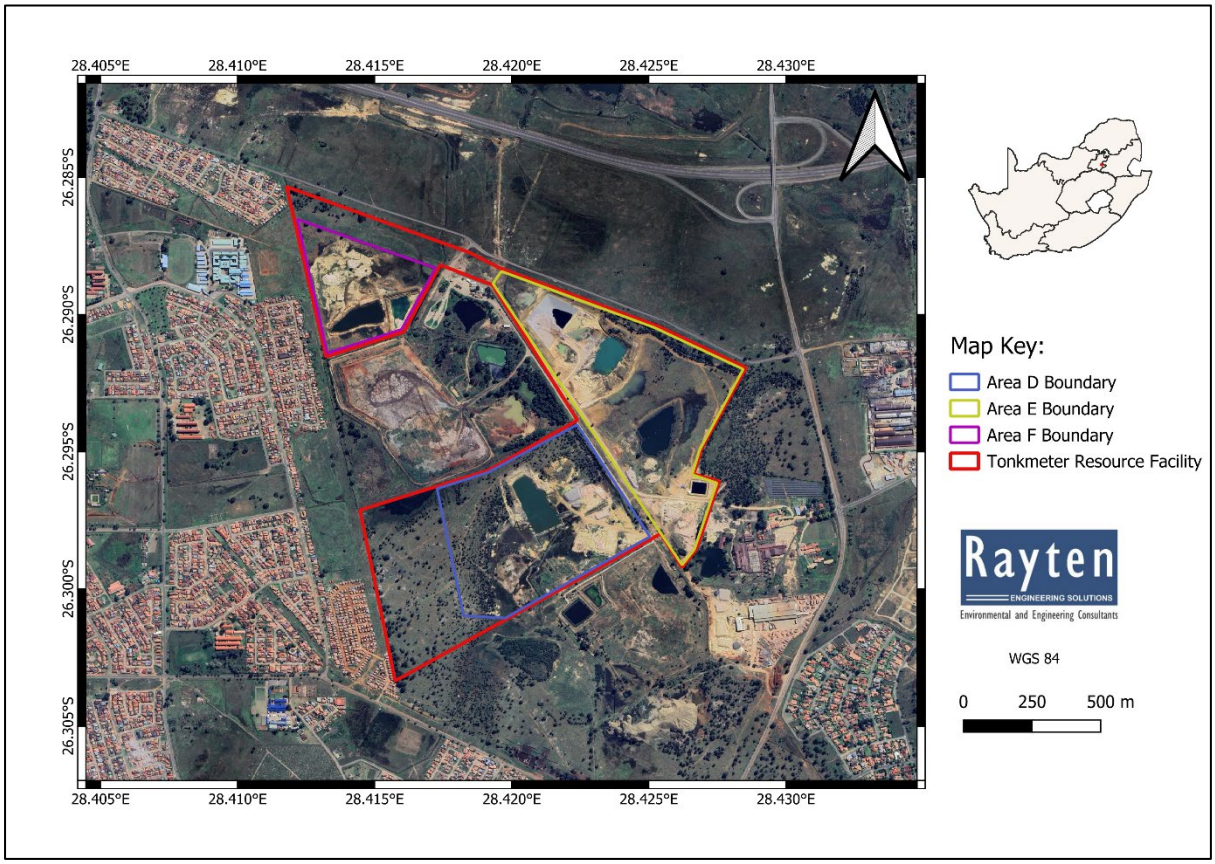


Figure 1: Regional Setting for the Tonkmeter WRF.

1.1. Climate Change Context

Climate change refers to long term changes in the average weather conditions experienced by a region over several decades. Examples of climate changes include rising temperatures, increased extreme weather events and variations in rainfall. Causes of climate change can be natural (e.g., due to changes in the sun, volcanic activity and variations in the Earth's orbit) or anthropogenic (i.e., due to human activities). Human activities that lead to climate change include land use change and increasing GHG emissions (IPCC, 2023). GHG's such as carbon dioxide (CO_2), CH_4 and nitrous oxide (N_2O) warm the Earth by absorbing and re-emitting heat energy in various directions (including downwards), which impacts Earth's surface temperature (The Royal Society, 2025). The concentration of GHGs in our atmosphere has significantly increased since the industrial revolution, largely due to the burning of fossil fuels, with CO_2 being widely recognized as the largest contributor.

The socio-economic impacts of climate change are considerable and included threats to food and water security, damage to infrastructure, health risks, and heightened vulnerability of communities and economies, particularly in developing regions. Climate change impacts are not evenly distributed, with some countries facing greater risks and fewer adaptive capacities.

In response, many nations have begun implementing policies and measures to mitigate GHG emissions and limit the progression of global warming.

CCIAs provide a framework to evaluate the GHG emissions expected for proposed activities and determine their potential environmental impact. A core element of CCIAs is the quantification of project-related GHG emissions against a carbon budget. A carbon budget refers to the maximum quantity of GHG emissions that can be emitted in total, over a specific time period, to keep temperatures below or within a specified limit. Globally, the focus has been on limiting warming to no more than 2°C above pre-industrial levels. Temperature increases above the 2°C limit are likely to result in significant adverse impacts in terms of climate change. To achieve this 2°C limit, carbon budgets have been developed on a global scale. Country specific and in some instances, industry specific carbon budgets have also been developed.

As a signatory of the Paris Agreement, South Africa has committed to reducing its GHG emissions as part of ongoing efforts to mitigate the impacts of climate change. Signatory nations submit their climate action plans, known as Nationally Determined Contributions (NDCs) every five years, with each submission reflecting a higher degree of ambition. Through NDCs, countries communicate how they plan to reduce their GHG emissions as well as improve resilience and adaptation to climate change impacts. South Africa submitted its second NDC in 2025, maintaining its economy-wide GHG emissions target range of 350 - 420 Mt CO_2e for 2030 and setting a more ambitious target of 320 - 380 Mt CO_2e by 2035, while pursuing a just transition to net-zero CO_2 emissions by 2050.

1.2. Terms of Reference

The primary objectives of this CCIA are to assess, firstly, the potential impact of the proposed Area E height increase on climate change and, secondly, the potential impact that climate change could have on the WRF and its associated operations.

The current application relates specifically to the proposed increase in height of Area E to 25 m. Areas D and F will remain operational as part of the broader facility but are not proposed to be increased in height under the current application.

For the purposes of determining the GHG emissions attributable to the proposed height increase, the assessment distinguishes between:

- a *no-go* scenario, representing continued operation of the WRF within its currently authorised capacity without the Area E height increase;
- a *go-ahead* scenario, representing operation of the WRF with the additional capacity created by the Area E height increase; and
- *the incremental GHG impact* of the height increase, calculated as the difference between the go-ahead and no-go scenarios.

The full cumulative GHG emissions of the facility with the proposed height increase will also be presented separately to provide context regarding the overall emissions profile and cumulative climate impact of the WRF.

Two operational throughput scenarios are assessed:

- Scenario 1: 7 500 tonnes/month, with an estimated facility life of approximately 87 years without the height increase and 126 years with the height increase; and
- Scenario 2: 15 000 tonnes/month, with an estimated facility life of approximately 44 years without the height increase and 63 years with the height increase.

The proposed application therefore provides approximately 39 additional years of operation under Scenario 1 and 19 additional years under Scenario 2.

While assessing the impact of the proposed height increase on climate change, the following actions are applicable:

- Developing GHG emissions inventories for the no-go and go-ahead cases under each waste disposal scenario;
- Quantifying landfill CH_4 generation associated with waste disposal and decomposition;
- Quantifying direct fuel-combustion emissions associated with operational diesel use;
- Quantifying indirect emissions associated with purchased grid electricity;
- Assessing the potential reduction in landfill CH_4 emissions associated with the proposed landfill gas collection and flaring system, where sufficient information is available;
- Determining the incremental GHG emissions attributable to the proposed Area E height increase;
- Presenting the cumulative facility GHG emissions separately for contextual purposes;
- Evaluating the incremental GHG emissions against the applicable Remaining Carbon Budget (RCB) assessment methodology; and
- Assessing the significance of the climate change impact associated with the proposed height increase and identifying appropriate mitigation measures.

While assessing the impacts of climate change on the facility, the assessment includes:

- Describing existing and projected climate conditions for the project region;
- Assessing the potential implications of climate change for landfill and resource recovery operations;
- Identifying the vulnerability of facility infrastructure and operations to relevant physical climate risks; and
- Providing appropriate climate change adaptation and resilience measures for facility planning, operation, maintenance and closure.

2. PROJECT DESCRIPTION

The WRF comprises a landfill and associated resource recovery facility located on Portions 222, 223 and 224 of the Farm Rietfontein 128IR, within the Ekurhuleni Metropolitan Municipality, Springs, Gauteng. Tonkmeter is the holder of the IEA for the facility, which is licensed as a GLB+/Class B landfill in terms of the National Environmental Management: Waste Act, 2008 (Act 59 of 2008).

The original licence for the facility was approved in 2019. Construction of the first landfill cell commenced in 2024, and the facility became operational for the landfilling of general municipal waste in January 2025. The recovery and recycling centre also became operational in 2025.

Phase 1 construction included Cell 1, with an airspace capacity of approximately 246 000 m³, together with the leachate drainage system, contaminated water dam, leachate tank, security fencing and monitoring station, internal roads, surface drainage, weighbridge and refurbishment of the administration and weighbridge office.

The current application relates specifically to the proposed increase in height of Area E to 25 m. The purpose of the application is to increase the available landfill capacity within Area E and thereby extend the operating life of the WRF. Areas D and F remain part of the operational facility but are not proposed to be increased in height under the current application. Refer to Table 1 for the operational scenarios and associated facility life estimates.

Table 1: Facility life estimates under operational scenarios with and without the Area E height increase

Operational Scenario	Without Area E Height Increase	With Area E Height Increase	Additional Operating Life
Scenario 1 – 7 500 tonnes/month	87 years	126 years	39 years
Scenario 2 – 15 000 tonnes/month	44 years	63 years	19 years

The additional 39 and 19 years of facility operation represent the increase in operating life directly enabled by the proposed Area E height increase under the respective throughput scenarios. These differences form the basis for determining the incremental GHG impact attributable to the current application.

No additional construction is required specifically to achieve the vertical increase in Area E. Additional landfill cells will nevertheless continue to be constructed within the facility as required. Construction emissions are therefore considered separately from the operational emissions attributable to the proposed height increase and are excluded from the current inventory where future construction timing and activity data have not been confirmed.

2.1. Basic Overview of Landfill and Recycling Operations

The WRF accepts general municipal waste for disposal. Waste transport vehicles enter the facility through the main gate, where access control and initial identification are undertaken. Drivers then proceed to the weighbridge office to sign in and present the required documentation. The laden vehicle is weighed on the weighbridge to record the gross weight of the truck and waste.

Following the initial weighbridge process, trucks proceed to the active landfill disposal cell, where general municipal waste is discharged at the designated working face under the direction of site marshals. Recyclable components, including plastics, metals and paper, are manually recovered from the working face by authorised waste pickers. Recovered materials are then transferred to the on-site Recycling Centre, where they are sorted by grade and baled for sale to external vendors.

After disposal, empty trucks return to the exit weighbridge, where the tare weight is recorded. The weighbridge system then calculates the net waste weight, and a weighbridge slip is issued as proof of disposal. Remaining non-recyclable waste at the working face is spread and compacted using heavy machinery to maximise landfill density. At the end of each operational day, the compacted waste is covered with soil or an alternative daily cover to control odours, pests and windblown litter.

All waste disposed at the facility is recorded by the on-site weighbridge, and customers are invoiced based on the tonnage of general municipal waste disposed at the facility. The facility has entered into multi-year contracts with private off-takers for approximately 72 000 to 96 000 tonnes per annum of general municipal waste, with additional non-contracted volumes of approximately 1 000 to 1 500 tonnes per month.

2.2. Infrastructure and Equipment

The WRF includes landfill disposal infrastructure, leachate and stormwater management infrastructure, access control and weighbridge facilities, internal roads, administration and recycling infrastructure, and mobile plant used for waste handling and compaction.

The main infrastructure and equipment relevant to the operation of the facility, and to the identification of potential GHG emission sources, are summarised in Table 2.

Table 2: Tonkmeter Facility Infrastructure and Operational Equipment

Facility Component	Infrastructure / Equipment
Landfill Disposal Facility	Cell 1 and future landfill cells constructed as required. The current application proposes increasing the permitted height of Area E to 25 m.
Leachate and contaminated water management	Leachate drainage system, contaminated water dam, leachate tank and associated aeration infrastructure.
Stormwater and surface drainage	Surface drainage and internal drainage infrastructure.
Access and traffic infrastructure	Main access control, internal roads and weighbridge.
Weighbridge and administration	Weighbridge office and refurbished administration building.
Resource recovery and recycling infrastructure	On-site Recycling Centre where recovered materials are sorted by grade and baled for sale to external vendors.
Operational mobile equipment	Waste compactor, tipper truck, bulldozer, water cart, articulated dump truck and TLB.
Construction equipment	Dozer, tipper truck, grader, water cart, ADT, TLB, front-end loader, excavator and roller. Excluded from GHG inventory due to the absence of confirmed construction timing, frequency and activity data.
Power supply	Combination of grid electricity, generator supply and solar photovoltaic power.

Landfill gas management	Landfill gas collection and flaring are proposed as a methane mitigation measure.

2.3. Potential GHG Emission Sources

The current application increases the available landfill capacity of Area E and consequently extends the period over which the WRF can continue to receive waste and operate. For the purposes of the CCIA, the principal GHG emission sources considered are therefore those that are affected by the additional waste disposal and operational life enabled by the height increase.

The primary GHG emission sources are:

- Fugitive landfill CH_4 emissions associated with the disposal and decomposition of additional waste;
- Diesel combustion from operational mobile equipment and generator use during the additional operating period; and
- Purchased grid electricity consumed during the additional operating period.

Operational diesel consumption is 5 500 L/month under Scenario 1 and 11 000 L/month under Scenario 2. These values include operational fuel use associated with mobile plant and diesel generator use.

Total electricity consumption is approximately 3 500 kWh/month, with the proportion supplied by grid electricity, solar PV and diesel generation split into 50%, 45% and 5% respectively. Solar PV has no direct operational GHG emissions, while generator emissions are accounted for through diesel consumption to avoid double counting.

A landfill gas collection and flaring system is proposed for the facility. The unmitigated assessment will quantify landfill CH_4 emissions without recovery, while the effect of the proposed flaring system will be incorporated into the mitigated assessment on the basis of 75% recovery from 2030 based on proposed considerations by Tonkmeter.

Waste composition is based on available Gauteng Waste Information System (GWIS) records and the allocation of waste into the relevant IPCC waste categories. The GWIS data is treated as reported operational information and has not been independently verified.

Indirect Scope 3 sources, such as third-party waste transport, employee commuting, upstream fuel and electricity emissions and downstream transport of recovered recyclable materials, fall outside the operational boundary of the current project-level assessment and are not quantified.

3. LEGISLATION AND REGULATIONS

The key legislation and guidelines that may have a bearing on the proposed project from a climate perspective are described in the subsections below. It should be noted that this is not an exhaustive list but rather aims to identify pertinent sections of relevant legislation.

3.1. The Climate Change Act (Act 22 of 2024)

South Africa's Climate Change Act was signed into law by the President in July 2024 and officially commenced on 17 March 2025. The Act establishes a legal framework for a coordinated, integrated, and just transition to a low-carbon and climate-resilient economy and society. The Act requires the establishment of a long-term national GHG emissions trajectory, mandates carbon budgets for major emitters, and provides for adaptation strategies and plans to manage impacts through enhanced resilience and reduced vulnerability.

3.2. National Environmental Management: Air Quality Act (Act 39 of 2004, as amended)

Air quality in South Africa is governed by the National Environmental Management: Air Quality Act (Act 39 of 2004) as amended in 2014, (NEM:AQA). The NEM:AQA makes provision for reasonable measures in order to protect the environment, prevent pollution and ecological degradation and secure ecological sustainable development. The NEM:AQA also provides national norms and standards for regulating air quality monitoring, management and control of specific air quality measures and matters.

3.2.1. National GHG Emission Reporting Regulations

The National Greenhouse Gas Emission Reporting Regulations, issued under the National Environmental Management: Air Quality Act (NEM:AQA), were first published on 3 April 2017 (Government Gazette No. 40762, GN 275) and subsequently amended. The Regulations establish a national system for the reporting of greenhouse gas (GHG) emissions and activity data.

Entities classified as Category A data providers are required to report GHG emissions from activities listed in Annexure 1 where the applicable reporting threshold is met or exceeded. Reporting is undertaken for the preceding calendar year in accordance with the applicable Methodological Guidelines for the Quantification of Greenhouse Gas Emissions.

For solid waste disposal, IPCC Code 4A1: Managed Waste Disposal Sites applies to facilities receiving 5 tonnes of waste per day or having a total capacity of 25 000 tonnes.

Based on the authorised capacity and waste acceptance rates of the Tonkmeter WRF, the facility exceeds the reporting threshold applicable to IPCC Code 4A1. Tonkmeter, as the owner and operator exercising operational control over the WRF, is therefore subject to the applicable GHG reporting requirements for this listed activity.

Regulatory GHG reporting is undertaken at facility level and is separate from the project-specific assessment undertaken for the current IEA application. The CCIA therefore distinguishes between the incremental emissions attributable to the proposed Area E height increase and the broader facility-level GHG inventory required for reporting and cumulative-impact purposes.

3.2.2. 2006 IPCC Guidelines

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories provide internationally recognised methodologies for estimating and reporting GHG emissions. Emission sources are

grouped into four principal sectors: Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and Waste. The principal listed activity applicable to the WRF is summarised in Table 3 below.

Table 3: Identified GHG Emitting Activities in terms of Annexure 1 of the National GHG Reporting Regulations (Government Gazette No. 40762 of 03 April 2017).

Listed Activity	Primary IPCC Code	Description	Secondary IPCC Code	Description	Associated Activity Emissions
4	4A	*WASTE, Solid waste disposal*	4A1	*Managed Waste Disposal Sites*	Emissions from solid waste disposal and storage

Landfill CH_4 emissions are quantified using the IPCC First Order Decay (FOD) approach, which accounts for waste disposal quantities, waste composition, degradable organic carbon, landfill management conditions, methane recovery and oxidation.

Operational diesel combustion from mobile plant and generator use is also included in the CCIA as a Scope 1 emission source. Purchased grid electricity is included as a Scope 2 emission source. These sources are included to provide a complete assessment of the operational GHG emissions relevant to the proposed application, irrespective of whether they independently trigger a reporting threshold under the National GHG Emission Reporting Regulations.

3.2.3. South African National Standard 14064 – 1

SANS 14064-1 provides principles and requirements for the quantification and reporting of organisational GHG emissions and removals. The standard supports the establishment of organisational and operational boundaries, identification of relevant GHG sources, selection of appropriate quantification methodologies and transparent reporting of assumptions and limitations.

For the purposes of this CCIA, the GHG inventory has been compiled using the scope-based approach applied in SANS 14064-1:2019, in conjunction with the GHG Protocol Corporate Accounting and Reporting Standard and the applicable South African GHG quantification methodologies.

3.2.4. Greenhouse Gas Protocol Corporate Standard

The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard provides internationally recognised guidance for the preparation of corporate GHG inventories and is compatible with the principles of SANS 14064-1.

The GHG Protocol categorises emissions as Scope 1, Scope 2 and Scope 3. For the purposes of this CCIA, Scope 1 and Scope 2 emissions relevant to the operation of the WRF are quantified. Scope 3 emissions are excluded from the quantitative assessment due to the absence of sufficient project-specific activity data and because these sources occur outside Tonkmeter's direct operational control.

3.2.5. Carbon Tax Act, Act No. 15 of 2019

The Carbon Tax Act, 2019 (Act No. 15 of 2019) gives effect to the “polluter pays” principle by placing a tax on GHG emissions from activities listed in Schedule 2 of the Act. The Act is intended to encourage emitters to reduce emissions and transition towards lower-carbon technologies and operational practices.

The Carbon Tax Act is implemented in phases. Phase 1 commenced on 1 June 2019 and was extended to 31 December 2025. Phase 2 commenced from 2026 and is expected to further strengthen the carbon tax framework. The carbon tax rate is amended periodically through the national budget and related tax instruments. As of 1 January 2026, SARS indicates that the carbon tax rate increased from R236/tCO_2e to R308/tCO_2e.

Schedule 2 of the Carbon Tax Act includes waste-sector activities, including IPCC Code 4A: Solid Waste Disposal and IPCC Code 4A1: Managed Waste Disposal Sites. The threshold for managed waste disposal sites is listed as receiving 5 tonnes of waste per day or having a total capacity of 25 000 tonnes. Based on the information available for the WRF, the facility is likely to fall within this listed activity due to the nature of the landfill operations and the authorised capacity of the site.

For solid waste disposal sites, landfills and waste resource facilities, no South African industry GHG emissions-intensity benchmark has been prescribed under the Section 11 performance allowance regulations. Therefore, no landfill or waste resource facility specific Carbon Tax Act performance benchmark can be applied to the WRF for purposes of assessing the Section 11 performance allowance.

For the purposes of this CCIA, the Carbon Tax Act has therefore been considered in terms of the relevant listed waste-sector activity and the broader need to quantify and manage direct GHG emissions. Emissions intensity may be calculated for internal tracking purposes, such as tonnes CO_2e per tonne of waste disposed, but this should not be interpreted as a prescribed Carbon Tax Act benchmark or as confirmation of tax liability, tax exemption or eligibility for a performance allowance. Formal carbon tax liability should be confirmed separately by the applicant, where required, based on the applicable tax period, current legislation and guidance from SARS and National Treasury.

3.3. NEMA and the EIA Regulatory Framework

The National Environmental Management Act (NEMA, Act No. 107 of 1998) provides the overarching framework for environmental management and sustainable development in South Africa. Section 24 of NEMA provides for the consideration, investigation, assessment and reporting of environmental impacts associated with listed or specified activities before an Environmental Authorisation may be granted.

The Environmental Impact Assessment Regulations, 2014, as amended, prescribe the process and information requirements for environmental authorisation applications. These regulations also include requirements for specialist assessments, with Appendix 6 setting out the required content of specialist reports where no specific assessment protocol has been prescribed for a particular environmental theme.

The current application relates to the proposed height increase of the IEA for the WRF. The current scope is understood to relate to the proposed increase in height of Area E to 25 m,

while Areas D and F will remain operational as part of the broader facility but are not proposed to be increased in height under the current application.

This CCIA has been compiled to support the environmental assessment process for the proposed height increase. The report assesses the potential impact of the WRF on climate change through the quantification of GHG emissions, as well as the potential impact of climate-related hazards on the facility and its operations.

At present, Draft National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licences and Waste Management Licences (Government Notice 6759, Government Gazette No. 53574, October 2025). This guideline, however, remains in draft form at the time of writing this report and has not yet been formally enacted as a binding regulation. This report has therefore been compiled with consideration of Appendix 6 of the NEMA EIA Regulations, as well as applicable climate change, GHG reporting and emissions quantification guidance. The compliance of this CCIA with the relevant Appendix 6 requirements is summarised in Table 4.

Table 4: Compliance of this CCIA with Appendix 6 of the NEMA EIA Regulations (2014), as amended.

Regulation GN 982 of Government Gazette No. 38282 (December 2014) as amended by GN 326 of 7 April 2017 and GN 517 of 11 June 2021, Appendix 6	Section of Report
(a) details of the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a *curriculum vitae*;	Page ii; Specialist CVs are also attached as Appendices
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Page ii;
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.2
(cA) an indication of the quality and age of base data used for the specialist report;	Section 4
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 6 and Section 7
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	N/A – No site investigation was conducted. The report is based on information provided by EcoPartners and Tonkmeter, and a desktop study was conducted.
(e) a description of the methodology adopted in preparing the report or carrying out the specialized process inclusive of equipment and modelling used;	Section 4
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 5.4, Section 6 and Section 7

(g) an identification of any areas to be avoided, including buffers;	N/A
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 1
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 4.1.8, Section 4.1.10
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment or activities;	Section 6
(k) any mitigation measures for inclusion in the EMPr;	Section 6.5 and 7.2
(l) any conditions for inclusion in the environmental authorization;	Section 6.5.1: It is recommended that a GHG inventory should be calculated on an annual basis.
(m) any monitoring requirements for inclusion in the EMPr or environmental authorization;	Section 6.5.1
(n) a reasoned opinion— i. whether the proposed activity, activities or portions thereof should be authorized; iA. Regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorized, any avoidance, management and mitigation measures that should be included in the EMPr or Environmental Authorization, and where applicable, the closure plan;	Executive Summary & Section 9.1
(o) a description of the consultation process that was undertaken during the course of preparing the specialist report;	N/A – the consultative process was undertaken by the EAP and the client and is detailed in the EIA report.
(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	The scoping report was provided, in which specific comments and concerns were raised based on the climate impact of the resource facility.
(q) any other information requested by the competent authority	N/A – No additional information has been requested by the competent authority.
(2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Draft National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licences and Waste Management Licences (Government Notice 6759, Government Gazette No. 53574, October 2025). This

	guideline, however, remains in draft form at the time of writing this report. Government Gazette No. 47257 of 07 October 2022, and Government Gazette No. 42483 of 23 May 2019 (Act No. 15 of 2019) has been used in the compilation of this report.

3.4. Draft National Guideline, GN 6759 of 24 October 2025

On 24 October 2025, the Minister of Forestry, Fisheries and the Environment published a revised draft National Guideline for the Consideration of Climate Change Implications in Applications for Environmental Authorisations, Atmospheric Emission Licences and Waste Management Licences for public comment. The draft guideline sets out when a climate change impact assessment is required, the matters such an assessment should address, and a framework for rating the significance of climate change impacts. It addresses both the impact of a proposed development on climate change and the impact of climate change on the development, and applies the mitigation hierarchy of avoidance, minimisation, rehabilitation and, as a last resort, offsetting.

The guideline was in draft form at the time of this assessment and has not been promulgated. This CCIA has nevertheless been compiled with regard to its general approach, in that it quantifies the project's GHG emissions, assesses the project's vulnerability to physical climate risks, compares the project's emissions against the applicable carbon budget, applies a significance rating methodology and identifies mitigation and adaptation measures in line with the mitigation hierarchy. Should the guideline be promulgated in a materially different form, the assessment should be reviewed against the final version.

4. METHODOLOGY

This section describes the methods used to assess the potential impact of the proposed Area E height increase on climate change, as well as the potential impact of climate-related hazards on the WRF. The assessment incorporates available project information, operational data, relevant legislation and guidance, meteorological information, published climate projections and GHG quantification methodologies. Both quantitative and qualitative approaches are applied. GHG emissions are quantified for the relevant operational scenarios, while physical climate risks are assessed qualitatively using available climate and hazard-screening information.

4.1. Determining Greenhouse Gas Emissions

GHG emissions are quantified in accordance with the GHG Protocol Corporate Accounting and Reporting Standard, SANS 14064-1:2019 and the applicable South African Methodological Guidelines for the Quantification of Greenhouse Gas Emissions.

The current GHG inventory includes relevant Scope 1 and Scope 2 emissions. Scope 1 includes fugitive CH_4 emissions from landfilled waste and diesel combustion from operational mobile equipment and generator use. Scope 2 includes emissions associated with purchased

grid electricity. Scope 3 emissions have not been quantified due to the absence of sufficient project-specific activity data and because these emissions occur from sources outside Tonkmeter's direct operational control.

Scope 1 (direct GHG emissions and removals)

Scope 1 emissions refer to direct GHG emissions from facilities within the defined organisational boundary. These are GHG emissions directly emitted from GHG sources/operations owned or controlled by the reporting company (including stationary combustion, mobile combustion, process, and fugitive emissions).

Scope 2 (energy indirect GHG emissions)

Scope 2 emissions refer to indirect GHG emissions from the generation of imported electricity, heat or steam consumed by the organisation. This is supplied from outside the organisational boundary and is often associated with electricity purchased from Eskom.

Scope 3 (other indirect GHG emissions)

Scope 3 emissions refer to other indirect GHG emissions which occur as a consequence of the company's operations/activities but occur at sources not owned or controlled by the reporting company (e.g., GHG emissions associated with the extraction and production of a material purchased by the reporting company).

4.1.1. Inventory Boundaries

The GHG Protocol standard requires a clear understanding of the organisational and operational boundaries for which GHG emissions are reported. The information box below provides a description of the types of boundaries considered.

Organisational Boundary

Organisational boundaries define the business sectors (subsidiaries, joint ventures, franchises, facilities, etc.) for which GHG emissions and removals are reported. The organisational boundaries define the units/sectors which constitute as the company for the purposes of the inventory.

Operational Boundary

Operational boundaries define which physical operations, activities, processes etc., the company will report and classify their GHG emissions and removals for accordingly, as well as categorizes them into direct emissions, energy indirect emissions and other indirect emissions.

Tonkmeter owns and operates the WRF and has operational control over the landfill and associated resource recovery activities. The organisational boundary for the assessment therefore includes operational GHG emission sources under Tonkmeter's control at the WRF.

The project boundary for the current CCIA is specifically related to the proposed increase in height of Area E to 25 m. The amendment increases available landfill airspace and consequently extends the period over which the entire WRF can continue to receive waste and operate.

To distinguish the climate change impact of the proposed height increase from emissions that would occur irrespective of the application, the GHG assessment considers:

- a no-go case, representing operation of the WRF within its currently authorised capacity without the Area E height increase;
- a go-ahead case, representing operation of the WRF with the additional capacity created by the proposed Area E height increase; and
- the incremental GHG emissions attributable to the height increase, determined as the difference between the cumulative emissions of the go-ahead and no-go cases over their respective assessed operational lives.

The incremental emissions attributable to the height increase will be used as the basis for the project-specific carbon budget comparison and impact significance assessment. The full cumulative GHG emissions of the WRF will also be presented separately to provide context regarding the facility's overall emissions profile and cumulative contribution to climate change. This facility-level inventory is also relevant to Tonkmeter's ongoing GHG reporting obligations.

4.1.2. Identified GHG Emitting Activities for the Facility

The GHG inventory includes Scope 1 and Scope 2 emission sources associated with operation of the WRF, as summarised in Table 5. Scope 3 emissions were excluded from the assessment.

Table 5: Characterisation of Emission Sources

Scope	Category	Emission Source	Assessed	Comment
Scope 1	Fugitive emissions	CH_4 generation from landfilled waste	Yes	Primary landfill-related emission source. Calculated using the IPCC waste model.
	Fuel combustion	Diesel used for mobile equipment and generator use	Yes	Diesel use is treated as total site diesel consumption because generator and mobile equipment diesel cannot be separated.

Scope 2	Purchased electricity	Grid electricity used for offices, weighbridge and leachate aeration	Yes	Based on estimated maximum electricity consumption and grid/solar/generator split.
	Renewable electricity	Solar PV electricity	No direct emissions	Solar PV is treated as zero direct operational emissions.
Scope 3	Scope 3 emissions not accounted for. See exclusions.			

The following sources are excluded from the quantitative GHG inventory:

- **Scope 3 emissions:** Third-party waste transport, transport of recovered recyclables, employee commuting, upstream fuel and electricity emissions and other third-party supply-chain activities are excluded due to insufficient project-specific activity data and because these sources fall outside Tonkmeter's direct operational control.
- **Construction-phase emissions:** No construction is required specifically to achieve the proposed vertical height increase. Additional landfill cells will nevertheless be constructed as required. Construction emissions are excluded because the future construction programme, equipment use, fuel consumption and material quantities have not been sufficiently defined.
- **Leachate and wastewater process emissions:** Process-related emissions are not separately quantified due to the absence of detailed flow and treatment data. Electricity used for leachate management is captured within total site electricity consumption.
- **Land-use change:** Emissions associated with future vegetation clearance and soil carbon disturbance are excluded due to insufficient site-specific activity data.
- **Recycling displacement benefits**: Avoided emissions associated with recycling and material substitution are not credited because sufficient information on recovered material quantities and downstream processing is unavailable.

The exclusions listed above are not expected to materially affect the outcome of the assessment. Fugitive landfill methane accounts for approximately 99% of the quantified GHG footprint, and the excluded sources are small by comparison. Construction-phase emissions associated with future cell development are estimated to be in the order of 0.1% of the total footprint, based on indicative construction fuel use, and Scope 3, leachate process and land-use-change emissions are each expected to be smaller still. The exclusion of avoided emissions from recycling is conservative, in that crediting these would reduce the net footprint. The confidence in the assessment is therefore considered moderate to high in respect of the relative significance of the impact, with the principal uncertainties being the landfill

management classification, the waste composition over the long assessment period and the performance of the proposed landfill gas collection system, rather than the excluded sources.

4.1.3. Reporting Period

The WRF commenced accepting waste in January 2025. The operational assessment periods are based on the updated facility-life estimates provided for the no-go and go-ahead cases under the two waste-throughput scenarios.

Landfill methane generation continues after waste acceptance ceases, as the biodegradable fraction of the waste already in place continues to decompose. The GHG inventory therefore distinguishes between the operational (waste-acceptance) period, over which the facility actively receives waste, and the post-closure period, over which residual methane generation continues to decline. Cumulative emissions are reported for the operational period, and post-closure emissions are quantified separately in Section 6.1.1 to provide a whole-life view of the landfill methane profile.

Table 6: Reporting Period for GHG Inventory

Operational Scenario	Waste Disposal Rate (tonnes/month)	No-Go Facility Life (years)	Go-Ahead Facility Life (years)	Additional Operating Life (years)
Scenario 1	7 500	87	126	39
Scenario 2	15 000	44	63	19

4.1.4. GHG Emissions Calculations

GHG emissions are calculated by identifying the relevant emission sources and applying the appropriate activity data, emission factors and Global Warming Potential (GWP) values. The following generic equation is applied:

GHG Emissions = Activity Data x Emission Factor x Global Warming Potential

With specific reference to this CCIA, the components of the equation are detailed in the sections below.

- **Activity Data** describes the activity being conducted by the source.
- **The Emission Factor** is a conversion factor that can be used to relate the activity data to the associated emissions.
- **Global Warming Potential** (GWP) expresses the heat-trapping effect of a GHG relative to CO_2 and allows emissions of different gases to be expressed as CO_2e.

For operational diesel-combustion emissions, GWP values of 23 for CH_4 and 296 for N_2O were applied in accordance with the South African Methodological Guidelines for the Quantification of Greenhouse Gas Emissions (DFFE, 2022). Landfill methane emissions calculated using the IPCC FOD waste model were converted from CH_4 to CO_2e using a CH_4 GWP value of 23,

thereby maintaining consistency with the GWP basis applied in the current South African GHG reporting methodology.

4.1.5. Activity Data

The activity data for this assessment was provided by EcoPartners as well as Tonkmeter, GWIS records, project correspondence, and the landfill and recycling process information. Where activity data was unavailable, conservative assumptions were applied and clearly stated. Table 7 summarises the activity data used.

Table 7: Activity Data Used to Calculate the GHG Inventory.

Activity Data	Scenario 1	Scenario 2	Unit
Waste Disposal Rate	7 500	15 000	tonnes/month
No-go operating lifespan	87	44	years
Go-ahead operating lifespan	126	63	years
Additional operating life	39	19	years
Operational diesel consumption (1)	5 500	11 000	L/month
Site electricity consumption (2) (3)	3 500	3 500	kWh/month

Notes:

(1) Operational diesel use includes all operational fuel used on-site (i.e., stationary and mobile combustion).

(2) Electricity based on 3 500 kWh/month where 50% will be grid-supplied electricity, 45% solar generated electricity (0 emissions) and 5% supplied via diesel generated electricity (included under operational diesel use).

(3) Construction-phase diesel use has been excluded from the GHG inventory due to the absence of confirmed construction timing, frequency and activity data.

4.1.6. Emission Factors

There are several different emission factors for GHG's that can be used to calculate emissions. Customised emission factors are used in more complex studies whereby the reporting company will develop their own emission factors based on their own available datasets and research. In a more general GHG accounting and reporting context default emission factor values can be applied.

The IPCC recommends the use of a tiered approach (i.e., tier 1 to 3) when calculating emissions and choosing emission factors. The tier 1 method is adopted when project/facility and country specific details are not known, therefore default emission factors need to be used. The tier 2 method is adopted when country specific emissions factors are available. Lastly, the tier 3 method is adopted when project/facility details are known, and specific emission rates can be applied.

a) Operational Energy Emission Factors

The GHG inventory used two calculation approaches. Emissions from operational diesel use and purchased electricity were calculated using activity data and published emission factors.

Landfill CH_4 emissions were calculated using the IPCC waste model, which applies a first-order decay approach based on waste quantities, waste composition, landfill management conditions and methane recovery assumptions. The emission factors used for the current GHG inventory are detailed in Table 8 below.

Table 8: Emission Factors and Net Calorific Values (NCV) for Fuels used in the Current Inventory

Fuel/Activity	Parameter	Value	Unit	Reference	Comment
Diesel Combustion	CO_2	74 638	$kgCO_2/TJ$	DFFE Methodological Guidelines (2022)	Country Specific
	CH_4	3.0	$kgCH_4/TJ$		
	N_2O	0.6	kgN_2O/TJ		
	NCV	35.5	MJ/L		
Grid Electricity	CO_2	1.08	Tonnes CO_2/MWh	Eskom Integrated Report (2025)	Page 149

The CH_4 and N_2O components of diesel combustion were converted to CO_2e using GWP values of 23 and 296, respectively. The DFFE Methodological Guidelines provide the methodological basis for quantification of emissions for South African GHG reporting.

b) Fugitive Emissions

Landfill CH_4 emissions were quantified using the IPCC FOD waste model. The FOD approach recognises that biodegradable waste decomposes progressively over time, with methane generated in a particular year arising from waste deposited during that year as well as waste deposited during preceding years. The model incorporates waste disposal quantities, waste composition, degradable organic carbon, decomposition rates, landfill management conditions, methane recovery and oxidation.

Landfill CH_4 emissions were calculated separately for the following four operational cases:

- **Scenario 1 No-Go:** 7 500 tonnes/month over approximately 87 years;
- **Scenario 1 Go-Ahead:** 7 500 tonnes/month over approximately 126 years;
- **Scenario 2 No-Go:** 15 000 tonnes/month over approximately 44 years; and
- **Scenario 2 Go-Ahead**: 15 000 tonnes/month over approximately 63 years.

The incremental landfill methane emissions attributable to the proposed Area E height increase were determined as the difference between the cumulative emissions of the corresponding go-ahead and no-go cases.

Two landfill gas management cases were assessed:

- an **unmitigated case**, assuming no methane recovery throughout the assessed operating period; and

- a **mitigated case**, assuming landfill gas collection and flaring from approximately 2030, with a methane collection efficiency of 75%.

The approximate 2030 implementation date is based on information provided by the client that current landfill gas volumes do not yet justify flaring, but sufficient volumes may become available by approximately 2030. In the absence of site-specific landfill gas collection performance data, a collection efficiency of 75% was applied as an industry-based modelling assumption. The US EPA indicates that 75% is a commonly applied landfill gas collection efficiency assumption where site-specific performance information is unavailable (US EPA, 2024).

A flare destruction efficiency of approximately 98% is assumed for the proposed flare. However, within the IPCC FOD calculation, methane recovered and directed to the flare is entered as recovered methane and flare destruction efficiency is not separately multiplied through the methane recovery input.

The principal input parameters for the landfill methane model are summarised in Table 9.

Table 9: Summary of Input Parameters into the IPCC FOD Waste Model for the WRF

Input Parameter		Value	Reference/Notes
Country/Region		Southern Africa	Regional basis in IPCC Waste Model
Scenario 1	Waste disposal rate	7 500 tonnes/month	Client-confirmed long-term throughput scenario.
	No-go operating life	87 years	Facility life without Area E height increase.
	Go ahead operating life	126 years	Facility life with Area E height increase.
	Additional operating life	39 years	Additional facility operating period attributable to the proposed height increase.
Scenario 2	Waste disposal rate	15 000 tonnes/month	Client-confirmed higher-throughput scenario.
	No-go operating life	44 years	Facility life without Area E height increase.
	Go ahead operating life	63 years	Facility life with Area E height increase.
	Additional operating life	19 years	Additional facility operating period attributable to the proposed application.
Waste activity data		Waste quantities allocated into IPCC waste categories based on	GWIS data was used as reported data. The GWIS report notes that

Input Parameter	Value	Reference/Notes
	the available GWIS waste records and the waste model input structure.	the accuracy of the information has not been independently verified.
Waste categories	Food, garden, paper, industrial, textiles and inert/other.	IPCC Waste Model
Degradable organic carbon (DOC), wet basis	Food: 0.15	IPCC default values
	Garden: 0.20	
	Paper: 0.40	
	Industrial: 0.01	
	Textiles: 0.00	
	Inert/Other: 0.00	
DOC fraction dissimilated (DOCf)	Food: 0.70	IPCC default values
	Garden: 0.70	
	Paper: 0.50	
	Industrial: 0.70	
	Textiles: 0.50	
	Inert/Other: 0.00	
CH_4 generation rate constant (k)	Food: 0.06	IPCC default values
	Garden: 0.05	
	Paper: 0.04	
	Industrial: 0.05	
	Textiles: 0.00	
	Inert/Other: 0.00	
CH_4 correction factor (MCF)	0.5	Waste Model Input
Fraction of CH_4 in landfill gas (F)	0.5	IPCC default value
Carbon to CH_4 conversion factor	16/12 = 1.33	IPCC FOD
Oxidation factor (OX)	0.1	Assumed managed site conditions
CH_4 recovery (unmitigated)	0 Gg CH_4/year	No methane collection or destruction applied in the unmitigated case.
CH_4 recovery (mitigated)	75% from 2030	Industry-based collection assumption
Flare destruction efficiency (mitigated)	98%	Industry-based flare assumption; documented separately from FOD recovery calculation
GWP for CH_4	23 tCO_2e/tCH_4	CH_4 to CO_2e conversion factor (country-specific reporting basis)
Model cases	Scenario 1 No-Go; Scenario 1 Go-Ahead; Scenario 2 No-Go; Scenario 2 Go-Ahead	Allows the emissions attributable specifically to the Area E height increase to be determined.
Assessment period	Operational/waste-acceptance life of each case	Post-closure methane tail excluded from cumulative totals

Notes:

(1) The IPCC FOD model does not apply a single emission factor to landfill CH_4 generation. Methane generation is calculated as a function of waste disposal quantity, waste composition, degradable organic carbon, decomposition rates, landfill management conditions, oxidation and methane recovery.

(2) The proposed increase in landfill height is not itself a direct input into the FOD model. The effect of the height increase is represented through the additional landfill capacity and resulting extension of the facility's waste-acceptance period.

(3) The incremental landfill methane emissions attributable to the height increase will be determined as the difference between the cumulative go-ahead and no-go model results under each throughput scenario.

(4) Cumulative landfill methane emissions have been assessed over the operational/waste-acceptance life of each case. Methane generated following cessation of waste acceptance has not been included in the cumulative totals.
(5) Construction-phase emissions are excluded from the current GHG inventory due to the absence of confirmed construction timing, frequency, duration and activity data.
(6) The CH_4 GWP value of 23 applies to landfill CH_4 emissions calculated using the IPCC FOD waste model. Operational diesel-combustion emissions were converted to CO_2e using the GWP values prescribed by the National GHG Reporting Guidelines, namely CH_4 = 23 and N_2O = 296.

4.1.7. GHG Emissions

All emissions are calculated as CO_2e, allowing the climate effects of CO_2, CH_4 and N_2O to be expressed on a common basis.

A CO_2e is a common unit used to express the climate impact of different GHGs relative to CO_2. Each GHG has a GWP, which reflects its heat-trapping ability relative to CO_2.

The GHG assessment will quantify emissions separately for each of the four operational cases:

- Scenario 1 – No-Go;
- Scenario 1 – Go-Ahead;
- Scenario 2 – No-Go; and
- Scenario 2 – Go-Ahead.

For each case, the inventory includes relevant Scope 1 emissions from landfill CH_4 generation and operational diesel combustion, together with Scope 2 emissions associated with purchased grid electricity.

The incremental GHG emissions attributable to the proposed Area E height increase was calculated as:

Incremental GHG Emissions = Go-ahead Cumulative GHG Emissions – No-go Cumulative GHG Emissions

The incremental emissions form the primary basis for the carbon budget comparison and environmental significance assessment for the current application. Cumulative no-go and go-ahead facility emissions are presented separately to provide context regarding the overall lifetime GHG footprint of the WRF.

For landfill CH_4, emissions are presented for both unmitigated and mitigated cases. The unmitigated case assumes no methane recovery, while the mitigated case incorporates 75% methane collection and flaring from 2030.

Operational diesel emissions were calculated using the applicable emission factors and GWP values for CO_2, CH_4 and N_2O. Purchased electricity emissions was calculated using the confirmed grid-electricity component of total site electricity consumption and the applicable electricity emission factor.

4.1.8. Assumptions and Limitations in Quantifying GHG Emissions

The accuracy of the GHG inventory depends on the quality and completeness of the available project information. The principal assumptions and limitations applicable to the current inventory are as follows:

- The current application relates specifically to increasing the permitted height of Area E to 25 m. Areas D and F remain part of the operational WRF but are not proposed to be increased in height.
- Scenario 1 assumes an average waste disposal rate of 7 500 tonnes/month, while Scenario 2 assumes 15 000 tonnes/month.
- The estimated no-go facility lives are 87 years and 44 years, increasing to 126 years and 63 years under the corresponding go-ahead cases.
- The height increase therefore extends the estimated facility operating life by approximately 39 years under Scenario 1 and 19 years under Scenario 2.
- The landfill has been modelled as a managed semi-aerobic waste disposal site with an MCF of 0.5.
- GWIS waste data has been used as reported and has not been independently verified by Rayten. Organic waste separately identified in the available data has been treated as garden waste.
- Future waste composition may vary over the long operating life of the facility. The available waste profile has therefore been assumed to remain representative for modelling purposes.
- The unmitigated case assumes no methane recovery.
- The mitigated case assumes 75% methane collection from approximately 2030. The implementation date and collection efficiency are modelling assumptions based on client information and industry guidance rather than an approved landfill gas system design.
- A flare destruction efficiency of approximately 98% has been assumed for contextual purposes. Within the IPCC FOD model, recovered methane is accounted for through the methane recovery input and destruction efficiency is not separately applied.
- Landfill methane emissions have been assessed over the operational/waste-acceptance life of each case. Methane generated after waste acceptance ceases has not been included in the cumulative totals. The calculated emissions should therefore be interpreted as operational-life emissions rather than a complete post-closure lifecycle inventory.
- Operational diesel consumption is assumed to remain at 5 500 L/month under Scenario 1 and 11 000 L/month under Scenario 2 throughout the respective operating periods.
- Total electricity consumption is assumed to remain at approximately 3 500 kWh/month, comprising 50% grid electricity, 45% solar PV and 5% diesel-generated electricity.
- Diesel consumption could not be separated between mobile equipment and generator use and has therefore been treated as total operational site diesel consumption.
- Construction-phase emissions are excluded because the future landfill cell construction programme and associated equipment, fuel and material requirements are not sufficiently defined.

- Scope 3 emissions, process-related leachate emissions and land-use-change emissions have not been quantified due to insufficient project-specific information.
- Avoided emissions arising from recycling and material substitution have not been credited.
- The inventory should be updated if materially different information becomes available regarding waste quantities or composition, landfill management, diesel consumption, electricity use or landfill gas recovery performance.
- The landfill has been modelled as a managed semi-aerobic waste disposal site with an MCF of 0.5. Modelled landfill methane emissions scale directly with this factor; an MCF of 0.7, applicable to a poorly managed site of the same type, would increase landfill methane emissions by approximately 40%.

4.1.9. Approach to Physical Climate Risk Assessment

The Task Force on Climate-related Financial Disclosures (TCFD) provides two categories of climate related risks. The first are transitional risks, which are related to the transition to a lower carbon economy and the second are physical risks, which are related to the physical impacts of climate change. This report will focus solely on the latter. Physical risks that are events based such as extreme weather, floods or fires are classified as acute risks. Alternatively, physical risks associated with longer-term shifts in climate patterns like rising mean temperatures are classified as chronic risks. Physical risks have many implications, often causing damage to assets and supply chain disruptions that effect business financially and/or impacting the wellbeing and safety of employees. The TCFD framework for climate-related risk reporting remains available as guidance; however, the task force itself is no longer active, with its responsibilities transferred to the IFRS Foundation.

Tools utilised	Description
The World Resources Institute (WRI) - Aqueduct Tool	This tool provides an understanding of water-related risks and assesses exposure to various water related risks across multiple locations (WRI, 2019), including that of the project site.
The Council for Scientific and Industrial Research (CSIR) - GreenBook Municipal Risk Tool	This tool provides information on vulnerabilities, population projections and exposure to climate hazards for various municipalities within South Africa (CSIR, 2023).
The Global Facility for Disaster Reduction and Recovery (GFDRR) - Think Hazard Tool	This tool provides a general overview of hazards for various locations, including that of the project site, that should be considered in project design and implementation to improve climate resilience (GFDRR, 2020). The likelihood of climate related hazards affecting the project site is assessed. Levels of likelihood include very low, low, medium and high.
The World Bank Groups Climate Change Knowledge Portal (World Bank Group, 2024)	This tool provides historical and projected climate data for various regions including that of the project site (i.e., Gauteng).

For the Physical Climate Risk Assessment (PCRA), a comprehensive analysis of climate change impacts specifically relevant to the project region was undertaken. This involved a thorough analysis of future climate projections, considering factors such as temperature changes, precipitation patterns and extreme weather events. Furthermore, the assessment investigated the potential impacts of these climate changes on the proposed projects processes and infrastructure. Material climate hazards were identified, and the associated risks assessed, considering both the likelihood and potential impacts of these hazards on the project site.

4.1.10. Assumptions and Limitation in the PCRA

The proposed project's risk to various climate-related hazards is assessed in this report through the analysis of available data sets. This physical climate risk analysis is subject to the following assumptions and limitations:

- Impacts solely related to the direct value chain of the proposed project were assessed;
- No modelling was conducted on the impacts of hazards identified, or the future timelines thereof;
- Only impacts anticipated to occur during the lifetime of the proposed project were assessed;
- Historical climate data and future climate projections at a regional level were utilised and assumed to be representative of the site;
- It is assumed that the information gathered from online resources is accurate and factual; and
- The outputs of the climate change models used are limited spatially and temporal.

4.2. Carbon Budget

There are many different approaches that can be used to calculate how to share the global carbon budget fairly across countries. Romanovskaya & Federici (2019) state that an equity approach on the basis of a simple per-capita distribution is the most viable option and is widely advocated for. This means that each individual person must be allowed to emit an equal amount of GHGs. Assuming a 50% probability of limiting warming to the intended target level, the 2°C global RCB has been revised to 1 050 Gt CO_2e, and the 1.5°C global RCB to 130 Gt CO_2e (IPCC, 2021). Average annual net emissions for the last few years have been approximately 42 Gt CO_2. Worldometer (2026), indicated the global population to be about 8 300 000 000, with South Africa's being approximately 63 100 000, comprising 0.76% of the world's population. South Africa's indicative share of the global Remaining Carbon Budget is approximately 0.99 GtCO_2 for the 1.5°C pathway and 7.98 GtCO_2 for the 2°C pathway. For purposes of this CCIA, the project's total GHG emissions expressed as CO_2e are compared against these indicative carbon-budget allocations as a screening approach adapted from Louw et al. (2020). The comparison should therefore be interpreted as an indicator of relative climate significance rather than a direct allocation of the IPCC CO_2-only carbon budget to project-level CO_2e emissions.

The magnitude of the impact of the project's incremental GHG emissions attributable to the proposed amendment to the national carbon budget, as per Table 10 (adapted from Louw et al., 2020). As the remaining carbon budget is a global quantity that will be substantially

depleted within the next decade, and the emissions assessed here occur over a multi-decade horizon, the comparison is applied as a screening indicator of relative magnitude rather than as a projected allocation.

Table 10: GHG Emissions Rating Table Adapted from Louw et.al., 2020

Scenario	Tonnes CO_2e	1.5°C	2°C
South Africa's Carbon Budget		0.99 Gt CO_2e	7.98 Gt CO_2e
Low impact by project – emissions up to:	10 000	0.0010%	0.0001%
Medium impact by project – emissions up to:	1 000 000	0.1012%	0.0125%
High impact by project – emissions up to:	10 000 000	1.0118%	0.1253%
Very High impact by project – emissions greater than:	>10 000 000	>1.0118%	>0.1253%

Note: Percentage values represent the indicative contribution of project-level CO_2e emissions to the allocated South African CO_2 remaining carbon budget and are presented as a screening comparison. Impact categories are applied using the project-emission thresholds adapted from Louw et al. (2020).

4.3. Impact Assessment

Following quantification of the GHG emissions attributable to the proposed height increase, an environmental significance assessment will be undertaken using the Rayten impact assessment methodology presented in Table 11 below.

Table 11: Description of Parameters Used to Establish Impact Significance.

Extent = E *(The area over which the proposed impact will be experienced).* **3**: Global **2**: Regional **1**: Site	***Reversibility = R*** *(The degree to which the proposed impact can be reversed upon completion of the proposed development/ activity).* **4**: Irreversible **3**: Barely Reversible **2**: Partly Reversible **1**: Completely Reversible
Status of Impact **+**: Positive (A benefit to the receiving environment) **N**: Neutral (No cost or benefit to the receiving environment) **-**: Negative (A cost to the receiving environment)	
Magnitude = M *(The severity of the proposed development/activity).* **5**: Very high/ don't know **4**: High **3**: Moderate **2**: Low **1**: Minor **0**: Not applicable/none/negligible	***Duration = D*** *(The timeframe for which the proposed impact will be experienced).* **5**: Permanent **4**: Long-term (ceases with the operational life) **3**: Medium-term (5-15 years) **2**: Short-term (0-5 years) **1**: Immediate **0**: Not applicable/none/negligible
Probability = P *(The likelihood / degree of certainty of the proposed impact occurring).* **5**: Definite **4**: Highly probable **3**: Medium probability **2**: Low probability **1**: Improbable	***Cumulative Effect = C*** *(The impact of the proposed development/ activity on the environmental parameter being assessed when added to other existing or potential impacts).* **4**: High Cumulative Impact **3**: Medium Cumulative Impact **2**: Low Cumulative Impact

	1: No Cumulative Impact **0**: Not applicable
Loss of Resources = L *(The degree to which a given resource will be lost as a result of the proposed development / activity.)* **4**: Complete Loss of Resources **3**: Intermediate Loss of Resources **2**: Low loss of resources **1**: No Loss of resources	
Significance will be determined through the *Rayten methodology for determining significance*. Significance will be determined through a synthesis of the assessed impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale and therefore indicates the level of mitigation required. This describes the significance of the impact on the environmental parameter. The calculation of the significance of an impact uses the following formula: **(Extent + probability + reversibility + loss of resources+ duration + cumulative effect) x magnitude/intensity.** The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.	

Significance	***Environmental Significance Points***	***Color Code***
High (positive)	>83	H
Medium (positive)	28 to 83	M
Low (positive)	<28	L
Neutral	0	N
Low (negative)	>-28	L
Medium (negative)	-28 to -83	M
High (negative)	<-83	H

The outcome of this assessment will indicate whether the WRF's GHG emissions represent a material contribution to climate impacts and guide the need for further mitigation measures. Activities that retain a "high negative" rating even after mitigation should be regarded as potential no-go activities.

5. BASELINE ENVIRONMENT - CLIMATE

5.1. South African Context

South Africa prepares National Communications, as required by the UNFCCC, to outline the country's efforts to address climate change. The Department of Forestry, Fisheries and the Environment (DFFE) submitted South Africa's Fourth National Communication in 2024, covering developments and data up to December 2022, and building upon the Third National Communication (DFFE, 2018).

The report indicates that South Africa's temperature trends closely follow global warming patterns. Provinces located inland are experiencing more rapid warming, while KwaZulu-Natal, the Eastern Cape, and the Western Cape have seen slower increases in temperature. Figure 2 illustrates how observed annual average mean surface air temperature (provided by the World Banks Groups Climate Change Knowledge Portal) has increased over South Africa since 1950. South Africa has also experienced below-average rainfall since 2012, coupled with significant year-to-year variability across all provinces. Long term data from 1981 to 2019, show a declining trend in total annual rainfall for KwaZulu-Natal, the Eastern Cape, and the Western Cape (DFFE, 2024).

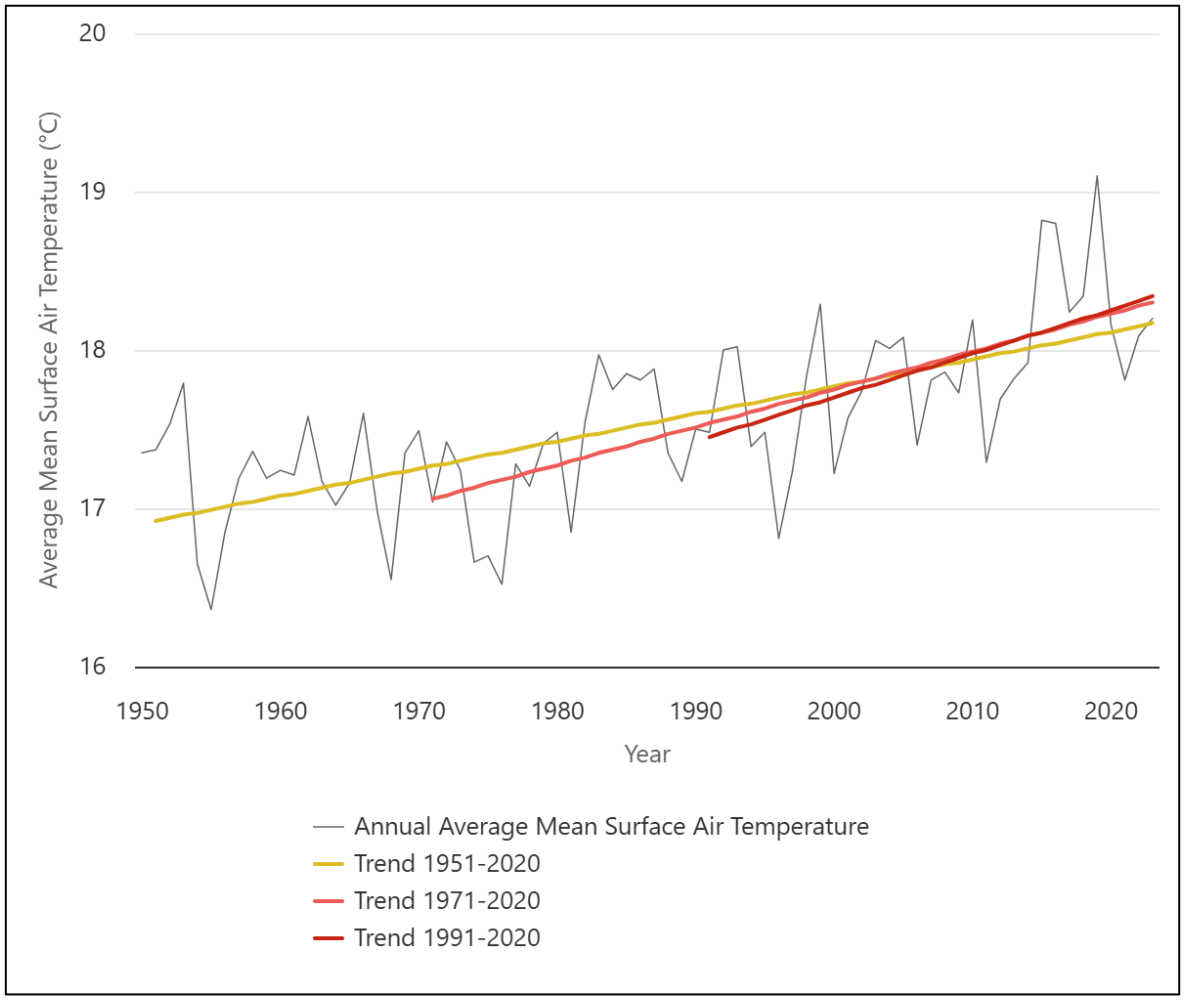


Figure 2: Observed Annual Average Mean Surface Air Temperature for South Africa (The World Bank, 2024)

Looking ahead, national climate projections indicate that under low mitigation scenarios, temperatures across inland South Africa could rise by at least 4°C by the end of the century, with generally drier conditions expected (DFFE, 2018). The magnitude of warming anticipated for South Africa's interior is reduced under a modest-high mitigation scenario, and projected drying patterns are weaker. Some modelled climate futures indicate that generally wetter conditions may occur over the central and eastern interior of the country under increased mitigation. Rising temperatures and increased variability in rainfall are significantly impacting key sectors across the country, with growing vulnerability in agriculture, human health, ecosystems and water resources (DFFE, 2018).

5.2. Greenhouse Gases in South Africa

South Africa's 9th National GHG Inventory Report, published by the DFFE in February 2025 (Government Gazette No. 52067), covers the period 2000 to 2022. It documents the country's GHG emissions for 2022 and trends since 2000. The energy sector remained the largest source of emissions in 2022, contributing 78% of total national emissions excluding Land Use, Land-Use Change and Forestry (LULUCF), or 86% including LULUCF. Within the energy sector, energy industries accounted for 60% of emissions and transport for 14%. Between 2000 and 2022, energy sector emissions declined by 2.5% overall, while emissions from electricity production rose by 11.5%, in line with an 8.7% increase in power generation (DFFE, 2025).

South Africa's energy intensity is high, mainly because of its large, energy-intensive mining and primary minerals beneficiation industries (DFFE, 2021). Electricity generation is also heavily reliant on fossil fuels.

Industrial Processes and Product Use (IPPU) contributed 6.4% of total emissions (excluding LULUCF). Agriculture contributed approximately 11% (12% including LULUCF), and agricultural emissions have decreased by 9.1% since 2000. Enteric fermentation showed the largest decrease (14%), mainly from lower emissions from non-dairy cattle, likely linked to a decline in livestock numbers.

The waste sector contributed 4% of national emissions excluding LULUCF (4.8% including LULUCF). Wastewater treatment and discharge (44.7%) and solid waste disposal (41.5%) made up most of the sector's emissions, followed by biological treatment of solid waste (12.2%) and incineration and open burning (1.6%). Waste sector emissions have increased by 44.1% since 2000 (DFFE, 2025).

5.3. Gauteng Context

Gauteng is situated in South Africa's interior Highveld region and experiences a summer-rainfall climate, with most rainfall occurring during the warmer months and comparatively dry conditions during winter. Climate projections for Gauteng indicate that the province is expected to become warmer, with higher temperatures and longer dry spells increasingly dominating the climate signal (Scholes and Engelbrecht, 2021). Although projections of total annual rainfall remain more uncertain, climate change is expected to increase rainfall variability, with intense rainfall events likely to increase runoff, flash-flood risk and erosion, particularly in urbanised areas with extensive paved or impermeable surfaces (Figure 3).

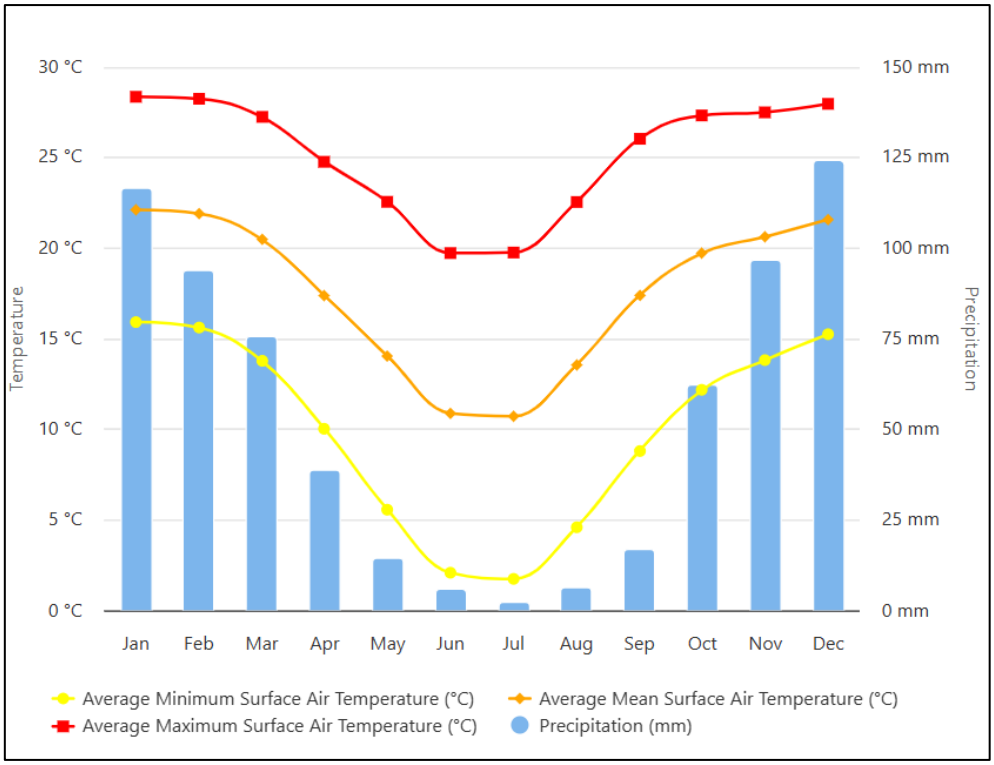


Figure 3: Observed Seasonal Cycle in Average Minimum, Mean and Maximum Surface Air Temperature, and Precipitation for Gauteng from 1991 - 2020 (The World Bank, 2024)

Historical climate studies for South Africa show a clear warming trend, although the magnitude of warming and rainfall trends vary regionally. MacKellar et al. (2014) assessed observed and modelled trends in rainfall and temperature across South Africa for 1960–2010 and found statistically significant decreases in rainfall and rain days over parts of the central and northeastern interior during autumn months. Kruger and Sekele (2013) also identified changes in extreme temperature indices across South Africa, with a general increase in warm extremes and decrease in cold extremes over the period assessed. These findings are relevant to Gauteng, where rising temperatures may increase heat stress, evaporation rates and pressure on water resources.

Climate projections available through South Africa's National Climate Change Information System are based on dynamically downscaled climate model outputs and express projected change as anomalies between a historical reference period and the projected short- to medium-term period from 2021 to 2050. These projections are based on RCP 4.5 and RCP 8.5 scenarios and provide nationally consistent information on projected temperature and rainfall changes. For Gauteng, annual average temperatures are projected to increase throughout the province by 2050 under a high-emissions scenario. Higher temperatures are expected to increase evaporation rates and may adversely affect water and food security (Gauteng City-Region Observatory and Gauteng Provincial Government, 2020).

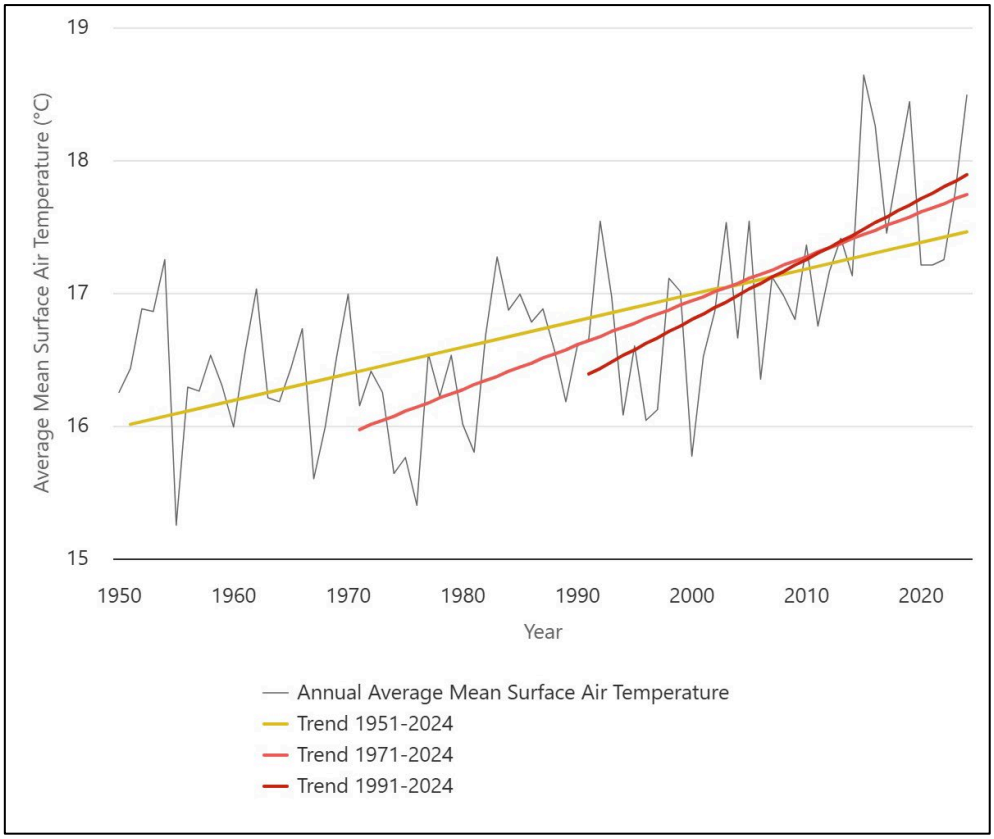


Figure 4: Observed Annual Average Mean Surface Air Temperature for Gauteng between 1950 and 2023 (The World Bank, 2024)

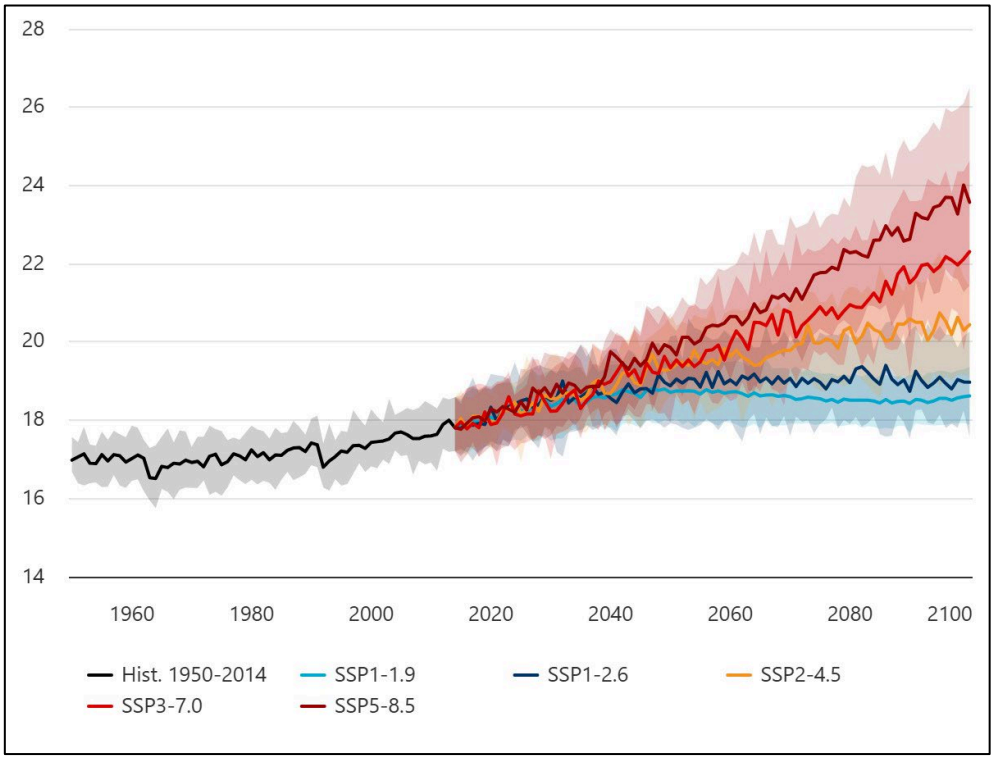


Figure 5: Projected Mean Temperature Gauteng, South Africa (Reference Period 1995-2014) (The World Bank, 2024)

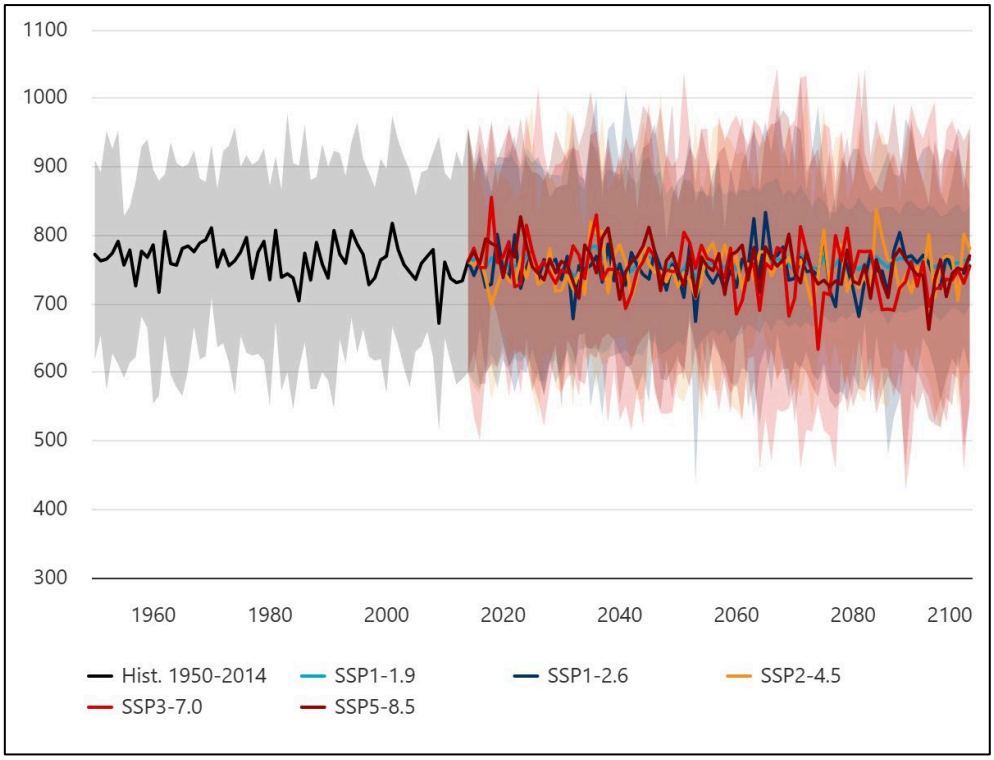


Figure 6: Projected Precipitation Gauteng, South Africa (Reference Period 1995-2014) (The World Bank, 2024)

Rainfall projections for Gauteng are more uncertain than temperature projections. However, the available evidence indicates increasing rainfall variability, with the potential for both longer dry spells and more intense rainfall events. The Gauteng City-Region Climate Change Response Strategy notes that, while annual rainfall projections remain variable, a drying trend becomes more apparent from the mid- to late-century, and the existing wet-summer / dry-winter rainfall pattern is expected to intensify. The Let's Respond Toolkit further indicates that increases in the annual average number of extreme rainfall days may increase the likelihood of intense storms and flooding events across Gauteng.

Gauteng's high level of urbanisation increases its vulnerability to certain climate-related hazards. Urban areas generally contain large areas of hard surfaces, reduced vegetation cover and dense built infrastructure, which can intensify runoff during heavy rainfall events and increase localised heat stress. A high-resolution urban heat study for Johannesburg and Ekurhuleni found distinct spatial differences in the urban heat island effect, with the greatest heat stress occurring in areas with high building density and limited vegetation. The same study highlighted the importance of shade and vegetation in reducing heat stress under both present and future climate conditions (Souverijns et al., 2022).

The GreenBook, developed by the CSIR and partners, provides quantitative scientific evidence on climate-related impacts for South African cities and towns, including hazards such as flooding, heatwaves, droughts, wildfires and storms. These hazards are relevant to the assessment of climate change impacts on landfill infrastructure and operations in Gauteng. For a landfill facility, projected increases in temperature, rainfall variability and intense rainfall events may have implications for leachate generation, stormwater management, erosion of cover material, slope stability, access road conditions, fire risk, odour management and operational continuity (CSIR, 2019; Scholes and Engelbrecht, 2021).

Overall, the climate change context for Gauteng is characterised by increasing temperatures, higher evaporation demand, greater heat-stress risk, uncertain but more variable rainfall, and a likely increase in intense rainfall and flooding events. These projected changes are relevant to the Tonkmeter WRF because landfill operations are sensitive to rainfall intensity, stormwater and leachate management, waste compaction and cover integrity, fire risk, and the safe movement of vehicles and personnel across the site.

5.4. Site Context

The climate tools currently available in South Africa provides information at provincial scale only. Therefore, the Gauteng context outlined above is regarded as relevant to the proposed site. To assess potential climate change impacts, it is important to establish the baseline meteorological conditions as a reference point for future changes. The prevailing climate in the region where the facility is located is described below.

MM5 modelled meteorological data was used for the project area and obtained from Lakes Environmental for the period January 2023 to December 2025. The meteorological data is representative of recent prevailing weather conditions that will likely be experienced at the project site.

5.4.1. Temperature and Relative Humidity

Average monthly temperatures at the project site range from 9.00 to 21.20 ºC (Table 12).

Table 12: Monthly Average, Minimum and Maximum Temperatures for January 2023 - December 2025.

TEMPERATURE 2023 - 2025 (avg, min, max)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average	21,2	21,2	19,6	16,1	12,8	9,1	9,0	12,4	15,5	17,6	20,1	21,0
Minimum	8,1	11,2	9,6	5,1	0,5	-1,4	-3,1	-1,0	3,6	1,9	4,5	10,6
Maximum	30,6	30,5	28,9	25,1	22,5	19,1	20,4	24,0	25,2	28,2	30,9	30,1

The average monthly temperatures and relative humidity profile for the project site presented in Figure 7 for the period of January 2023 to December 2025. The highest temperatures are observed during the late-spring, summer and early-autumns months (November to March) while reduced temperatures are observed during the late autumn and winter months (May – August), with milder temperatures experienced during mid-autumn and early-to-mid spring March; September – October). Relative humidity fluctuates throughout the year, with the highest (71.80%) being in June (winter) and the lowest (62.20%) being in October (spring).

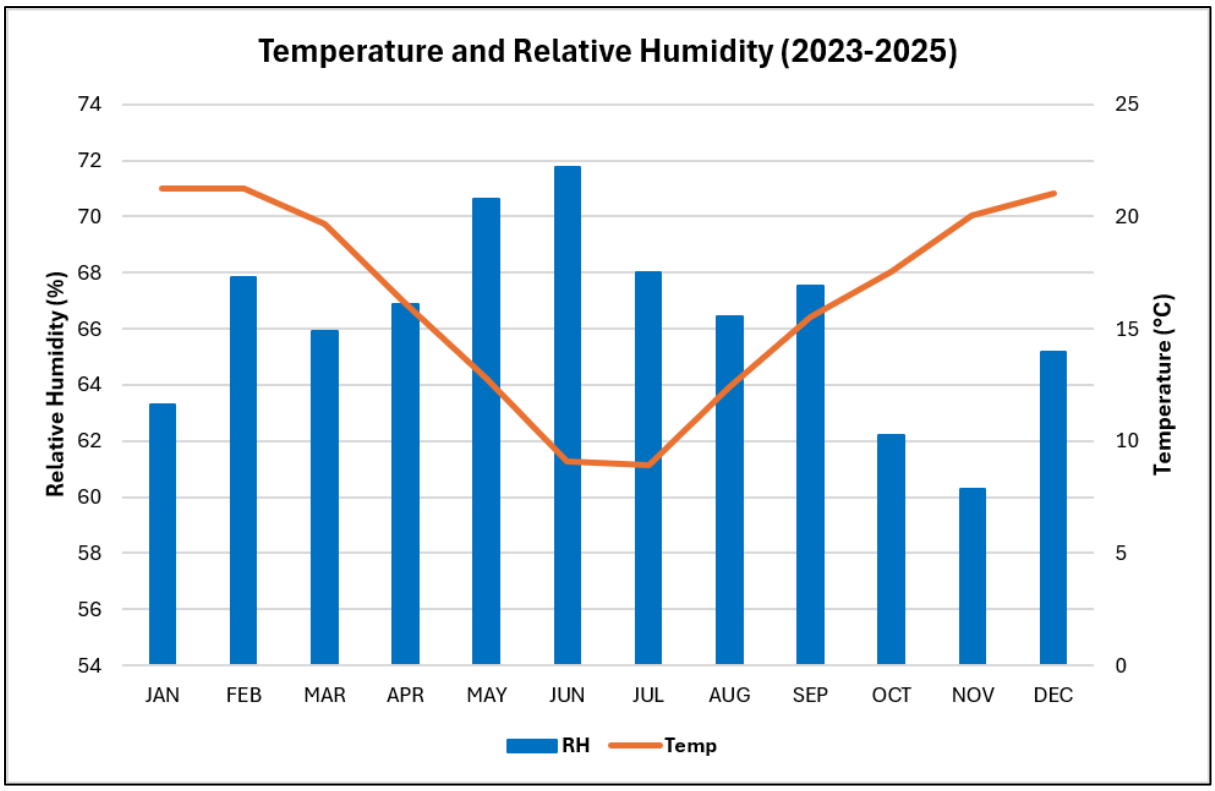


Figure 7: Monthly Average Temperature and Relative Humidity Profiles for the Project Site (January 2023 - December 2025).

5.4.2. Precipitation

Total monthly rainfall for the project site between January 2023 and December 2025 is provided Table 13.

Table 13: Total Monthly Rainfall for January 2023 - December 2025.

TOTAL RAINFALL in mm 2023- 2025 (SUM OF)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2023	67,8	139,4	48,5	17,0	73,9	7,6	3,8	5,1	41,1	125,0	129,0	237,5
2024	215,9	91,2	46,2	16,0	0,0	23,1	0,0	1,8	58,4	65,8	101,3	158,0
2025	187,2	281,7	107,2	62,7	16,0	2,3	12,4	7,1	85,9	106,9	261,4	165,4
Average	**156,97**	**170,77**	**67,31**	**31,92**	**29,97**	**11,01**	**5,42**	**4,66**	**61,81**	**99,23**	**163,91**	**186,94**

Total monthly rainfall for each year as well as the average monthly rainfall across all three years is depicted in Figure 8. The project site receives most of its rainfall during late spring and summer (November to February). Very little rainfall occurs during winter (July to August).

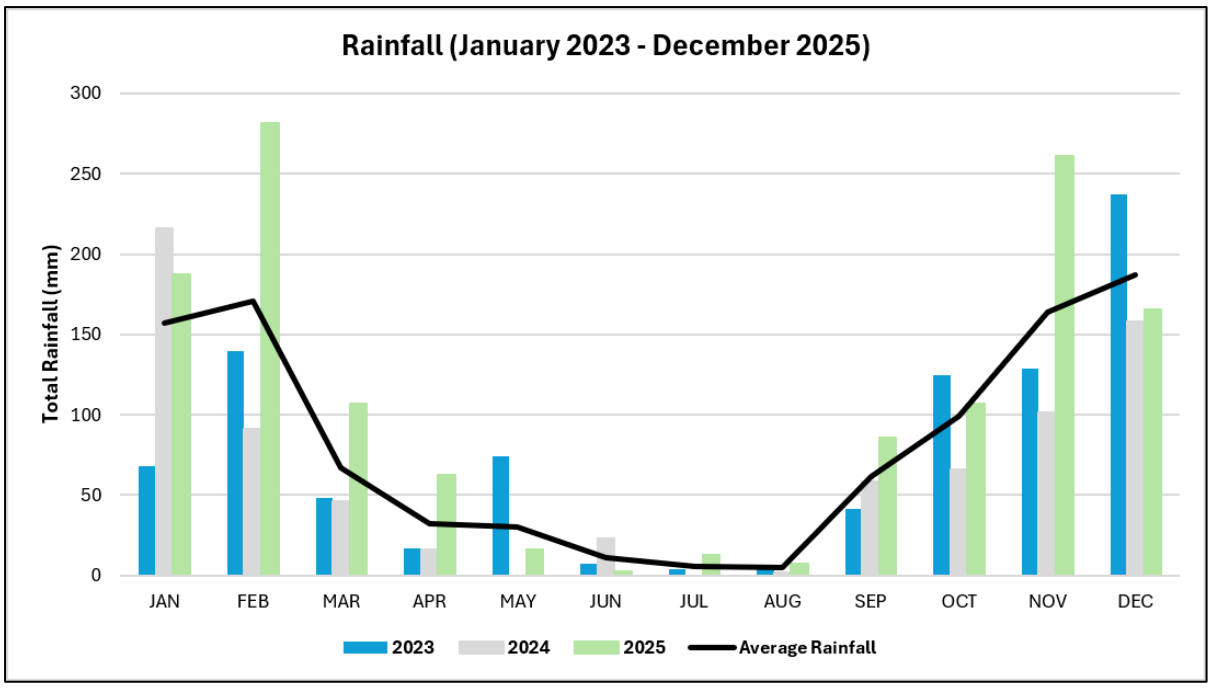


Figure 8: Total Monthly and Average Rainfall (mm) for the Project Site (January 2023 - December 2025).

6. ANTICIPATED IMPACTS OF THE PROJECT ON CLIMATE CHANGE

The operation of the Tonkmeter WRF results in GHG emissions, principally from fugitive CH_4 emissions associated with landfilled waste, diesel combustion from operational equipment and generator use, and purchased grid electricity.

The current application relates specifically to the proposed increase in height of Area E to 25 m. Accordingly, the climate change impact attributable to the height increase has been determined by comparing the cumulative GHG emissions of the go-ahead case against the corresponding no-go case under each waste throughput scenario.

The difference between the go-ahead and no-go cases represents the incremental GHG emissions attributable to the proposed Area E height increase and forms the basis of the carbon budget comparison and environmental significance assessment.

6.1. GHG Inventory Quantification

The GHG inventory includes Scope 1 emissions from landfill CH_4 generation and operational diesel combustion, together with Scope 2 emissions from purchased grid electricity. Scope 3 emissions have been excluded.

Two operational throughput scenarios were assessed:

- **Scenario 1:** 7 500 tonnes/month; and
- **Scenario 2:** 15 000 tonnes/month.

For Scenario 1, the WRF is expected to operate for approximately 87 years under the no-go case and 126 years under the go-ahead case, representing an additional 39 years of operation attributable to the Area E height increase. For Scenario 2, the corresponding operating lives are approximately 44 years and 63 years, representing an additional 19 years.

Landfill methane emissions were quantified using the IPCC First Order Decay (FOD) waste model. The landfill was modelled as a managed semi-aerobic waste disposal site, with a Methane Correction Factor (MCF) of 0.5. Annual CH_4 emissions calculated by the FOD model were summed over the respective operational periods to determine cumulative landfill emissions. CH_4 emissions were converted to CO_2 equivalent using a Global Warming Potential (GWP) of 23.

The unmitigated case assumes no landfill gas recovery throughout the operating period.

For the mitigated case, landfill gas collection and flaring are assumed to commence from approximately 2030, based on information provided by the client that current landfill gas volumes do not yet justify flaring but are expected to become sufficient by approximately 2030. In the absence of site-specific collection performance data, a methane collection efficiency of 75% was applied from 2030 onwards. This represents a commonly applied industry assumption where site-specific landfill gas collection performance data are unavailable (US EPA, 2024). A flare destruction efficiency of approximately 98% is assumed for the proposed flare; however, consistent with the IPCC FOD methodology, methane collected and flared is treated as recovered methane within the model.

Operational diesel consumption was assessed at 5 500 L/month under Scenario 1 and 11 000 L/month under Scenario 2. Total site electricity consumption is approximately 3 500 kWh/month, comprising 50% purchased grid electricity, 45% solar PV and 5% diesel-generated electricity. Generator emissions are incorporated within the operational diesel inventory to avoid double counting.

The calculated GHG emissions for the no-go, go-ahead and incremental cases are presented in Table 14. It should be noted that landfill methane generation does not cease when a facility stops accepting waste, as waste already in place continues to decompose over time. This CCIA assesses the emissions generated during the operational life of the facility, that is, the period over which the WRF accepts and disposes of waste. Emissions occurring after the cessation of waste acceptance have not been quantified and fall outside the scope of the current assessment. Landfill gas management, including the proposed gas collection and flaring system, should nevertheless be addressed as part of the facility's closure and post-closure planning.

Table 14: GHG Emissions Inventory for the Tonkmeter WRF.

Scenario / Case	Landfill CH_4 Unmitigated (tCO_2e)	Landfill CH_4 Mitigated (tCO_2e)	Diesel (tCO_2e)	Grid Electricity (tCO_2e)	Total Unmitigated (tCO_2e)	Total Mitigated (tCO_2e)
Scenario 1 (No-Go)	2 051 019.83	523 446.67	15 264.55	1 973.16	2 068 257.54	540 684.39
Scenario 1 (Go-Ahead)	3 254 297.49	824 266.09	22 107.28	2 857.68	3 279 262.45	849 231.05
Scenario 1 (Incremental)	**1 203 277.66**	**300 819.42**	**6 842.73**	**884.52**	**1 211 004.91**	**308 546.67**
Scenario 2 (No-Go)	1 579 272.50	416 231.05	15 440.01	997.92	1 595 710.42	432 668.98
Scenario 2 (Go-Ahead)	2 663 532.22	687 295.98	22 107.28	1 428.84	2 687 068.34	710 832.10
Scenario 2 (Incremental)	**1 084 259.72**	**271 064.93**	**6 667.28**	**430.92**	**1 091 357.91**	**278 163.13**

The results indicate that the proposed Area E height increase would result in incremental unmitigated GHG emissions of approximately 1 211 005 tCO_2e under Scenario 1 and 1 091 358 tCO_2e under Scenario 2. It is noted that the cumulative emissions reported for Scenario 2 are lower than those for Scenario 1, despite the higher monthly waste disposal rate. This arises because the facility is constrained by available airspace rather than by throughput, and both scenarios therefore landfill a comparable total quantity of waste over their respective operating lives. Scenario 2 deposits that waste over approximately half the period, and the annual rate of methane generation under Scenario 2 is correspondingly higher, at approximately double that of Scenario 1 at any given point in the operating life. The cumulative totals reported here are those generated during the operational (waste-acceptance) period of each case. Under the shorter Scenario 2 operating life, a greater proportion of the methane arising from waste deposited in the later years is generated after the cessation of waste acceptance and therefore falls outside the reported operational period. Scenario 1 is accordingly the more conservative case in terms of cumulative operational-period emissions, while Scenario 2 is the more conservative case in terms of annual emission rates.

Following implementation of the proposed landfill gas collection and flaring system, the incremental emissions decrease to approximately 308 547 tCO_2e under Scenario 1 and 278 163 tCO_2e under Scenario 2. This represents an overall reduction in the incremental GHG footprint of approximately 74.5% under both scenarios. Fugitive landfill CH_4 is the dominant emission source. Prior to mitigation, landfill CH_4 contributes approximately 99.4% of the incremental footprint under both scenarios. Following mitigation, landfill CH_4 still contributes approximately 97.5%, demonstrating that landfill gas management remains the most material opportunity for reducing the climate change impact of the proposed height increase. Diesel combustion represents a comparatively small secondary contribution, while purchased grid electricity contributes less than 1% of the incremental GHG footprint.

The modelled emissions are directly proportional to the methane correction factor applied, which reflects the standard of landfill management. The WRF has been modelled as a well-managed site (MCF of 0.5). Waste disposed at a poorly managed facility of the same type (MCF of 0.7) would generate approximately 40% more landfill methane for the same waste quantity and composition. Continued operation of the facility in accordance with its approved operating and engineering design is therefore itself a material emissions control.

The full cumulative emissions presented for the no-go and go-ahead cases provide context regarding the overall lifetime GHG footprint of the WRF. However, the incremental difference between the two cases is used to assess the climate change impact attributable specifically to the current application.

The projected annual landfill GHG emission profiles for the no-go and go-ahead cases under each throughput scenario are presented in Figure 9 to Figure 12. Each figure compares the unmitigated emission profile with the corresponding mitigated profile incorporating landfill gas collection and flaring from approximately 2030.

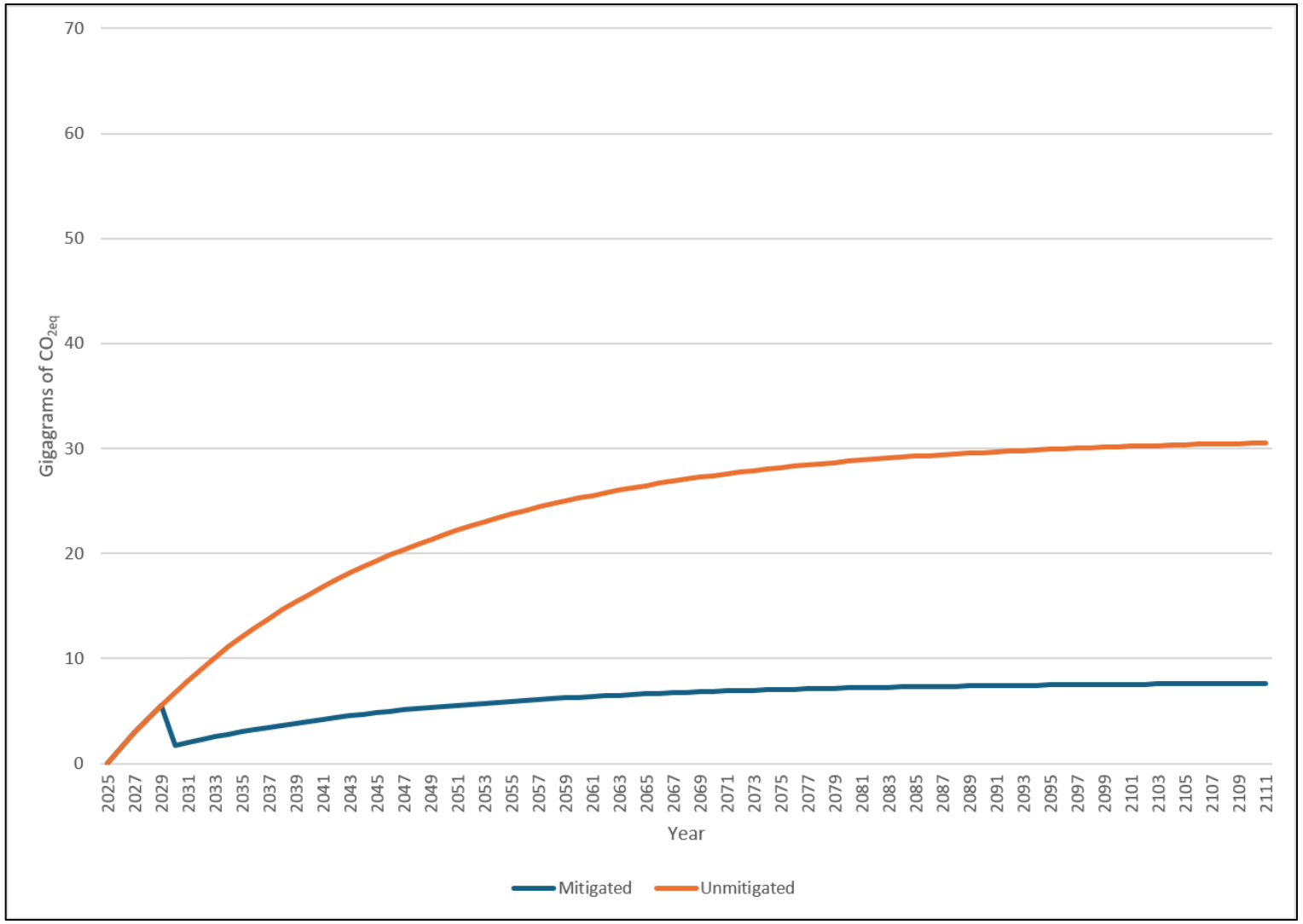


Figure 9: Projected Annual GHG Emissions from Landfill Gas – Scenario 1 No-Go, Mitigated and Unmitigated

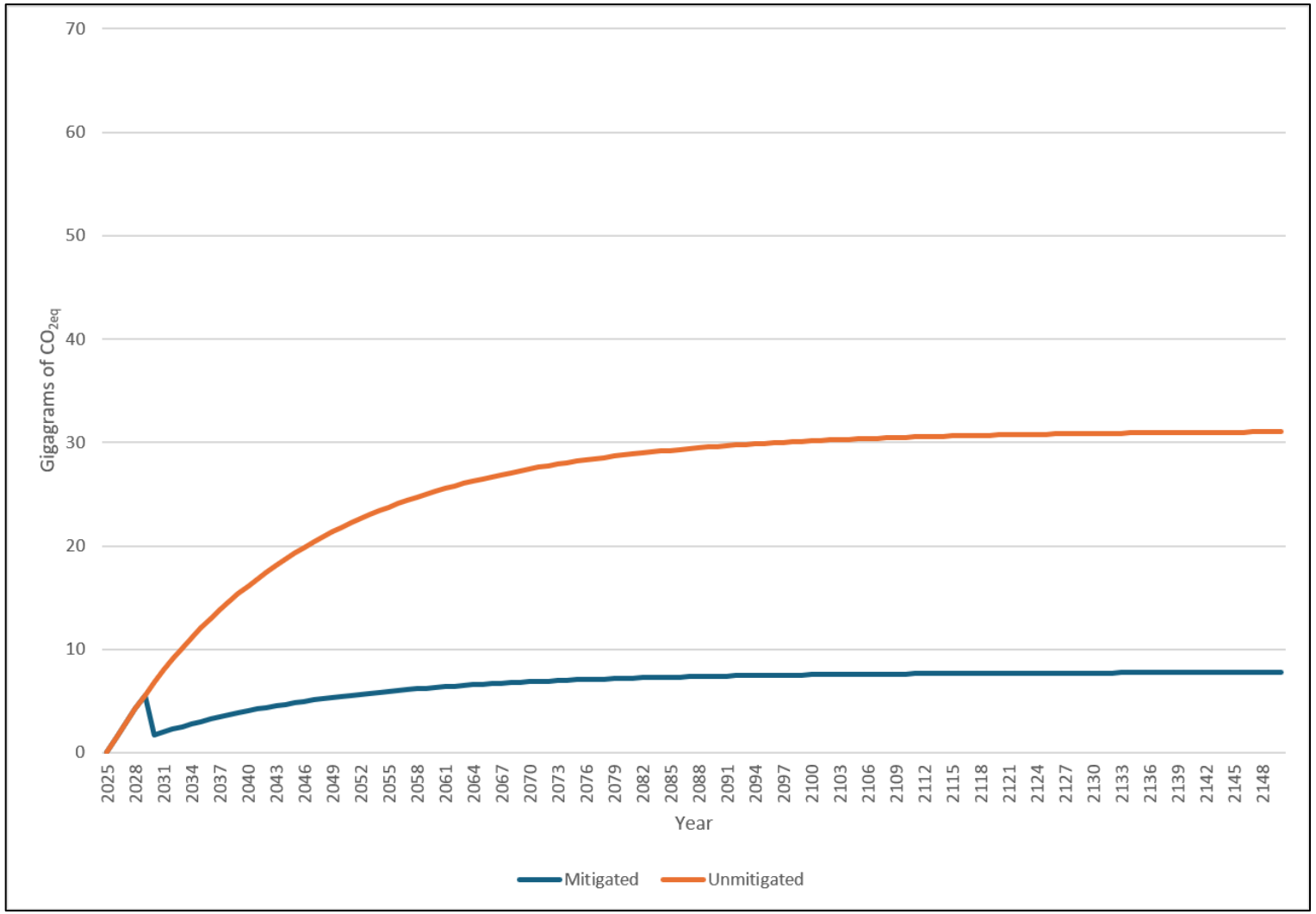


Figure 10: Projected Annual GHG Emissions from Landfill Gas – Scenario 1 Go-Ahead, Mitigated and Unmitigated

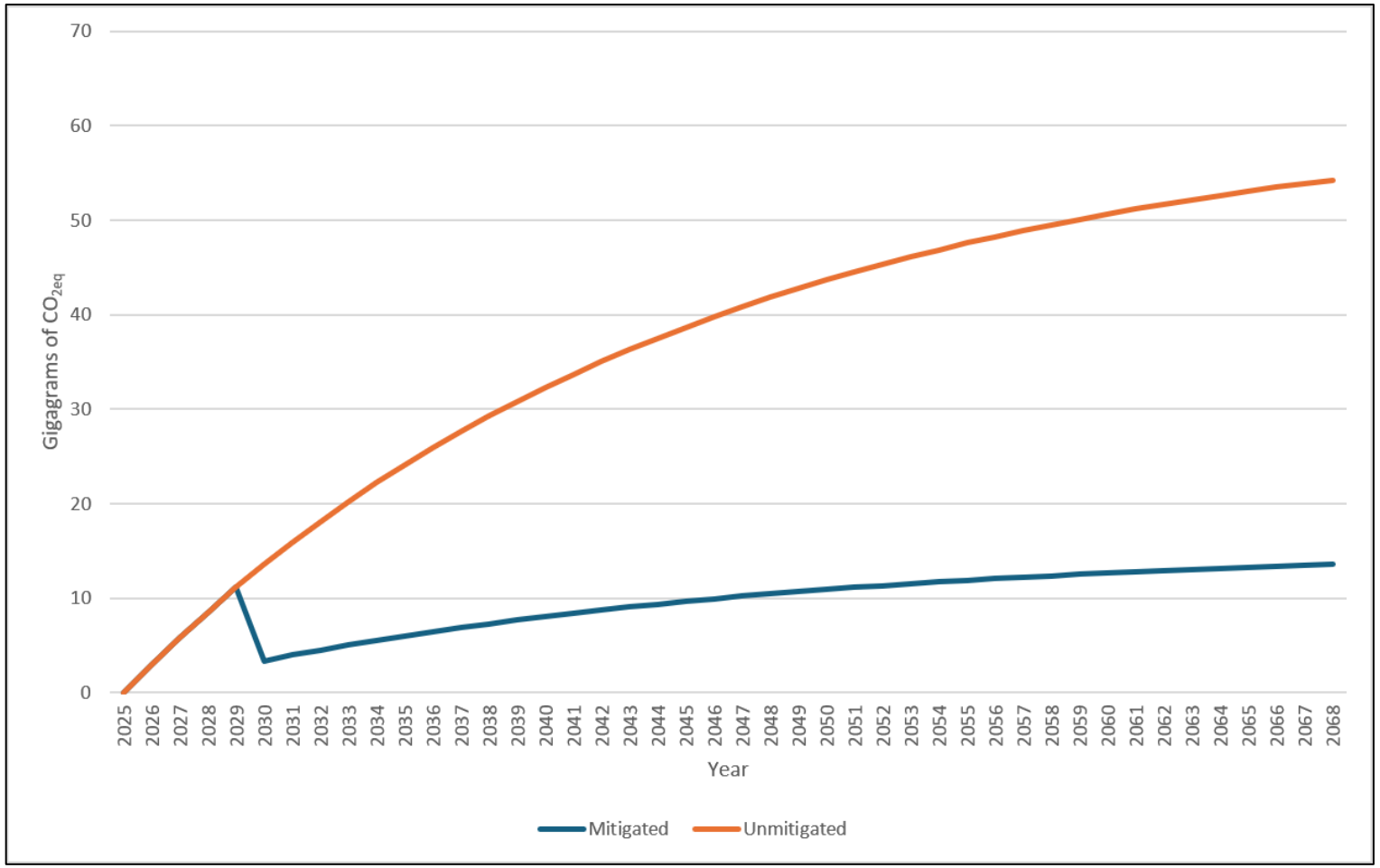


Figure 11: Projected Annual GHG Emissions from Landfill Gas – Scenario 2 No-Go, Mitigated and Unmitigated

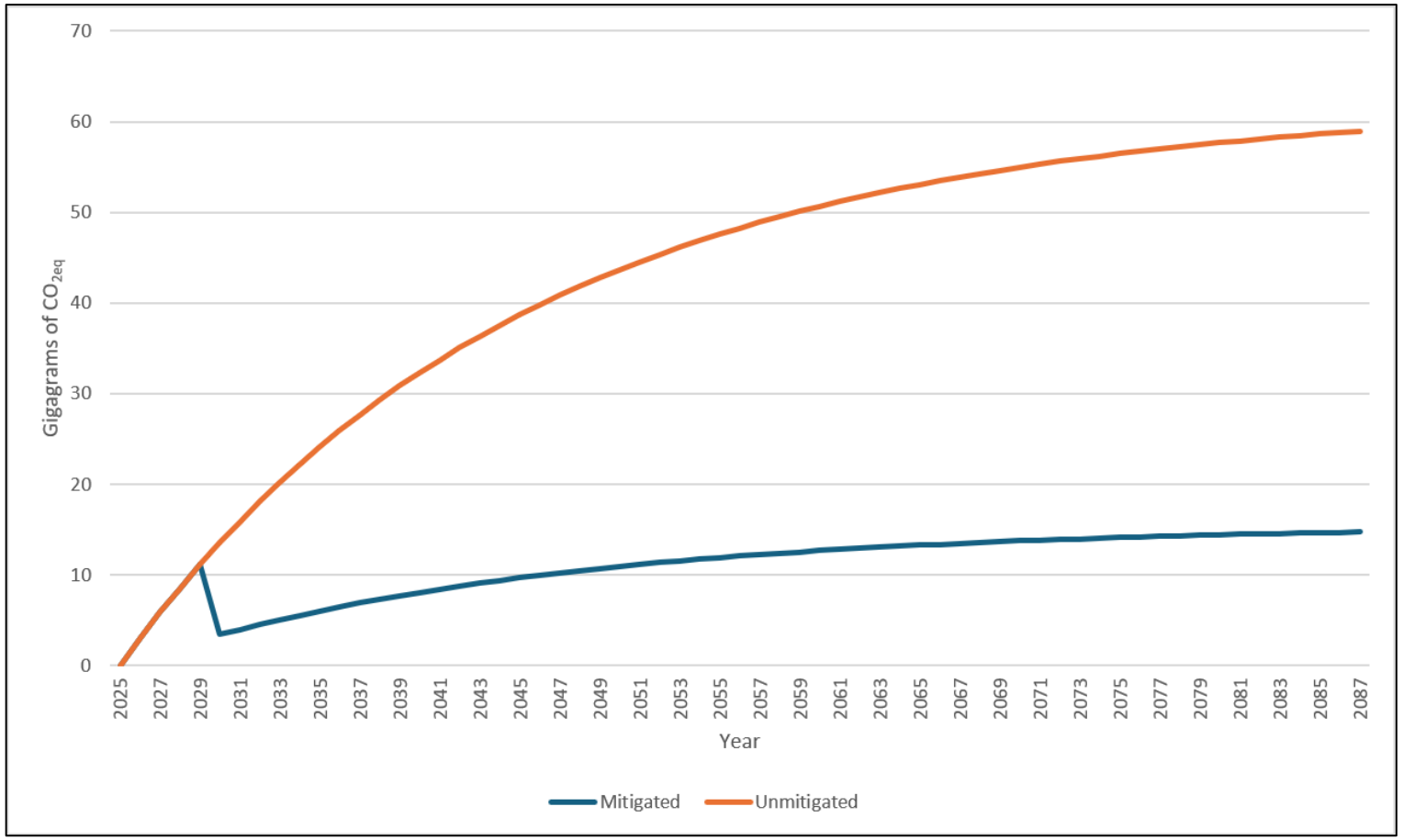


Figure 12: Projected Annual GHG Emissions from Landfill Gas – Scenario 2 Go-Ahead, Mitigated and Unmitigated

As illustrated in Figure 9 to Figure 12, there is a substantial reduction in annual landfill GHG emissions following the assumed commencement of landfill gas collection and flaring from approximately 2030. Prior to this point, the mitigated and unmitigated emission profiles are identical, as no methane recovery has been assumed.

From 2030 onwards, the mitigated profiles decline significantly relative to the unmitigated cases as a proportion of the generated methane is recovered and flared. Annual emissions subsequently increase gradually as additional waste is deposited and biodegradable material continues to decompose, however, the mitigated emission profiles remain substantially below the corresponding unmitigated profiles throughout the remaining operational life of the facility.

Emissions from the adjacent municipal waste disposal facility have not been quantified in this assessment. No waste quantity, composition or landfill management data was available for that facility, and it is operated by a separate entity outside Tonkmeter's operational control. Unlike localised pollutants, greenhouse gases are globally mixed, and their climate effect is a function of total emissions rather than of the proximity of sources to one another. The cumulative climate change impact of multiple facilities is therefore appropriately addressed through the carbon budget comparison in Section 6.2, which assesses the project's emissions against the national share of the global remaining carbon budget, and through the cumulative effect criterion applied in the significance assessment in Section 6.4. Cumulative air quality impacts associated with the adjacent facility are addressed separately in the Air Quality Impact Assessment prepared for the project.

6.2. Project Emissions within the Carbon Budget

The updated global RCB from the beginning of 2026 is approximately 130 $GtCO_2$ for a 50% likelihood of limiting warming to 1.5°C and 1 050 $GtCO_2$ for a 50% likelihood of limiting warming to 2°C (Forster et al., 2026). Applying the population-based allocation approach adopted for this assessment results in an indicative South African share of approximately 0.99 $GtCO_2$ for the 1.5°C pathway and 7.98 $GtCO_2$ for the 2°C pathway.

As the RCB is expressed in CO_2 while the project inventory is expressed as CO_2e, the comparison is used as an indicative screening measure of relative climate significance. The calculated contribution of the height increase to the indicative South African RCB is presented in Table 15.

Table 15: Contribution of Incremental Project Emissions to South Africa's RCB

Scenario	Case	Incremental GHG Emissions (tCO_2e)	GHG Emissions ($GtCO_2e$)	Contribution to 1.5°C RCB (%)	Contribution to 2°C RCB (%)	Impact Rating
Scenario 1	Unmitigated	1 211 004.91	0.001211005	0.12253	0.01517	High
	Mitigated	308 546.67	0.000308547	0.03122	0.00387	Medium
Scenario 2	Unmitigated	1 091 357.91	0.001091358	0.11043	0.01367	High
	Mitigated	278 163.13	0.000278163	0.02815	0.00348	Medium

The results indicate that the incremental GHG emissions associated with the proposed Area E height increase are classified as High prior to mitigation under both Scenario 1 and Scenario 2. Following implementation of the modelled landfill gas collection and flaring measures, the incremental emissions decrease substantially, and both scenarios fall within the Medium impact category.

Under Scenario 1, the indicative contribution to South Africa's 1.5°C RCB decreases from approximately 0.12253% to 0.03122% following mitigation, while the contribution to the 2°C RCB decreases from approximately 0.01517% to 0.00387%. Under Scenario 2, the corresponding contributions decrease from approximately 0.11043% to 0.02815% for the 1.5°C pathway and from approximately 0.01367% to 0.00348% for the 2°C pathway.

The results demonstrate that landfill gas collection and flaring materially reduce the climate change impact associated with the proposed application. Although the mitigated emissions remain an additional contribution to the remaining carbon budget, landfill gas management reduces the magnitude of the project-specific impact sufficiently to lower the rating from High to Medium under both operational scenarios.

At current global emissions of approximately 42 $GtCO_2$ per year, the remaining 1.5°C budget of 130 $GtCO_2$ would be exhausted around 2030, and the 2°C budget of 1 050 $GtCO_2$ within approximately 25 years (Forster et al., 2026). The majority of the emissions assessed in this CCIA occur well beyond these dates, as the incremental emissions attributable to the height increase arise towards the end of the facility's operating life. The comparison presented above should therefore be understood as a screening indicator of relative magnitude, rather than as an allocation of a budget that will still be available when those emissions occur.

Beyond that point, the applicable framework will be national and sectoral emission constraints under a net-zero trajectory, including South Africa's Nationally Determined Contribution targets, the objective of net-zero CO_2 emissions by 2050, and the sectoral emission targets and carbon budgets provided for under the Climate Change Act (Act 22 of 2024). As national emissions decline, the relative significance of the facility's emissions is likely to increase, which strengthens the case for early implementation of landfill gas collection and flaring.

6.3. Projects Emissions within the Carbon Tax Act and GHG Reporting Framework

The National Greenhouse Gas Emission Reporting Regulations identify IPCC Code 4A1: Managed Waste Disposal Sites as a reportable activity where a facility receives 5 tonnes or more of waste per day or has a total waste disposal capacity of 25 000 tonnes or more. The WRF exceeds this threshold under both operational scenarios assessed and is therefore subject to the applicable facility-level GHG reporting requirements (DFFE, 2020). It is important to distinguish the annual regulatory GHG inventory from the project-specific emissions calculated for this CCIA. The cumulative emissions presented in Section 6.1 have been calculated over the respective operating lives of the no-go and go-ahead cases to assess the climate change impact attributable to the proposed Area E height increase. These cumulative emissions should therefore not be interpreted as the annual emissions required to be reported in terms of the National GHG Emission Reporting Regulations. For regulatory

reporting purposes, Tonkmeter should calculate and report actual annual facility-level GHG emissions using the applicable quantification methodology and annual activity data, including waste received, waste composition and methane recovery where applicable.

The Carbon Tax Act (Act No. 15 of 2019) similarly includes IPCC Code 4A1: Managed Waste Disposal Sites under Schedule 2, subject to the applicable thresholds of 5 tonnes per day or a total capacity of 25 000 tonnes. Managed solid waste disposal activities are, however, allocated a 100% basic tax-free allowance under Schedule 2. Furthermore, no South African industry GHG emissions-intensity benchmark has been prescribed for solid waste disposal sites, landfills or waste resource facilities under the Section 11 performance allowance regulations. Accordingly, the landfill methane emissions quantified in this CCIA should not be assessed against a landfill-specific Carbon Tax Act performance benchmark or interpreted as generating a direct carbon tax liability through the application of the prevailing headline carbon tax rate to the cumulative GHG footprint. Any carbon tax liability applicable to Tonkmeter should instead be determined separately on an annual basis, taking into account the applicable activity, emissions during the relevant tax period, statutory allowances and any subsequent amendments to the Carbon Tax Act.

The implementation of landfill gas collection and flaring nevertheless remains important from both a climate change and regulatory-management perspective, as it substantially reduces fugitive methane emissions and provides improved facility-specific data for future annual GHG inventories.

6.4. Significance Assessment of Potential Impacts

The proposed increase in height of Area E will increase the available landfill capacity at the WRF and extend the period over which waste can be accepted and disposed of. Relative to the no-go case, this will result in additional GHG emissions from landfill methane generation, diesel combustion and purchased grid electricity. The significance assessment is therefore based on the incremental emissions attributable specifically to the proposed height increase, rather than the total cumulative emissions of the facility.

Prior to mitigation, the incremental GHG emissions are approximately 1 211 005 tCO_2e under Scenario 1 and 1 091 358 tCO_2e under Scenario 2. In terms of the impact rating table presented in Table 16, both scenarios fall within the High magnitude category. Following implementation of landfill gas collection and flaring, the incremental emissions decrease to approximately 308 547 tCO_2e under Scenario 1 and 278 163 tCO_2e under Scenario 2. Both scenarios therefore fall within the Medium magnitude category following mitigation. The remaining impact criteria are considered the same for both scenarios, as the nature, spatial extent, duration, reversibility and cumulative effect of GHG emissions do not materially differ between the two throughput cases.

Table 16: Significance Assessment of the Climate Change Impact

IMPACT RATING TABLE			
Item	Description	Pre-mitigation impact rating	Post mitigation impact rating
Environmental Parameter	Climate change impacts of the proposed resource facility		
Extent (E)	The impacts of climate change are global and far reaching. They cannot be contained locally.	3	3

Probability (P)	With the type of operations, GHG emissions will definitely occur, and contribute to climate change.	5	5
Reversibility (R)	GHG emissions and their contribution to climate change cannot be reversed. Landfill methane will keep being generated for decades after closure, and gas collection can only reduce it. Once emitted, GHGs stay in the atmosphere for decades (CH_4) to centuries (CO_2).	4	4
Loss of Resources (L)	There will be an intermediate loss of resource. Once GHGs have been emitted into the atmosphere, they contribute to the already increasing global temperatures and diminish the already constrained carbon budget available (to limit global temperature increase to unsustainable levels).	3	3
Duration (D)	The climate change effect of the emitted GHGs is long-lasting and extends well beyond the operational life of the facility, including post-closure landfill methane emissions.	5	5
Cumulative Effect (C)	The impact of the facility on climate change is cumulative in nature, in that it will add to an already strained global temperature status, as well reducing the global carbon budget, which is being depleted at a significant rate.	4	4
Magnitude or Intensity (M)	The magnitude/severity of the impact of the proposed height increase's climate change impacts is considered to be High (unmitigated) to Medium (mitigated), in terms of their contribution to South Africa's GHG emissions and resulting carbon budget depletion.	4	3
Item	Description	Pre-mitigation impact rating	Post mitigation impact rating
Environmental Significance Points: ***(Extent + probability + reversibility + loss of resources+ duration + cumulative effect) x magnitude/intensity=***	The significance points before mitigation are -96 (High Negative). This indicates the facility will impact on climate change. Mitigation measures should be implemented and may have the potential to reduce the significance points to -72.	- 96 (High negative)	- 72 (Medium negative)

The same significance rating applies to Scenario 1 and Scenario 2, as both scenarios fall within the same magnitude categories before and after mitigation. The proposed height increase is therefore assessed as having a High Negative climate change impact prior to mitigation. Following implementation of landfill gas collection and flaring, the significance decreases too Medium Negative. The reduction in significance demonstrates the material benefit of landfill gas management. Although the proposed application will continue to result in additional GHG emissions relative to the no-go case, methane recovery and flaring substantially reduce the magnitude of the impact and represent the principal mitigation measure for the climate change impact associated with the additional landfill capacity.

6.5. Mitigation Measures for the Facility's Impact on Climate Change

The main contributor to the WRFs GHG emissions is fugitive landfill gas generation associated with the decomposition of landfilled waste. Diesel combustion from operational mobile equipment and generator use also contributes to the facility's carbon footprint, while purchased grid electricity represents a comparatively minor emission source. Scope 3 emissions and construction-phase emissions have been excluded from the inventory due to

limited activity data and because these sources fall outside the confirmed operational boundary of the current assessment.

Mitigation measures should therefore focus primarily on reducing fugitive methane emissions through improved landfill gas management, while also reducing diesel and grid electricity consumption where practicable. The following mitigation measures are recommended for implementation during the operational phase of the facility:

- Landfill gas monitoring to determine gas generation rates and methane concentrations (these systems should continue post closure);
- Development of landfill gas collection and flaring infrastructure once sufficient gas volumes are available, modelled in this assessment from approximately 2030;
- Optimisation of landfill gas collection efficiency, with the current assessment assuming 75% methane recovery in the absence of site-specific performance data;
- Appropriate waste compaction and cover practices;
- Diversion of suitable organic waste from landfill where practicable;
- Diesel efficiency and improved operational management;
- Increased use of solar power to reduce dependence on grid-supplied and diesel-generated electricity;
- Energy-efficiency measures for lighting, cooling systems and other support infrastructure; and
- Consideration of credible carbon offsets for residual emissions that cannot reasonably be avoided or reduced.

Implementation of landfill gas collection and flaring is expected to provide the greatest reduction in the facility's GHG footprint. Under the assumptions applied in this assessment, the incremental emissions associated with the Area E height increase decrease from approximately 1 211 005 tCO_2e to 308 547 tCO_2e under Scenario 1, and from approximately 1 091 358 tCO_2e to 278 163 tCO_2e under Scenario 2. This represents an overall reduction of approximately 74.5% and reduces the climate change significance from High Negative to Medium Negative under both scenarios.

6.5.1. Monitoring Requirements

It is recommended that Tonkmeter calculate, maintain and update a facility-level GHG inventory on an annual basis using actual operational data and the applicable national GHG quantification methodology.

The inventory should, as a minimum, incorporate annual waste quantities and available waste composition data, calculated landfill methane emissions, methane recovered or flared, operational diesel consumption and purchased grid electricity. Once a landfill gas collection and flaring system is operational, records should additionally include landfill gas flow rates, methane concentrations, estimated methane recovered, flare operating hours, system downtime and other relevant performance information.

The GHG inventory and associated mitigation measures should be reviewed where material changes occur in waste throughput, waste composition, landfill management practices, fuel

consumption, electricity supply or landfill gas recovery performance. This will enable the assumptions applied in the current CCIA to be progressively replaced with site-specific measured data and provide a more representative assessment of the facility's actual GHG performance.

7. ANTICIPATED IMPACTS OF CLIMATE CHANGE ON THE PROJECT

Climate change presents growing risks to ecosystems, economies, and human health, making it essential to identify and address these vulnerabilities. Climate change risk assessments serve this purpose by identifying potential impacts and evaluating the exposure and sensitivity of people, infrastructure, and natural systems. They provide a foundation for proactive planning and adaptation, helping businesses to reduce risks and build resilience, under changing climatic conditions.

7.1. Climate Change Risk and Vulnerability Assessment

According to the IPCC (2022), risk analysis provides us with a framework that can be used to understand the interconnected impacts of climate change on various systems which are becoming more and more severe. When considering climate change, risks typically originate from interactions between climate-related hazards and the exposure or vulnerability of the affected systems, whether human or ecological. Vulnerability is defined by the IPCC (2022) as the degree to which a system is susceptible to, and unable to cope with or adapt to, the adverse effects of climate change.

According to the Global Facility for Disaster Reduction and Recovery (GFDRR, 2020), the Ekurhuleni Metropolitan Municipality (EMM), where the WRF is located, is vulnerable to wildfires, water scarcity, earthquakes, extreme heat and urban flooding. Wildfires, extreme heat and urban flooding are event-based and are therefore considered acute physical climate risks, while water scarcity reflects longer-term chronic stress. Earthquakes are not climate-related but are included as a natural hazard relevant to site resilience. The potential impacts of each hazard on the facility, and their likelihood of occurrence, are detailed in the tables that follow.

Risk of river flooding, cyclones and landslides are considered to be very low by the GFDRR (2020), meaning there is <1% chance of potentially damaging and life-threatening river floods occur in the coming 10 years, a < 1% of potentially-damaging cyclone-strength winds in the next 10 years and localised landslides a rare hazard phenomenon based on the areas rainfall patterns, terrain slope, geology, soil, land cover and potential earthquakes. Given their very low risk ratings, river flooding, cyclones and landslides are not explicitly considered for this project.

Table 17: Risk of Wildfires.

Risk Background/Description	Project Impacts	
In EMM, the likelihood of weather conditions conducive to significant wildfires (i.e., increased temperature and rainfall variability) resulting in loss of life and/or property, in any given year, is more than 50%. Consequently, the wildfire risk in the area is classified as high (GFDRR, 2020).	**Health and Safety:** • Vegetation fires spreading onto the site may ignite waste, resulting in injuries, hospitalisation or loss of life. • Smoke, ember storms and landfill fire emissions may cause respiratory harm to staff and neighbouring communities. • Staff working at the open face are particularly exposed during fire conditions. **Operational and Value Chain:** • Hot, dry and windy conditions increase the risk of surface and subsurface landfill fires, which are difficult to extinguish and may burn for extended periods. • Fires may damage the liner, cover material, leachate infrastructure, landfill gas wells and the recycling centre, and destroy baled recyclables awaiting sale. • Landfill fires release uncontrolled emissions and may trigger regulatory reporting, complaints and possible non-compliance under the facility's environmental authorisation. • Fire-fighting demands significant volumes of water, which may compete with dust suppression and general site water needs. • Loss of grid electricity during fire events may disrupt weighbridge, office and leachate aeration operations. • Access roads may become impassable, delaying waste deliveries and the removal of recovered materials.	
Scoring (GFDRR, 2020 – Think Hazard)	Scoring (WRI, 2023 – Aqueduct)	Adjusted Risk
High	N/A	High

Table 18: Risk of Water Scarcity.

Risk Background/Description	Project Impacts	
In EMM, the possibility of droughts occurring in the coming ten years is up to 20%. Consequently, the risk of water scarcity in the area is classified as medium (GFDRR, 2020). According to the WRI (2026), the risk of water depletion in the project region, defined as "the ratio of total water consumption to available renewable water supplies" is considered extremely high. Based on all risk tools reviewed, the risk rating applicable to the site has been adjusted to high.	**Health and Safety:** • Reduced water availability on site and in surrounding areas may create health risks for staff and nearby communities. • Limited water for dust suppression may increase dust exposure at the working face and on internal roads. **Operational and Value Chain:** • Water is required for dust suppression on internal roads and active disposal areas. Restrictions may limit compliance with dust management requirements. • Reduced water availability may constrain fire-fighting supplies at a time when fire risk is highest. • Drier waste slows anaerobic decomposition, which may reduce landfill gas generation and affect the viability and sizing of the proposed gas collection and flaring system. • Drought followed by intense rainfall may cause desiccation cracking of cover material, increasing fugitive methane and odour emissions. • Higher water costs, or the need for alternative supplies, may increase operating costs. • Water restrictions may place additional pressure on leachate and stormwater management, including on-site storage capacity.	
Scoring (GFDRR, 2020 – Think Hazard)	Scoring (WRI, 2023 – Aqueduct)	Adjusted Risk
Medium	Extremely High	High

Table 19: Risk of Earthquakes.

Risk Background/Description	Project Impacts	
In EMM, the likelihood of at least one potentially damaging earthquake occurring in the next fifty years, is greater than 10%. Consequently, the risk of earthquakes in the area is classified as medium (GFDRR, 2020).	**Health and Safety**: • Ground shaking may create unsafe conditions around active disposal areas, slopes and operating heavy machinery. • Injuries may result from falling objects, unstable surfaces or damage to buildings. • Damage to access routes may delay emergency response and evacuation. **Operational and Value Chain**: • Seismic loading may affect the stability of the waste body, particularly where the waste mass is saturated after heavy rainfall. • Damage to the liner, cap, leachate drainage or the contaminated water dam could cause leachate release and groundwater contamination. • Damage to landfill gas wells and pipework could interrupt gas collection and flaring, increasing fugitive methane emissions. • Damage to buildings, internal roads, the weighbridge and stormwater infrastructure may disrupt operations. • Ground instability may temporarily halt waste acceptance, placement, compaction, daily cover and recycling activities.	
Scoring (GFDRR, 2020 – Think Hazard)	Scoring (WRI, 2023 – Aqueduct)	Adjusted Risk
Medium	N/A	Medium

Table 20: Risk of Extreme Heat.

Risk Background/Description	Project Impacts	
The risk of extreme heat to the EMM is considered low, meaning that there is a 5% to 25% chance that at least one period of prolonged exposure to extreme heat, causing heat stress, will take place in the following five years (GFDRR, 2022). Thus, extreme heat events can be expected in the short term.	**Health and Safety**: • Heat stress may cause heat-related illness, dehydration and fatigue among staff, and contractors working at the open face without shade. • Higher temperatures accelerate odour generation and vector breeding (flies, rodents and birds), affecting workers and nearby receptors. • Heatwaves may worsen local air quality through higher ozone formation, adding to the site's own emissions. **Operational and Value Chain**: • Equipment, vehicles and electrical infrastructure may lose performance or reliability, and cooling demand in buildings will rise. • Hot and dry conditions may increase dust generation from internal roads, exposed soil and active disposal areas, increasing the need for dust suppression. • Higher temperatures may increase water demand for dust suppression and staff welfare, thereby compounding existing water-scarcity risks. • Prolonged hot and dry conditions may increase the likelihood of waste, vegetation or landfill fires. • Higher average temperatures can accelerate waste decomposition, resulting in higher methane generation rates.	
Scoring (GFDRR, 2022 – Think Hazard)	Scoring (WRI, 2023 – Aqueduct)	Adjusted Risk
Low	N/A	Low

Table 21: Risk of Urban Floods.

Risk Background/Description	Project Impacts	
According to the GFDRR (2022), the EMM is at low risk of urban floods, meaning there is a greater than 1% chance of potentially damaging or life-threatening floods occurring in the next 10 years. Thus, floods may be expected in the medium to long term. It should be noted however, that with inconsistencies in modelled projections of rainfall for Gauteng, this hazard level may increase in the future due to climate change. According to the WRI (2026), riverine flood risk is also considered low. Riverine flood risk is defined as the percentage of the population anticipated to be affected by riverine flooding in an average year and accounts for flood-protection standards. Based on all risk tools reviewed, the risk rating applicable to the site has been adjusted to low.	**Health and Safety**: • Flooding of the working area and internal roads may cause slips, vehicle incidents and injuries. • Contact with leachate-contaminated stormwater presents a health risk to staff, contractors and downstream communities. **Operational and Value Chain**: • Intense rainfall may overwhelm stormwater infrastructure or cause localised ponding within the facility. • Increased stormwater infiltration may increase leachate generation and place additional pressure on leachate-management infrastructure. • Flooding or erosion may damage internal roads, drainage infrastructure, cover material and other landfill infrastructure. • Runoff may erode daily and intermediate cover, exposing waste, increasing windblown litter and creating pathways for fugitive gas and odour. • Wet waste is harder to compact, which reduces achieved density and may shorten the effective airspace life. • Flooding of surrounding roads may delay waste deliveries, staff access and the movement of equipment.	
Scoring (GFDRR, 2022 – Think Hazard)	Scoring (WRI, 2023 – Aqueduct)	Adjusted Risk
Low	Low	Low

7.2. Mitigation Measures for Climate Change Impacts on Project

Mitigation and adaptation measures should be implemented to reduce the vulnerability of the WRF to the identified physical climate and natural hazards. Recommended measures are presented in Table 22.

Table 22: Recommended Adaptation and Mitigation Measures

Risk	Adaptation and Mitigation Measures
Wildfires	• Identify infrastructure and operational areas vulnerable to fire. • Maintain appropriate firebreaks and vegetation management. • Maintain fire-fighting equipment and suitable water supplies. • Implement emergency response and evacuation procedures. • Minimise the potential for uncontrolled waste fires. • Maintain backup power arrangements where practicable.
Earthquakes	• Ensure that site infrastructure is designed, constructed and maintained in accordance with applicable structural and geotechnical requirements. • Conduct routine inspections of buildings, roads, slopes, stormwater infrastructure and containment systems, particularly following seismic events. • Develop and implement emergency response and evacuation procedures for earthquake events. • Ensure that staff are aware of safe response procedures and designated assembly areas. • Secure critical infrastructure and equipment where possible to reduce the risk of damage during ground shaking. • Undertake post-event inspections before normal operations resume.
Water Scarcity	• A water scarcity management plan should be developed to mitigate water scarcity risks. • Facility operations should increase water storage, reduce water use and improve water consumption efficiencies. • Ensure that multiple potable water sources are available for the site to alternate between should it be required. • Investigate monitoring and forecasting systems to help predict future periods of drought and enhance preparedness. • Monitor water consumption during drought periods to prevent compromising water availability.
Extreme Heat	• Keep facilities/buildings cool with efficient use of air-conditioning. • Consider building designs appropriate for local climate that are conducive to cooling in summer i.e., consider building orientation, natural shading, and ventilation. • Ensure that equipment and vehicles purchased for use on site can operate under increased ambient temperatures to avoid downtime. • Investigate early warning/monitoring systems to inform the site of expected heat wave occurrences.

	• Ensure health and safety of employees by regularly monitoring hydration levels, avoiding work hours during the hottest part of the day and providing medical attention/resources to those who are vulnerable.
Urban Floods	• Ensure that drainage infrastructure is well maintained. • Ensure infrastructure built on site is resilient to projected flood levels, and that site design and layout planning considers the potential for flooding event on site. • To ensure health and safety of employees, site evacuation and emergency response plans for flooding events should be implemented. • Ensure backup power systems are available, should energy supply be disrupted.

7.3. Business Implications

Climate change can result in risks to the business other than environmental-related risks. An overview of the continuity and transition risks that have the potential to impact the project cabe be seen below.

7.3.1. Continuity Risks

- **Business Continuity Risks:** Facility operations may be disrupted by extreme weather events, such as floods, storms, or droughts, which could interrupt processes.
- **Health and Safety Risks:** Climate-related events can pose direct health and safety risks to employees and nearby communities. These may include accidents caused by extreme heat, flooding etc., as well as increased risks associated with emergency response and evacuation during severe weather events.
- **Reputational and Social Risks:** Investor and public scrutiny of environmental performance is increasing. Facilities that exacerbate the impacts of climate change on surrounding communities or ecosystems may face reputational damage, reduced stakeholder trust and pressure from local communities or advocacy groups.
- **Financial Risks:** Climate-related transition and physical risks can have financial implications, including reduced access to funding, higher insurance premiums, and increased reporting requirements. Additional financial risks may arise from the need to invest in renewable energy, environmentally friendly technologies, and/or alternative water sources to support expansion in water-stressed regions.

7.3.2. Transitional Risks

- **Waste diversion policy:** national and provincial measures to divert organic and recyclable waste from landfill would reduce both the biodegradable fraction of waste received and total landfilled volumes, affecting the facility's revenue and its projected operating life.
- **Carbon pricing:** managed waste disposal is a listed activity under Schedule 2 of the Carbon Tax Act. Landfill emissions currently attract a 100% basic tax-free allowance,

but any future narrowing of that allowance during Phase 2 (2026–2030) or beyond would create a direct cost linked to landfill methane.

- **Methane regulation and carbon budgets:** growing international and national focus on methane, together with sectoral emission targets and carbon budgets under the Climate Change Act (Act 22 of 2024), may lead to requirements for gas capture, monitoring and reporting at landfill facilities.
- **Client and market expectations:** customers increasingly report Scope 3 emissions from waste disposal and may favour facilities that can demonstrate gas capture and verified emissions performance.
- **Access to finance and insurance:** lenders and insurers increasingly assess climate performance, which may affect the cost or availability of funding for future cell development.

8. ALTERNATIVES

No alternative properties or facility layouts were assessed as part of this CCIA. The Tonkmeter facility is an existing and operational waste disposal and resource recovery facility, and the current application relates specifically to the proposed increase in height of Area E to 25 m. The climate change assessment therefore considers the no-go and go-ahead cases associated with the current application under each of the two waste throughput scenarios.

The scenarios assessed are summarised in Table 23.

Table 23: No-Go and Go-Ahead Assessment Scenarios

Scenario	Waste Disposal Rate	No-Go Scenario	Go-Ahead Scenario	Additional Operating Life
Scenario 1	7 500 tonnes/month	Facility operates for approximately 87 years without the Area E height increase	Facility operates for approximately 126 years with the Area E height increase	39 years
Scenario 2	15 000 tonnes/month	Facility operates for approximately 44 years without the Area E height increase	Facility operates for approximately 63 years with the Area E height increase	19 years

8.1. No-Go Alternative

The no-go alternative represents the case in which the proposed increase in height of Area E is not authorised. Under this alternative, the WRF would continue operating within its existing authorised capacity until the available landfill airspace is exhausted. The no-go alternative

would therefore not result in zero GHG emissions, as the facility is already operational and would continue accepting and disposing of waste for a substantial period. Waste already deposited, as well as waste accepted during the remaining authorised operating period, would also continue generating landfill methane after waste acceptance ceases.

The estimated operating life of the facility under the no-go alternative is approximately:

- 87 years under Scenario 1 at 7 500 tonnes/month; and
- 44 years under Scenario 2 at 15 000 tonnes/month.

The GHG emissions calculated for the no-go case therefore represent the emissions expected to occur under the currently authorised facility configuration.

Under the no-go alternative, the cumulative GHG emissions over the facility's remaining authorised operating life are approximately 2 068 258 tCO_2e under Scenario 1 and 1 595 710 tCO_2e under Scenario 2, prior to mitigation. The corresponding go-ahead emissions are approximately 3 279 262 tCO_2e and 2 687 068 tCO_2e. The difference between the two alternatives is therefore material in absolute terms, and represents the incremental impact assessed in Section 6. The no-go alternative does not, however, result in zero emissions, as the facility is already authorised and operational.

8.2. Go-Ahead Alternative

The go-ahead alternative represents the case in which the proposed increase in height of Area E to 25 m is authorised.

The additional landfill capacity created by the height increase would extend the operating life of the broader WRF to approximately:

- 126 years under Scenario 1 at 7 500 tonnes/month; and
- 63 years under Scenario 2 at 15 000 tonnes/month.

The proposed height increase would therefore extend the operating life of the facility by approximately 39 years under Scenario 1 and 19 years under Scenario 2.

The additional operating period would allow further waste disposal and would result in additional landfill methane generation, operational diesel consumption and electricity consumption relative to the no-go case.

9. SUMMARY AND CONCLUSION

This CCIA was undertaken for the Tonkmeter WRF to assess the potential impact of the proposed increase in height of Area E to 25 m on climate change, as well as the potential impact of climate-related hazards on the facility and its operations. Areas D and F remain part of the operational facility but are not proposed to be increased in height under the current application.

The GHG inventory included Scope 1 emissions from landfill methane generation and operational diesel combustion, together with Scope 2 emissions associated with purchased grid electricity. Scope 3 emissions and construction-phase emissions were excluded due to insufficient project-specific activity data and because these sources fall outside the confirmed operational boundary of the current assessment.

Two waste throughput scenarios were assessed. Under Scenario 1, waste disposal of approximately 7 500 tonnes/month results in an estimated facility life of 87 years under the no-go alternative and 126 years under the go-ahead alternative, representing an additional 39 years of operation. Under Scenario 2, waste disposal of approximately 15 000 tonnes/month results in an estimated facility life of 44 years under the no-go alternative and 63 years under the go-ahead alternative, representing an additional 19 years of operation.

The climate change impact attributable specifically to the proposed height increase was determined as the difference between the cumulative go-ahead and no-go GHG emissions. Prior to landfill gas mitigation, the amendment results in incremental GHG emissions of approximately 1 211 005 tCO_2e under Scenario 1 and 1 091 358 tCO_2e under Scenario 2. Fugitive landfill methane is the dominant emission source, contributing approximately 99.4% of the incremental pre-mitigation GHG footprint.

For the mitigated assessment, landfill gas collection and flaring were modelled from approximately 2030, with a methane collection efficiency of 75%. Under these assumptions, incremental GHG emissions decrease to approximately 308 547 tCO_2e under Scenario 1 and 278 163 tCO_2e under Scenario 2, representing an overall reduction of approximately 74.5%. Landfill methane remains the principal emission source following mitigation, although its absolute contribution is substantially reduced.

When assessed against South Africa's estimated Remaining Carbon Budget, the incremental emissions are classified as High prior to mitigation and Medium following mitigation under both scenarios. In terms of the Rayten impact assessment methodology, the corresponding environmental significance decreases from High Negative (-96) prior to mitigation to Medium Negative (-72) following implementation of the proposed landfill gas management measures.

The WRF also exceeds the applicable threshold for IPCC Code 4A1: Managed Waste Disposal Sites under the National GHG Emission Reporting Regulations. It is therefore recommended that Tonkmeter maintain and update a facility-level GHG inventory annually using actual waste disposal, waste composition, fuel, electricity and landfill gas management data. The annual regulatory inventory should be distinguished from the cumulative project-specific emissions calculated for this CCIA.

The physical climate risk assessment identified wildfires and water scarcity as the highest risks to the facility. Earthquake risk was assessed as Medium as part of the broader natural-hazard screening, while extreme heat and urban flooding were assessed as Low. Recommended adaptation measures include wildfire preparedness, water-scarcity planning, maintenance of stormwater and drainage infrastructure, emergency-response planning, infrastructure inspections, heat-stress management and contingency planning for operational disruptions.

Overall, the proposed Area E height increase will result in additional GHG emissions relative to the no-go alternative due to the additional waste capacity and extended operating life of the facility. However, landfill gas collection and flaring provide a material opportunity to reduce this impact. Continued landfill gas monitoring, implementation of gas capture and flaring when technically feasible, annual GHG accounting, efficient diesel use, increased renewable energy utilisation and appropriate climate adaptation measures are therefore recommended as key management measures for the WRF.

The disposal of biodegradable waste to landfill inevitably generates GHG emissions, principally methane, as organic material decomposes under anaerobic conditions. This is an inherent characteristic of landfilling rather than a feature of the proposed height increase. The quantity of methane generated and released is, however, strongly influenced by how a facility is designed, operated and managed. A well-managed facility that applies controlled waste placement, compaction and daily cover, together with engineered containment and landfill gas management, generates materially lower emissions than a poorly managed facility receiving the same waste, with the difference in modelled landfill methane emissions in the order of 40%. Where landfill gas collection and flaring is implemented, emissions are reduced further still.

It should further be noted that, in the absence of licensed disposal capacity, waste is more likely to be directed to unlicensed disposal or to uncontrolled dumping and open burning. These practices generate uncontrolled methane emissions along with products of incomplete combustion, offer no opportunity for gas capture, recovery or recycling, and carry additional air quality, health and environmental risks for surrounding communities. The continued availability of licensed, well-managed and monitored disposal capacity, combined with resource recovery and future landfill gas management at the WRF, therefore represents a lower-emission and better-controlled outcome than the realistic alternatives.

9.1. Reasoned opinion regarding the acceptability of the proposed activity

Taking the findings of this CCIA into account, the proposed increase in height of Area E to 25 m is expected to result in an additional climate change impact relative to the no-go alternative due to the increased landfill capacity and associated extension of the operating life of the WRF.

Prior to mitigation, the incremental GHG emissions attributable to the proposed height increase are approximately 1 211 005 tCO_2e under Scenario 1 and 1 091 358 tCO_2e under Scenario 2, resulting in a High Negative climate change significance rating. Fugitive landfill methane is the dominant contributor to these emissions.

Following implementation of the modelled landfill gas collection and flaring measures from approximately 2030, using an assumed methane collection efficiency of 75%, the incremental

GHG emissions decrease to approximately 308 547 tCO_2e under Scenario 1 and 278 163 tCO_2e under Scenario 2. This represents an overall reduction of approximately 74.5% and reduces the climate change significance to Medium Negative under both scenarios.

The comparison against the remaining carbon budget is a screening indicator. Because the majority of the assessed emissions occur beyond the period over which that budget will be exhausted, the facility's emissions should also be managed with reference to South Africa's longer-term national and sectoral emission trajectories, which reinforces the importance of early implementation of landfill gas collection and flaring.

The physical climate risk assessment identified wildfire and water scarcity as the principal risks to the facility, with earthquake risk assessed as Medium and extreme heat and urban flooding assessed as Low. These risks are considered manageable through implementation of the recommended adaptation and resilience measures.

No fatal flaws have been identified from a climate change perspective. The proposed application may therefore be considered acceptable from a climate change perspective, provided that the recommended mitigation, monitoring and adaptation measures are implemented. In particular, landfill gas monitoring should be undertaken and landfill gas collection and flaring should be implemented once technically feasible, with actual site-specific methane recovery data progressively replacing the assumptions applied in this assessment.

It is further recommended that Tonkmeter maintain and update a facility-level GHG inventory on an annual basis, incorporating actual waste quantities and composition, methane emissions and recovery, diesel consumption and purchased electricity. The inventory and associated mitigation measures should be reviewed where material changes occur in facility operations or landfill gas management.

This reasoned opinion is limited to the findings of the CCIA and should not be interpreted as approval of the proposed application as a whole. The final decision should take into account the findings of all relevant specialist studies, the broader environmental assessment process, applicable regulatory requirements and the requirements of the competent authority.

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CURRICULUM VITAE

Name	**Michael Brugman**
Cell:	+27 (0)73 790 9084
Email:	mikeb@rayten.co.za
Nationality:	South African
ID Number:	9112175166085
Marital Status:	Married
Languages:	English

QUALIFICATIONS

- **BSc Geology (2011-2014)**
  Rhodes University, South Africa

- **BSc Honors Environmental Monitoring and Modelling (2016-2017)**
  University of South Africa, South Africa

PROFESSIONAL EXPERIENCE

Having graduated with a BSc in Geology and a BSc (Hons) in Environmental Monitoring and Modelling, my work experience can be summarised as follows:

- Senior Air Quality and Nose Specialist – Air quality monitoring / Noise monitoring (Rayten Engineering Solutions)
- Air Quality Consultant – Air quality monitoring (Rayten Engineering Solutions)
- Teacher – Mathematics Teacher (St Catherine's School)
- Air Quality Scientist – Air quality monitoring (Rayten Engineering Solutions)
- Junior Geologist – Intern geologist (EIM)

EMPLOYMENT HISTORY

Rayten Engineering Solutions, Randburg, South Africa
July 2025 – Current

- Managed all noise monitoring projects.
- Conducted and compiled noise assessment reports.
- Collected and analysed air quality data following South African air quality monitoring guidelines.
- Processed and interpreted meteorological and air quality data using statistical methods and software tools, ensuring data quality and compliance.
- Conducted research on local pollutants, emission sources, and environmental impacts, contributing to scientific reports and studies.
- Assisted in the operation, maintenance, and sampling of air quality monitoring stations, adhering to quality control procedures.
- Managed air quality datasets, including data entry, validation, collation from multiple sources, and secure storage.
- Conducted air quality impact assessments, including dispersion modelling, emission inventories, baseline studies, and report compilation.
- Drafted Atmospheric Emission Licence (AEL) applications, variations, and renewals, and assisted with project administration.
- Compiled emission inventories and captured emissions data on NAEIS for regulatory compliance.
- Prepared and submitted annual AEL reports, including information collection, drafting, and submissions to clients and authorities.
- Assisted in AEL compliance audits, including data collection, audit execution, and follow-up with senior reviewers.
- Processed AQMS data and drafted dust, passive, and air quality monitoring reports on a monthly, quarterly, and annual basis.
- Gathered client and online information to support reporting, assessments, and regulatory compliance

Rayten Engineering Solutions (Consultant/Contractor), Randburg, South Africa
February 2024 – June 2025

- Conducted and compiled air quality impact assessments (AQIAs).
- Compiled emission inventories and captured emissions data on NAEIS.
- Compiled AEL Reports and Compliance Audits.
- Developed pollution prevention plans and conducted ambient air quality reporting for key stakeholders.
- Gathered client and online information to support reporting, assessments, and regulatory compliance

St Catherine's School, Germiston, South Africa
January 2018 – June 2025

- Taught Senior Phase Mathematics, fostering academic growth and problem-solving skills.
- Coordinated subject management and curriculum planning to enhance learning outcomes.
- Provided remedial academic support to underperforming students, improving performance by 30% on average.

Rayten Engineering Solutions, Randburg, South Africa
January 2017 – December 2017

- Conducted and compiled air quality impact assessments (AQIAs).
- Collected and analysed air quality data following South African air quality monitoring guidelines.

- Processed and interpreted meteorological and air quality data using statistical methods and software tools, ensuring data quality and compliance.
- Conducted research on local pollutants, emission sources, and environmental impacts, contributing to scientific reports and studies.
- Assisted in the operation, maintenance, and sampling of air quality monitoring stations, adhering to quality control procedures.
- Managed air quality datasets, including data entry, validation, collation from multiple sources, and secure storage.
- Conducted air quality impact assessments, including dispersion modelling, emission inventories, baseline studies, and report compilation.
- Drafted Atmospheric Emission Licence (AEL) applications, variations, and renewals, and assisted with project administration.
- Compiled emission inventories and captured emissions data on NAEIS for regulatory compliance.
- Prepared and submitted annual AEL reports, including information collection, drafting, and submissions to clients and authorities.
- Assisted in AEL compliance audits, including data collection, audit execution, and follow-up with senior reviewers.
- Processed AQMS data and drafted dust, passive, and air quality monitoring reports on a monthly, quarterly, and annual basis.
- Gathered client and online information to support reporting, assessments, and regulatory compliance

EIM, Johannesburg, South Africa
Intern 6 month contract
June 2016 – December 2016

- Assisted with geological surveys.
- Conducted site inspection reports.
- Assisted with mine wall stability compliance checks.
- Conducted ground and surface water quality assessments.
- Assisted with environmental compliance audits.

CURRICULUM VITAE

Name Jessica Burger

Cell no 076 170 8564

E-mail Jessica.burger@rayten.co.za

Nationality South African

Marital Status Married

QUALIFICATIONS

Academic Qualifications

- **Doctor of Philosophy (PhD) in Ocean & Atmospheric Science** – University of Cape Town
  - 2019 – 2023
  - Research Thesis: Drivers of spatial and temporal variability in sources and cycling of inorganic aerosols from the remote marine atmosphere of the Southern Ocean
- **Master of Science (MSc) in Ocean & Atmospheric Science** – University of Cape Town
  - 2017 – 2019
  - Research Thesis: Drivers of short-term variability in phytoplankton production in an embayment of the southern Benguela upwelling system: an observational and modelling study
- **Bachelor of Science Honours (BSc Hons) in Ocean & Atmospheric Science** – University of Cape Town
  - 2016
- **Bachelor of Science (BSc) in Marine Biology and Ocean & Atmospheric Science** – University of the Cape Town
  - 2013 - 2015

Academic Achievements

- Dean's Merit List (2013-2015)
- Nellie Brown Spilhaus Scholar (2017)
- Vice Chancellor Research Scholarship (2019-2020)

Additional Qualifications

- E-Science Tools: Linking Models and Observations (Tjärnö Marine Laboratory, 2022)

Language Proficiency

LANGUAGE	SPEAK	READ	WRITE
English	Fluent	Fluent	Fluent

PROFESSIONAL EXPERIENCE

Jan 2024 – Present	Atmospheric Scientist at Rayten Engineering Solutions
Jan – December 2023	Post doctoral researcher at MARiS and the Marine Biogeochemistry Laboratory (UCT)
Feb – Jun 2021	Teaching assistant and academic tutor at the Department of Oceanography (UCT)

Responsibilities and Experience

- Data Handling, Analysis and Visualisation
- Research and Report Writing
- Report Reviewing and Editing
- Project Management
- Compilation of Quotes
- NAEIS Reporting
- Greenhouse Gas Reporting
- Annual AEL Reporting and AEL Compliance Auditing
- Climate Change Impact Assessments
- Physical Climate Risk Assessments

Key Projects Completed

MONTHLY MONITORING REPORTS

Responsible for monthly atmospheric data analysis and quality checks, and monthly air quality report compilation for different clients:

- Air Quality Monitoring Reports (for AECI, Prime Resources and Sibanye Wonderkop)
- Dust Fallout Reports (for Monoweld, Universal Coal Kangala, Bushveld, Maxam Corp and Ezee Tile)
- Passive/BTEX reporting (for Denny Mushroom, Eskom Rotek, Maxa, Corp and Sibanye)

CLIMATE IMPACT ASSESSMENTS

Responsible for compiling climate impact assessments and physical climate change risk analyses:

- Tendele Anthracite Mine
- Dikwena Chrome Co-generation Plant
- Cape Winelands Airport Expansion (In partnership with Brundtland Consulting)
- Cons Modder Mine
- Umgala and Knights Hill Mining Operations
- Eswatini White Pellet Plant

GREENHOUSE GAS EMISSION INVENTORIES

Responsible for greenhouse gas emission inventories taking into account fuel and energy usage:

IPCC Clients:

- Flexilube
- RSP Processing
- Northbound Processing
- Interwaste
- Maximin

GHG Protocol Clients:

- ARM Andalusite
- Afrox
- BP Wiggill
- Desco electronic
- Ezee Tile (Cape Town and Mokopane)
- Fabio Chains
- Heneken Alloys and Minerals
- FCS Foundry
- Maskal Tubes
- Matt Cast
- Maxam Dantex South Africa
- Metcon Cape Town and Kempton Park
- NCIS
- Nimag group
- Northern Natal Bronze
- Pro-Tech Galvanisers
- Rely Intercast
- Rustenburg Engineering
- SMT Afritech
- Scamont Engineering
- Transvaal Galvanizers
- Vereeniging Foundry

Carbon Footprint Assessments:

- Lepelle Northern Water

CURRICULUM VITAE

Name Brenton Rodney Faulds

Cell no 079 515 7577

E-mail Brenton.faulds@rayten.co.za

Nationality South African

Marital Status Married

QUALIFICATIONS

MSc	Geography	2022 – 2023	University of Johannesburg
BSc Hons	Geography	2019 - 2019	University of Witwatersrand
BSc	Geography and Archaeology	2015 - 2018	University of Witwatersrand

Academic Awards

Golden Key Award – 2023

Golden Key Award - 2019

ADDITIONAL QUALIFICATIONS

Energy Performance Certification (EPC) GBCSA Academy, 2022.

Language Proficiency

LANGUAGE	SPEAK	READ	WRITE
English	Fluent	Fluent	Fluent
Afrikaans	Fair	Fair	Fair

PROFESSIONAL EXPERIENCE

Aug 2021 – Present Rayten Engineering Solutions (Pty) Ltd
May 2020 – July 2021 Integrated Reporting & Assurance Services (IRAS)

RESPONSIBILITIES AND EXPERIENCE

- Project Management
- Project Financial Management
- Compiling Quotes and Tenders
- Compiling and Reviewing Reports
- Liaising with Suppliers and Clients
- ESG Training
- Greenhouse Gas Inventories and AEL application requirements

- Strong Report Writing Skills
- Strong Research Skills
- Report Reviewing
- Company Administration
- Business Development and Marketing
- Attending Meetings and Forums

KEY PROJECTS COMPLETED

CLIMATE IMPACT ASSESSMENTS AND GREENHOUSE GAS EMISSION INVENTORIES

Responsible for compiling and analyzing climate impact assessments and greenhouse gas emission inventories:

- IPCC - RussellStone Protein – Bronkhorstspruit
- IPCC - Interwaste
- IPCC – Zimco Group
- IPCC – Prima Industrial
- IPCC – Evander Gold Mines
- IPCC – Barberton Mines
- IPCC – Goldfields (South Deep)
- IPCC – Bushveld Vanchem
- IPCC – Kalagadi Manganese
- IPCC – Rappa Resources
- IPCC – Sparta Beef
- Kyoto Protocol - Nimag Group
- Kyoto Protocol - Metalloy Products
- Kyoto Protocol - GE Patterns and Foundry
- Kyoto Protocol – Rustenburg Engineering and Foundry
- Kyoto Protocol – Norther Natal Bronze and Iron
- TotalEnergies
- Vlakfontein Opencast Mine
- Vrygenhoek Platinum Mine
- Tendele Opencast Mine
- Samancor Dikwena Chrome – Co Generation Facility.
- Cape Winelands Airport Expansion (In partnership with Brundtland Consulting)
- Cons Modder Mine

ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG)

Responsible for the data collection and collation

- SDTI Annual Report
- Tongaat Hulett

- SA Corporate
- RCL Foods
- Scamont Engineering

DATA VERIFICATION AND VALIDATION

Responsible for the data collection, collation and reporting

- Harmony Group
- ATNS
- Scamont Engineering

STACK EMISSION MONITORING PROGRAMS

Responsible for data analysis, report compilation and reviewing.

- Harmony – Central, Kopanang, One and Target operations
- Afrisam
- Rustenburg Engineering and Foundry
- Scamont Engineering
- Bushveld Vanchem
- Sibanye Stillwater – Beatrix and Driefontein operations
- Cape Bentonite
- Maksal
- Village Main Reef – Nicolor and West Gold operations
- Zinchem - Benoni
- Consol – Clayville
- Zimalco
- SMT Afritech (Techmet)
- Buffalo City Metropolitan Municipality
- Multotec
- Tranvaal Galvanizers

CURRICULUM VITAE

Name	**Clive John Wray**
Cell:	+27 (0)82 579 3376
Email:	clivew@rayten.co.za
Nationality:	South African
ID Number:	7908145191083
Marital Status:	Married
Languages:	English

QUALIFICATIONS

- **Professional Engineer (Pr. Eng.)** **Reg. No: 20090334**
  Engineering Council of South Africa (ECSA)

- **BSc (Eng) Honors Mechanical Engineering (1998-2002)**
  University of Natal, South Africa (Awarded a Sasol Bursary (2000))

ADDITIONAL QUALIFICATIONS

• SoundPlan and Noise Assessments	SoundPlan-UK 2023
• Certified Risk Assessor	
• Project Management Prof. (PMP)	Davis and Dean, 2012
• PDMS	Uhde Internal Training, 2010
• Pressure Vessel Design and Analysis	PVElite, 2007
• Project Management	OD&L Learning Centre, 2003.
• Time Management	OD&L Learning Centre, 2003.
• Effective Problem Solving (EPS)	OD&L Learning Centre, 2003.

PROFESSIONAL EXPERIENCE

Having graduated with a BSc (Eng) Mechanical Engineering degree, I have since gained Professional Engineering (Pr. Eng.) status through the Engineering Council of South Africa (ECSA). My work experience can be summarised as follows:

- Environmental Assessments – Ambient Air Quality / Climate Change Assessments and Risks, GHG Assessments / Noise Impact Assessments / Engineering services (Rayten Engineering Solutions)

- Manager Engineering - Mining Process Plants / Chemical Plants (Basil Read Matomo)

- Senior / Lead Mechanical Engineer – Petrochemical (ThyssenKrupp Uhde)
- Risk Analyst / Project Engineer – Consulting (Amec Ltd)
- Mechanical Engineer - Building Services (Linaker Ltd)
- Jnr. Mechanical Engineer - Oil and Petrochemical (Sasol Ltd)

EMPLOYMENT HISTORY

Rayten Engineering Solutions, Randburg, South Africa
July 2014 – Current

- Research, report writing and report reviewing.
- Manage all air quality monitoring projects.
- Climate Change Impact Assessment and associate risks (Expert Level)
- Greenhouse gas emission Inventories and reports for foundries and other industrial developments (Kyoto Protocol Method) (Expert Level)
- Dispersion modelling and Air Quality Impact Assessor (Expert Level)
- Noise Impact Assessments (Expert Level)
- Ambient Emission monitoring (Expert Level)
- Fugitive Dust Management Plans for coal mines, several foundries and other industrial developments.
- Engineering consulting and designs.
- Project management and company administration.
- Compiling quotes and tenders.
- Managing and providing mentorship to junior and senior Air Quality Scientists.
- Providing expert scientific air quality advice to several industrial developments.

  Climate Impact Assessments (CIAs) for different projects – Expert Level, e.g.:
  - Vlakfontein Open Cast Mine
  - Vrygenhoek Platinum Mine
  - Tendele Anthracite Mine
  - Fuleni Colliery
  - Samancor DCM Co-Generation Plant

  Greenhouse gas emission Inventories and reports for foundries and other industrial developments (Kyoto Protocol Method) – Expert Level, e.g.:
  - IPCC Barberton Mine
  - IPCC Bushveld Vanchem
  - IPCC Evander Gold Mines
  - IPCC Flexilube
  - IPCC Kalagadi Manganese (2019-2022)
  - IPCC Interwaste
  - IPCC Prima Industrial
  - IPCC Rappa resources
  - IPCC RussleStone Processing
  - IPCC Safal
  - IPCC South Deep
  - IPCC Sparta
  - IPCC Zimco Group

Air Quality Impact Assessments (AQIAs) for different projects (based on AERMOD and CALPUFF) – Expert Level, e.g.:

- Industrial Plants & Developments
  - Ezee Tile Adhesives Manufacturing (Pty) Ltd – Proposed Zeerust Plant, Port Elizabeth and Durban Plants.
  - Proposed Oya Energy Hybrid Facility
  - Plascon Luipaardsvlei – Proposed Storage and Handling of Organic Liquids
  - Proposed Nuvest Recovery Solutions chemical plant in Meyerton.
  - Bushveld Vanchem
  - Proposed Vanadium Resources – Salt Roast Leach Plant
  - Transvaal Galvanisers (proposed expansion)
  - Anglo-American Platinum, Rustenburg Platinum Mines – Waterval Smelter Complex (proposed expansion)
  - Proposed Bojanala Regional Special Economic Zone – Waste-Water Treatment Plants Expansion.

- Coal Mines
  - South 32 - Khutala Colliery (Pty) Ltd.
  - Proposed Driefontein Coal Mine
  - Proposed Springfield Coal Mine.
  - Proposed Wonderhoek Colliery
  - Proposed Vlakfontein Opencast Coal Mine

- Other types of mines
  - Evander Gold Mine (Pty) Ltd
  - Proposed new TSF construction and proposed historic dump reclamation project for Fairview Mine.
  - Harmony Moab Khotsong Mine – Odour Impact Assessment (Landfill & Waste-Water Treatment Plants) and AQIA (Mining & Processing Operations)
  - Proposed Vygenhoek Platinum Mine
  - Proposed VanMag (Vanadium Magnetite) Mine
  - Foskor- Mining Division
  - Proposed Vanadium Resources – Steelportdrift Opencast Mine
  - Gold One - Modder East Mining & processing operations (proposed TSF expansion)
  - Level One Air Quality Impact Assessments (Screening assessments) for several foundries (Active Foundry (Pty) Ltd, Metal Concentrators SA (Pty) Ltd – Cape Town, Hi Alloy Castings and NI Foundry.

Basil Read Matomo, Melrose Arch, South Africa
October 2011 – July 2014

Managed the following tasks during the project proposal stage:

- Assisted with development of a Work Breakdown Structure (WBS) and costing structure for engineering man-hours as required by project controls.
- Developed a project organogram for engineering.
- Generated engineering management cost estimates.
- Developed a resource loading plan in conjunction with the Project Manager and Engineering Managers based on the cost execution philosophy and schedule.
- Assisted with compiling the proposal where necessary.

Managed the following tasks during project execution:

- Provided technical assistance during design and procurement of engineering packages.
- Developed a project execution strategy with regards to engineering packages, supplier packages, Project Engineers and erection contractor packages.
- Setting up the project engineering standards and engineering specifications register.
- Managed the review and acceptance of Client specifications together with the Lead Engineers.
- Participated in the project kick-off meeting.

Employees:

- Reviewed actual project resource needs with the Project/Lead Engineers on an on-going basis.
- Generated a responsibility matrix based on the deliverable list.
- Participated in interviews and selection of suitable candidates.
- Resolved conflict between engineering employees on a project.
- Ensured correct allocation of man-hours per cost code in the man-hour budget as generated by Project Controls.
- Ensured the correct adjustment of man-hours according to scope changes/design changes.
- Monitored and reported on engineering progress against man-hours spend.

Engineering:

- Managed all engineering work and resources on projects including technical acceptability of work, scheduling of works, man-hour efficiency and cost.
- Ensured that the technical integrity and work scope definition is maintained through the Procurement and Construction activities.
- Issued progress, efficiency and technical overview reports.
- Ensured project quality requirements were clearly defined and adhered to.
- Generated Technical Data Sheets and Scope of Works for various types of mechanical equipment for Enquiry and for Purchase.
- Verification and approving of vendors designs calculations and drawings.
- Preparation of project standards, engineering and technical specifications.
- Preparation of technical enquiries.
- Responsible for resolving and addressing all technical queries that rose during basic and detailed engineering on all projects.
- Promote company business.
- Promote a safety conscience environment.

ThyssenKrupp (Uhde Division), South Africa
February 2006 – October 2011

Projects:

- **New Multiple Products Pipeline (NMPP / Transnet) - Lead Mechanical Engineer**
- **Temane Expansion (Sasol Petroleum) - Lead Mechanical Engineer**
- **MIBK2 (Sasol) - Senior Mechanical Engineer**

Head office based works:

- Managed project budgets, schedules, man-hour, and staff.
- Generated Technical Data Sheets and Scope of Works for various types of mechanical equipment for Enquiry and for Purchase.

- Responsible for the design of Pressure Vessels, Tanks, Heat Exchangers, Turbines, Pumps and Bulk Handling Equipment in accordance with relevant codes and client requirements.
- Verification and approving of vendors designs calculations and drawings.
- Preparation of project standards, engineering and technical specifications.
- Preparation of technical enquiries.
- Responsible for resolving and addressing all technical queries that rose during basic and detailed engineering on all projects.
- Monitored the execution and progress of all phases during basic and detailed engineering and procurement associated with all mechanical equipment.
- Selection of Vendors/ Contractors on a technical basis.
- Compiled technical bid evaluations.
- Reviewed Vendor Documentation to ensure design integrity and compliance with specifications.
- Liaised with other departments to ensure the integrity of the equipment and machinery. Coordinated with home office, Site and Client during detailed engineering, construction, pre-commissioning and commissioning when required.
- Worked with the construction and commissioning teams to progress up to the final acceptance of the work within the project milestones.
- Controlled and reported the engineering Project Budget man-hours, costs and schedule.
- Liaison with Clients to ensure alignment of design with Client requirements. Closely coordinated with Client and tried to identify the engineering issues which were critical for cost, schedule, quality, operability, safety etc. from the mechanical engineering point of view, and recommended technical solution for Client.
- Project Planning and budgeting.
- Assisted the Project Manager (Site) related to mechanical engineering (rotating machines, pressure vessel, piping etc.).
- Report writing.

Field based work:

- Handled all mechanical engineering matters, drawings, specifications, field requisitions, as built drawings, etc.
- Provided engineering expertise to field construction for permanent and temporary works, ensuring that the works were completed safely.
- Verified the scope of work were completed and handed over to the Client/Operator in a defined, timely and systematic process.
- Studied and assessed all drawings, specifications etc and obtain rulings on all construction matters that require engineering interpretation.
- Ensured that all drawings, specifications, procedures, work practices, method statements, quality plans etc were indexed, available and retrievable and that the latest issues are being worked to.
- Checked and arranged approval of design when applicable and alerted the Resident Construction/Site Manager of any special aspects of engineering design or changes.
- Carried out general liaison with the Client Site Engineers in conjunction with the Resident Construction/Site Manager, attending all necessary meetings when required.

Amec Limited, Eli Lilly Site, Surrey, UK
Risk Analyst/ Project Engineer (6 Month Contract)
June 2005 – Dec 2005

- 6 Month Contract to manage and conduct Risk Assessments during the commissioning phase of a new R&D / Chemistry block.
- Managed Engineering Systems within the Eli Lilly pharmaceuticals R&D Building Site.
- Responsible for conducting all System Risk Assessments for the old/new Chemistry R&D Block.

Linaker Limited, Redhill, Surrey, UK
Mechanical Project Engineer (6 Month Contract)
November 2004 – May 2005

- Project Management in the Building Services sector.
- Completed all projects to client's specifications and budget requirements.
- Conducted Risk Assessments and Method Statements.
- Planning and Co-ordination.
- Supervised all site activities that were outsourced to contractors, responsible for safety of contractors.
- Project costing and valuation.
- Responsible for preparing quotations/tenders/proposals
- Dedicated to building strong, enduring working partnerships.
- Responsible for design and sizing of all mechanical systems in each project.
- Responsible for the production of design fees, conceptual design, design innovation, design calculation and final detailed designs in accordance with the subcontract agreement with the end user/client.
- Report writing.

Sasol Limited, Sasolburg, South Africa
Project/Mechanical Engineer (Permanent)
January, 2003 – October, 2004

- Implemented/managed all new projects from the Front-end-loading phases to completion by applying Project Management principles and the Sasol Business Development and Implementation (BD&I) Model.
- Supervised all site activities that was outsourced to contractors, responsible for safety of contractors and controlled the commissioning of projects.
- Cost Control and Project Budgeting.
- Coordinated other disciplines.
- Conducted Risk assessments.
- Conducted Risk Based Inspections (RBI) in preparation for the Sasol Wax GTL 2004 Shutdown.
- Planning and Co-ordination.
- Ensured maintenance of all assets according to company standards.
- Organized Root Cause Analysis (RCA) for recurring problems and attended problem break-through strategies used for defect elimination.
- Responsible for planning a range of potential solutions to problems.
- Attended meetings and communicated the information promptly. (Verbal and Written).
- Worked independently with minimum supervision.