yellowtree ADVISORY

ASSMANG MAKGANYENE MINE

ATMOSPHERIC IMPACT REPORT

2025-07-11

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1. Executive Summary

Assmang (Pty) Ltd has applied for a mining right over an area of approximately 1 550 hectares on the farm Makganyene No. 667, located within the Tsantsabane Local Municipality in the Northern Cape. The proposed Makganyene Iron Ore Mine represents a greenfield development and is designed to extract iron ore via open-pit methods, with manganese and diamonds as potential secondary minerals. Mining activities will include drilling, blasting, hauling, stockpiling, and on-site crushing of run-of-mine (ROM) ore, with all further processing to occur off-site at the Beeshoek Mine.

As part of the Environmental Impact Assessment (EIA) process required under the National Environmental Management Act (NEMA), 1998 (Act 107 of 1998), and in support of the Environmental Authorisation (EA) and associated waste management licences, an Atmospheric Impact Report (AIR) is required to assess potential air quality implications on the surrounding area.

This AIR has been compiled in accordance with the *Regulations Prescribing the Format of an Atmospheric Impact Report,*[1] and the requirements in Section 7.2.2 of the Code of Practice in the *Regulations Regarding Air Dispersion Modelling*.[2] The forms that are contained in the *Regulations Prescribing the Format of the Atmospheric Impact Report* were completed and are contained in Sections 3 to 5 of this report. Section 7 of this report contains the information that is required by the *Regulations Regarding Air Dispersion Modelling*. This AIR has also been prepared to inform the EA Application Process in terms of NEMA, and thus meets the content requirements of Appendix 6 of the 2014 EIA Regulations.[3]

An air dispersion model was conducted using a Level 2 approach in terms of the *Regulations Regarding Air Dispersion Modelling* to assess the impact of the proposed mining site on ambient air quality. The AERMOD model was used to predict ambient concentrations of particulate matter that is smaller than 10 µm (PM_{10}) and 2.5 µm ($PM_{2.5}$). The ambient concentrations that were predicted were then compared to the NAAQS to assess compliance.

Two modelling scenarios were developed:

- **Scenario 1** reflects baseline conditions, incorporating only the dust mitigation measures currently proposed by the client.
- **Scenario 2** evaluates the potential benefits of additional dust mitigation measures, including windbreaks around stockpiles and open pits, and the use of chemical dust suppressants on high-traffic haul roads.

The modelling results from Scenario 1 indicate that both the daily and annual NAAQS for PM_{10} and $PM_{2.5}$ would be exceeded at locations along the northern fence line of the site, particularly in the vicinity of the waste stockpile and ore stockpile. These exceedances highlight the need for additional dust control measures to ensure compliance during the operational phase of the mine. However, it's important to note that the assessment conservatively assumed that the maximum possible surface areas of the pits would be exposed throughout the entire operational period of the mine. In practice, only portions of

[1] GNR 747 of 2013

[2] GNR 533 of 2014

[3] GNR 983 of 2014

the pits will be active at any given time, and actual emissions are therefore likely to be lower than those predicted.

In Scenario 2, the implementation of additional dust mitigation measures results in notable improvement in predicted ambient PM concentrations. All $PM_{2.5}$ concentrations remain below both the daily and annual NAAQS, and the predicted annual PM_{10} concentrations also comply with the applicable standard. While the daily PM_{10} NAAQS is still exceeded, the extent and magnitude of the daily exceedance is significantly reduced compared to Scenario 1. It is once again important to note that the assessment conservatively assumed that the maximum possible surface areas of the pits would be exposed throughout the entire operational period of the mine, and actual emissions are therefore likely to be lower than those predicted.

Based on the results of the dispersion modelling, the implementation of additional dust control measures, such as windbreaks and chemical suppressants, would significantly reduce the predicted ambient concentration of PM at the proposed site. However, it should be noted that these measures were assessed in isolation of operational, technical and economic feasibility considerations. Furthermore, the model adopts conservative assumptions, including the maximum surface area of the open pits for the entire operational life of the mine, which may overstate actual emissions during the operational phase of the mine.

2. Introduction

Assmang (Pty) Ltd proposes to develop a new open-pit iron ore mine on Plot 667 of the farm Makganyene, near Potmasburg in the Northern Cape. The proposed Makganyene Mine will extract primarily iron ore, with manganese and diamonds as potential secondary minerals. Mining operations will include standard open-pit activities, such as drilling, blasting, loading, hauling, crushing, and stockpiling. Ore will not be processed on site beyond primary crushing. The ore will instead be transported to the existing Beeshoek Mine for further processing.

Infrastructure at the proposed site will comprise of two open pit mines (developed in phases), haul roads, waste rock dumps, a run-of-mine (ROM) stockpile, a screening and crushing facility, and supporting infrastructure. The latter includes container offices, meeting rooms, employee change houses, security points, a temporary equipment workshop, wash bays, a diesel depot, parking areas, and access gates.

Although the proposed activities do not currently trigger any Listed Activities under G.N. 893 of 2013, as amended, Assmang is undertaking an Atmospheric Impact Report (AIR) as part of the environmental assessment process under NEMA (Act 107 of 1998). The purpose of the AIR is to evaluate the potential impact of the proposed mining and materials handling activities on ambient air quality in the project area. It specifically considers fugitive emissions of particulate matter (PM_{10} and $PM_{2.5}$) from sources such as blasting, vehicle entrainment, crushing, material handling, and wind erosion from stockpiles.

This AIR has been prepared in accordance with Section 7.2.1 of the Code of Practice in the Regulations Regarding Air Dispersion Modelling. A compliance checklist is included in Appendix B of this report.

3. Enterprise Information

3.1. Enterprise Details

Enterprise Name	Assmang (Pty) Ltd
Trading As	Assmang (Pty) Ltd
Company/Close Corporation/Trust Registration Number (Registration Numbers if Joint Venture)	M1935/007343/07
Registered Address	24 Impala Road, Chislehurston, Gauteng, 2196
Postal Address	P.O. Box 782058, Sandton, Gauteng
Telephone Number (General)	011 779 1300
Industry Sector	Mining and beneficiation of heavy mineral sands
Land Use Zoning as per Town Planning Scheme	Agriculture
Land Use Rights if outside Town Planning Scheme	N/A

Name of Responsible Officer (ACO)	Mr. Andre Joubert
Name of Emission Control Officer (ECO)	TBC
Telephone Number	-
Cell Phone Number	079 879 4766
Email Address	christokuhl@assore.com
After Hours Contact Details	N/A

3.2. Location and Extent of Plant

Physical Address of the Plant	Assmang Makganyene Mine Site, Plot No. 667, Route 385
Description of Site (Where No Street Address)	The mining rights cover the following plots/ farms: • Remainder of Makganyene No 667 • Remainder portion of Portion 1 of Makganyene No 667. • Portion 2 (a portion of Portion 1) of Makganyene No 667; and • Portion 3 of Makganyene No 667. The crusher plant will be on the remainder of Makganyene No 667.
Coordinates of Approximate Centre of Operations	−28.14756, 22.93336
Extent (km^2)	15.19
Elevation Above Mean Sea Level (m)	1 321
Province	Northern Cape
Metropolitan/District Municipality	ZF Mgcawu District Municipality
Local Municipality	Tsantsabane Local Municipality
Designated Priority Area (if applicable)	N/A

Description of surrounding land use (within a 5 km radius)

The proposed Makganyene Iron Ore Mine is situated in an area that is currently zoned for agricultural use. The surrounding land within a 5 km radius is predominantly undeveloped and used for agricultural purposes, including grazing and dryland farming. This land use context suggests a low potential for sensitive receptors in the immediate vicinity, as the area surrounding the site consists mainly of agricultural and mining properties. The nearest urban centre is Postmasburg, located approximately 25 kilometres southeast of the proposed site.

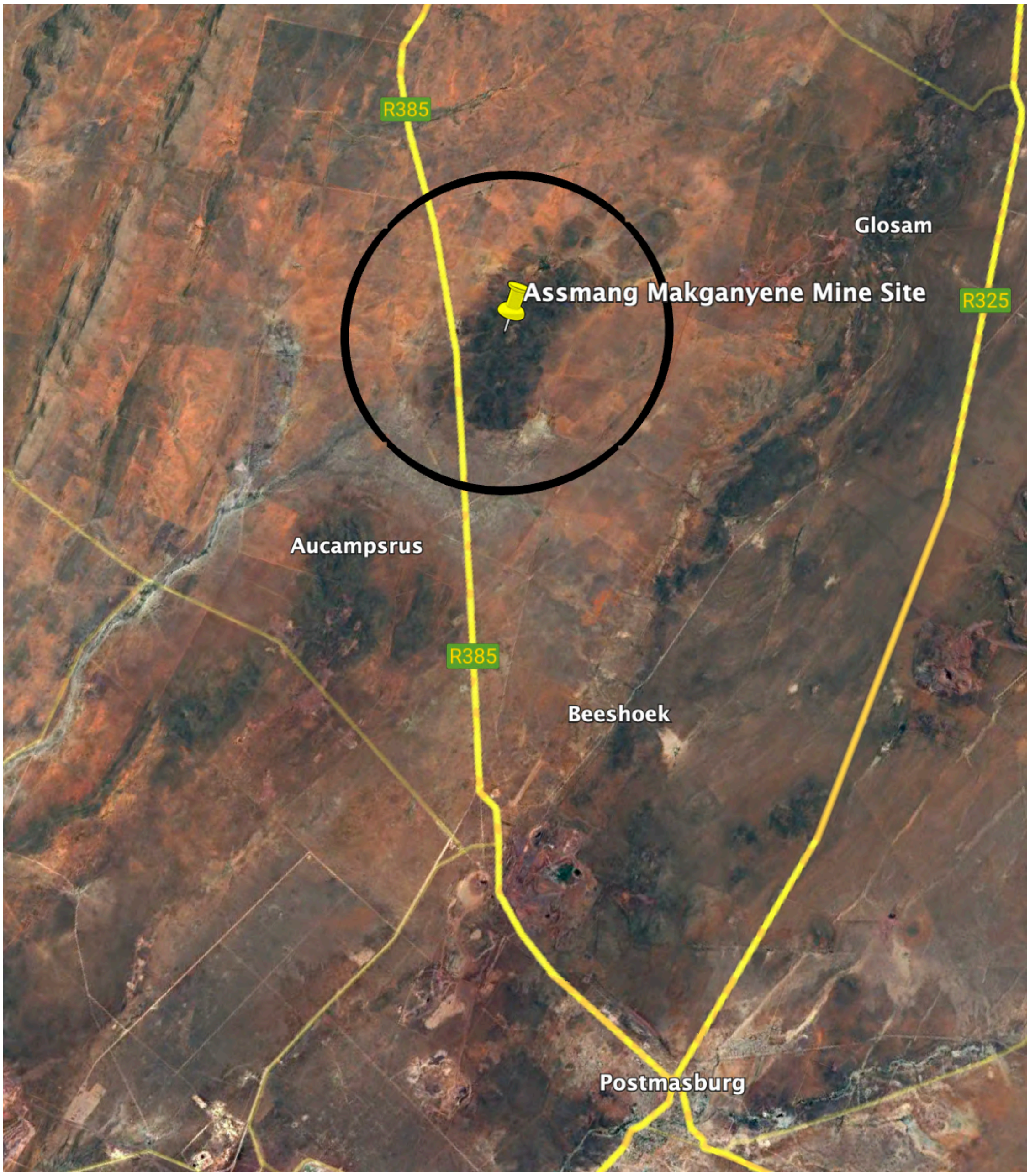

Figure 1: Map Indicating the Surrounding Land Use within a 5 km Radius of the Facility

3.3. Atmospheric Emissions Licence and Other Authorisations

Licence Type	Licence Number
Atmospheric Emissions Licence	Not Applicable[6]
Mining Right	TBC
Environmental Authorisation	TBC
Waste License	TBC

[6] An Atmospheric Emissions Licence (AEL) is not required for the proposed Makganyene mining project. The site will not include any Listed Activities under Section 21 of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) that would trigger the need for an AEL.

4. Nature of Process

4.1. Process Description

The proposed Makganyene mining site will comprise two open pit mines, a surface screening and primary crushing facility, a surface waste rock stockpile, and a surface ore stockpile.

During the operational phase, opencast mining will commence with the pre-stripping of surface material. Topsoil will be stripped and stored separately to preserve its integrity for future rehabilitation efforts. Waste rock will be excavated to expose the ore body and transported by truck to the designated waste rock stockpile. Mining will then proceed in Pits 1 and 2 using conventional open-pit methods, including drilling, blasting, and truck-and-shovel operations.

Run-of-Mine (ROM) ore extracted from Pits 1 and 2 will undergo primary screening and crushing on-site. The crushed ore will then be stockpiled on the surface ore stockpile before being transported via side tipper trucks along the R385 to the Beeshoek Mine for further processing. No mineral beneficiation beyond primary crushing will take place at the Makganyene site.

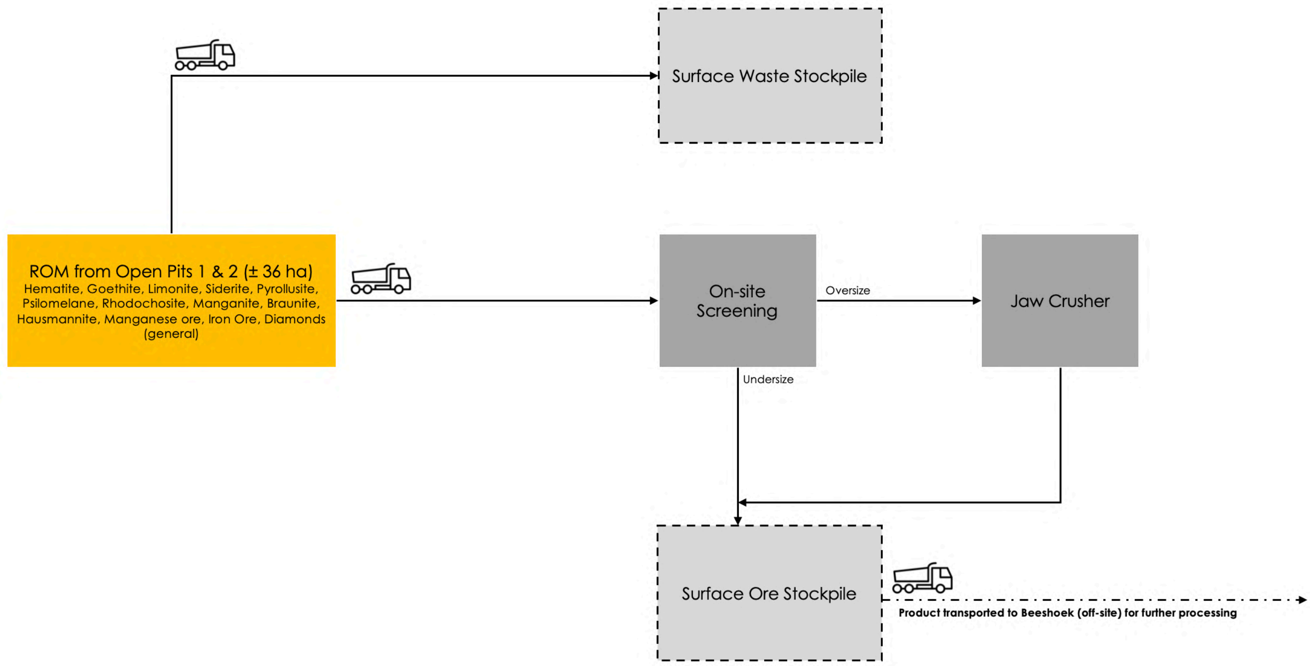

Figure 2: Process Flow Chart (Operational Phase)

4.2. Unit Processes

Unit Process	Unit Process Function	Batch/Continuous Process
Topsoil Stripping and Stockpiling	Removal and separate storage of topsoil for future rehabilitation	Batch
Waste Rock Excavation and Hauling	Excavation of waste rock to access ore and hauling to waste stockpile	Continuous
Open Pit Mining (Drilling and Blasting)	Fragmentation of rock to allow ore extraction	Batch
Truck and Shovel Operations	Transport of fragmented ore and waste within the site using trucks and excavators	Continuous
ROM Ore Screening	Separation of oversized and undersized material prior to crushing	Continuous
Primary Crushing	Size reduction of ROM ore to prepare for transport	Continuous
Crushed Ore Stockpiling	Temporary storage of crushed ore before off-site transport	Continuous
Crushed Ore Transport to Beeshoek	Road haulage of crushed ore to Beeshoek Mine for further processing	Continuous

5. Technical Information

5.1. Raw Materials Used

Raw Material Type	Maximum Production Rate (Quantity)	Units (Quantity/Period)
Iron Ore	7 076 378	Tonnes/ 38 months
Waste rock from site development	53 807 016	Tonnes/ 38 months

5.2. Production Rates

Production Name	Maximum Production Capacity Permitted (Quantity)	Units (Quantity/Period)
Crushed Ore[7]	7 076 378	Tonnes/ 38 months

5.3. Materials Used in Energy Sources

TBD

5.4. Appliances and Abatement Equipment Control Technology

No abatement control technology to be used on equipment beside dust suppression sprayers on the jaw crusher.

[7] Total ore through crusher assumed to be the same as total iron ore produced (i.e. all ore goes through crushing & screening circuit)

6. Atmospheric Emissions

6.1. Point Source Parameters

Not applicable.

6.2. Point Source Maximum Emission Rates (Normal Operating Conditions)

Not applicable

6.3. Point Source Maximum Emission Rates (Start-Up, Shut-Down, Upset and Maintenance Conditions)

Not applicable.

6.4. Emergency Incidents

None.

6.5. Fugitive Emissions (Area and/or Line Sources)

Area and/or Line Source Code	Area and/or Line Source Description	Latitude (UTM) of SW corner	Longitude (UTM) of SW corner	Height of Release above ground (m)	Area (m^2)	Emissions Hours	Type of emission (continuous/ batch)
AS1	Waste Dump	690444.26	6885174.91	0	606 000	24	Batch
AS2	Ore Stockpile	689838.09	6885324.12	0	89 400	24	Batch
AS3	Open Pit Development 1	691049.98	6886441.79	0	267 000	24	Batch
AS4	Open Pit Development 2	690127.11	6884108.58	0	85 800	24	Batch
AS5	Crushing Facility	690277.53	6885588.66	0	100	24	Batch
LS1	Trucking Route 1	690803.47	6886105.86	3.4	5 194.08	24	Batch
LS2	Trucking Route 2	690815.26	6886090.85	3.4	5 636.88	24	Batch
LS3	Trucking Route 3	690074.27	6885411.35	3.4	16 495.20	24	Batch

7. Impact of Enterprise on the Receiving Environment: Proposed Air Dispersion Model

7.1. Facility Information

7.1.1. Project Location

Proposed Project Area

Figure 3 below shows the portion of land on which the Makganyene Iron Ore Mining Site will be located.

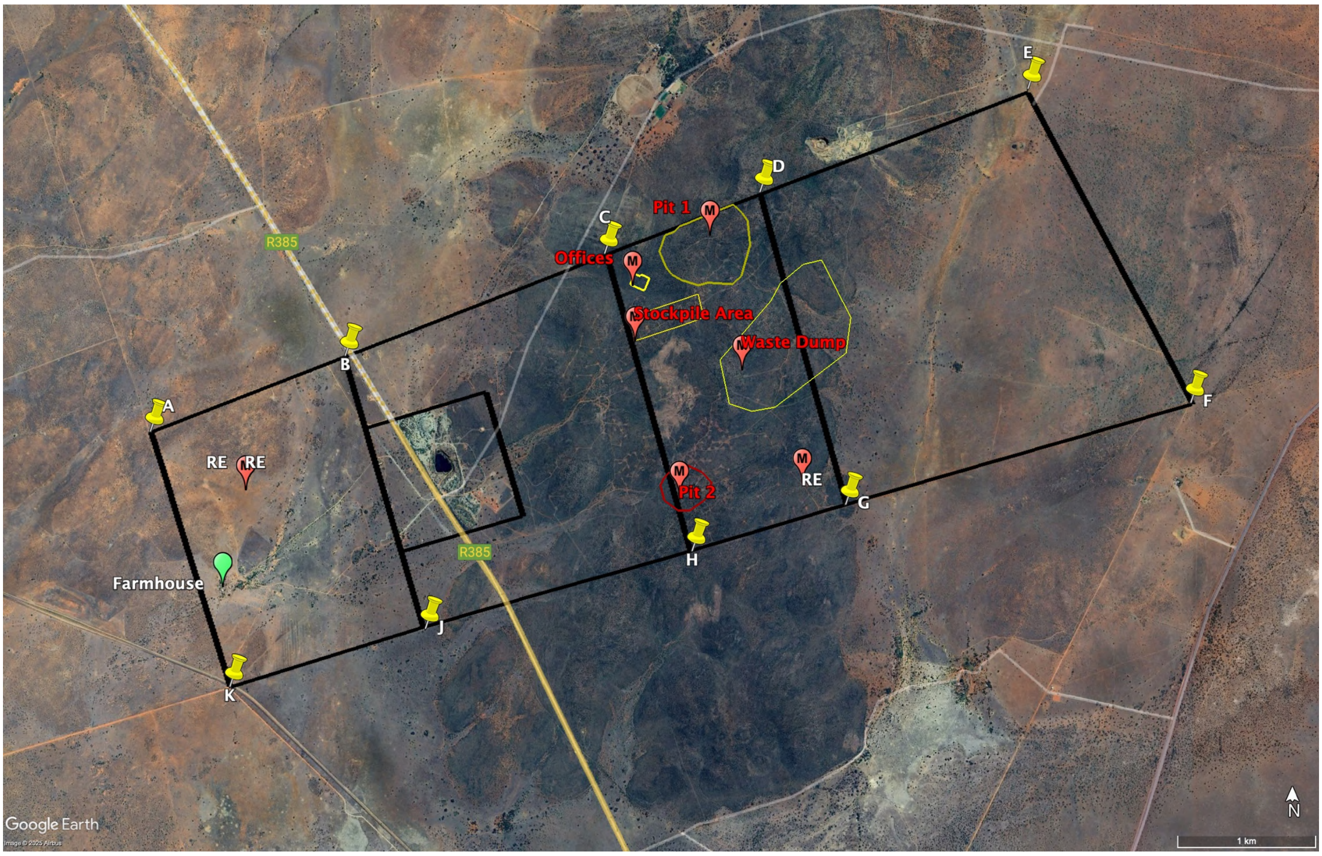

Figure 3: Satellite Map Showing the Site with all Area and Line Sources Considered in the Model

The buildings that were modelled to account for the effect of building downwash are indicated in blue in Figure 4 below.

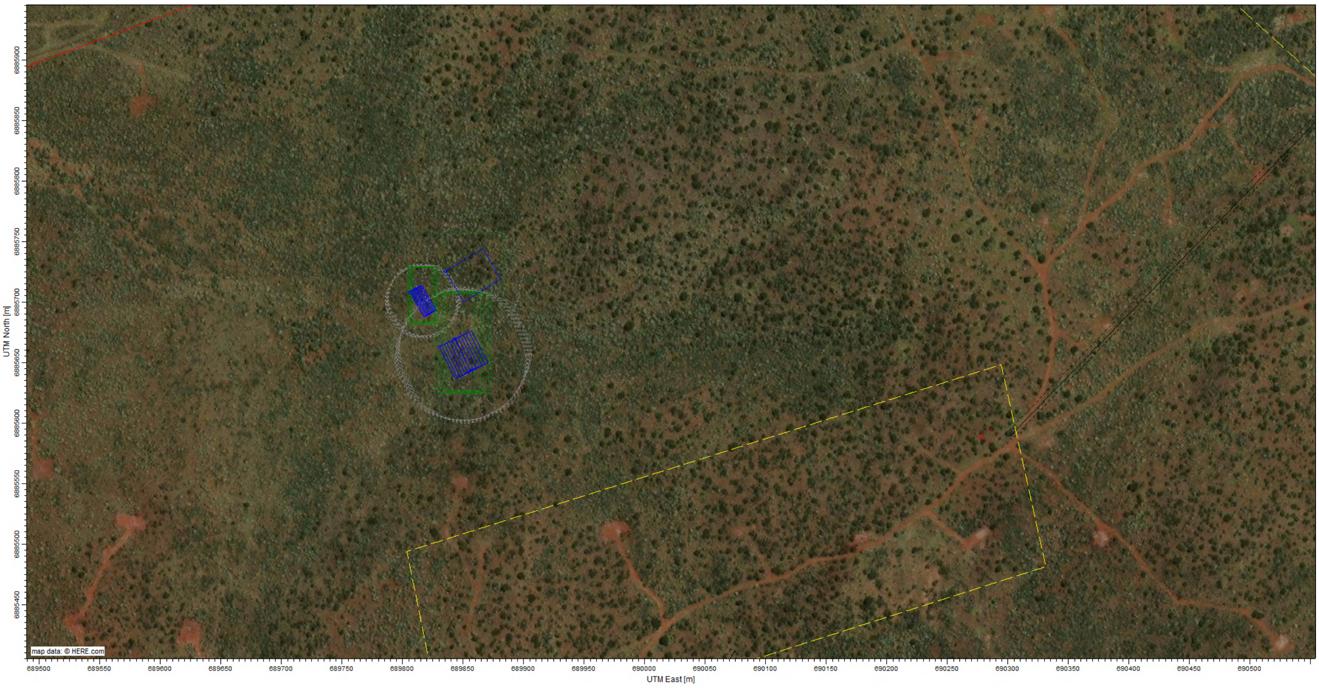

Figure 4: Buildings Modelled for Building Downwash

Area Maps

A satellite map showing the 10 km surrounding the site is presented in Figure 5, and a topographical map showing the 10 km surrounding the site is presented in Figure 6.

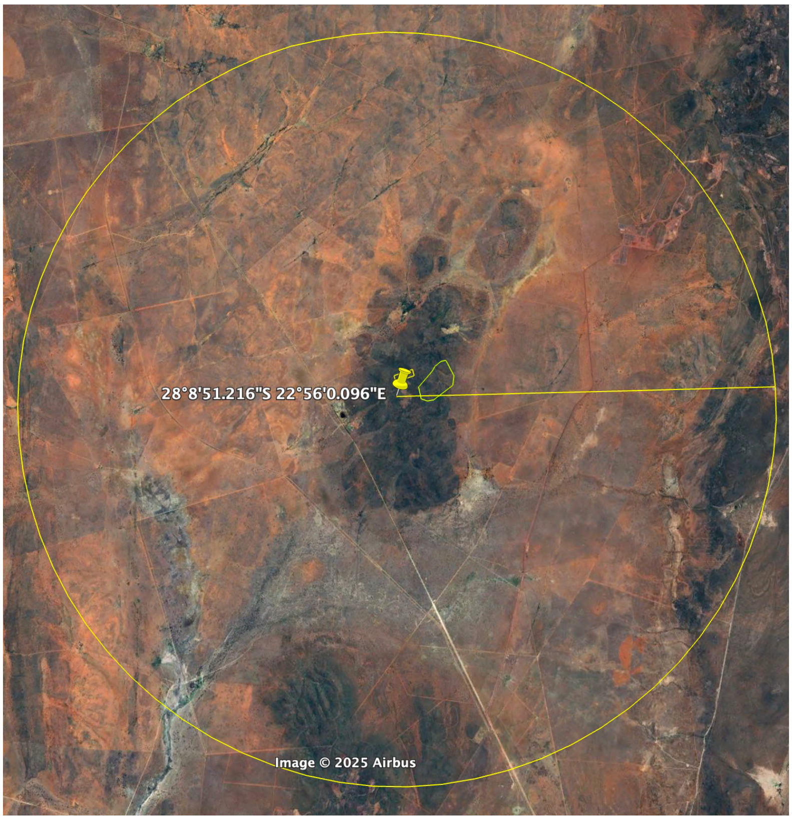

Figure 5: Satellite Map Showing the Area 10 km surrounding the Makganyene Mining Site (in Yellow)

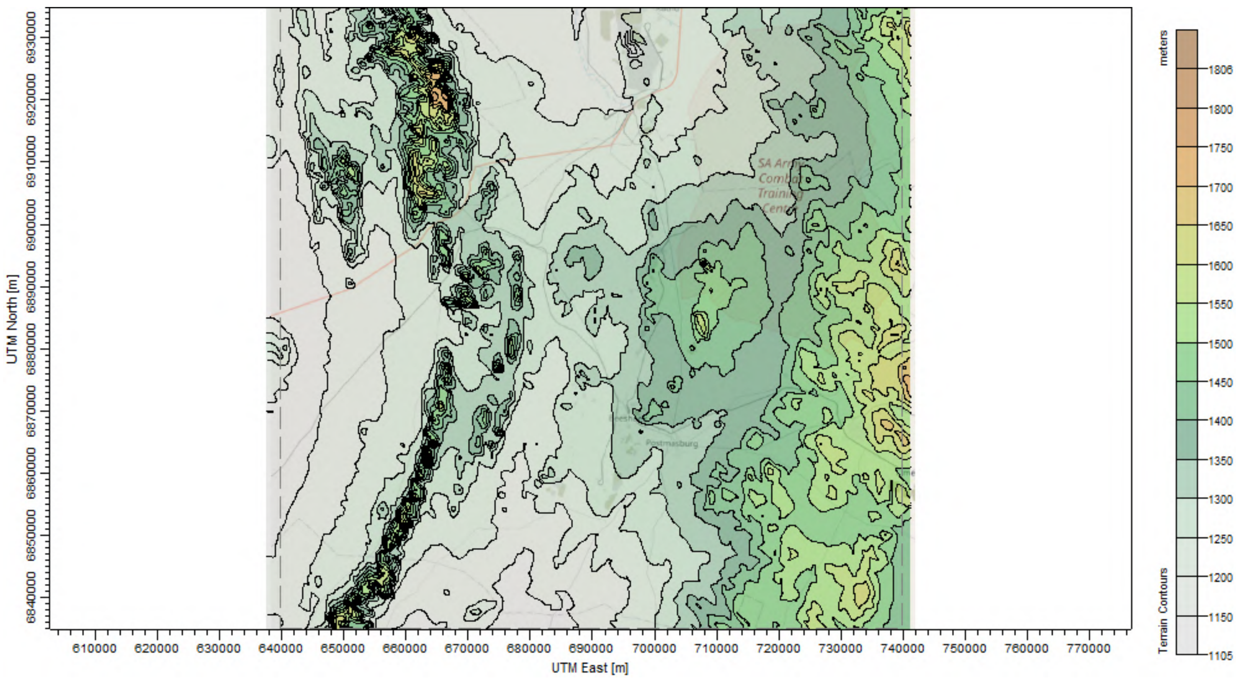

Figure 6: Topographical Map Showing the Area 10 km surrounding the Makganyene Mining Site

A street map of the 10 km surrounding the Makganyene Mining Site is shown in Figure 7 below. There are no hospitals, clinics/healthcare centres or schools in the 10 km radius surrounding the Makganyene facility, as seen in Figure 7 below.

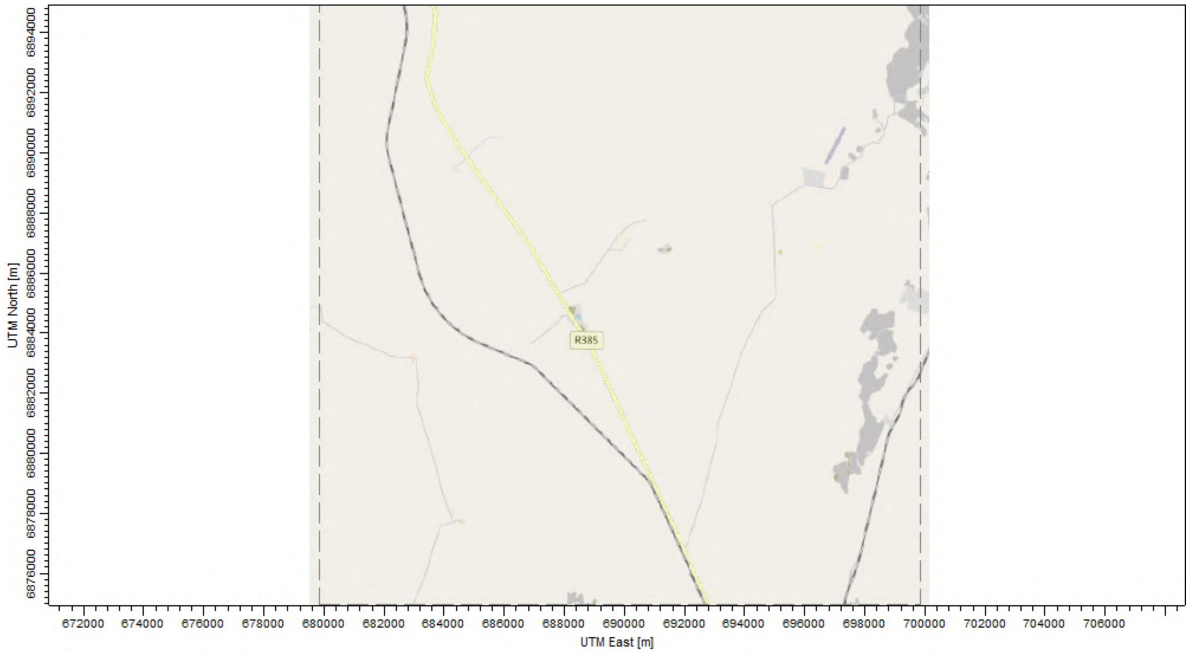

Figure 7: Street Map Showing the Area 10 km surrounding the Makganyene Mining Site

On-site meteorological data was obtained from the WRF-MMIF model, and thus, no meteorological stations have been indicated on the map.

A regional satellite map of the area 50 km from the Makganyene Mining site is shown in Figure 8 below, and a topographical map of the 50 km from the site is shown in Figure 9.

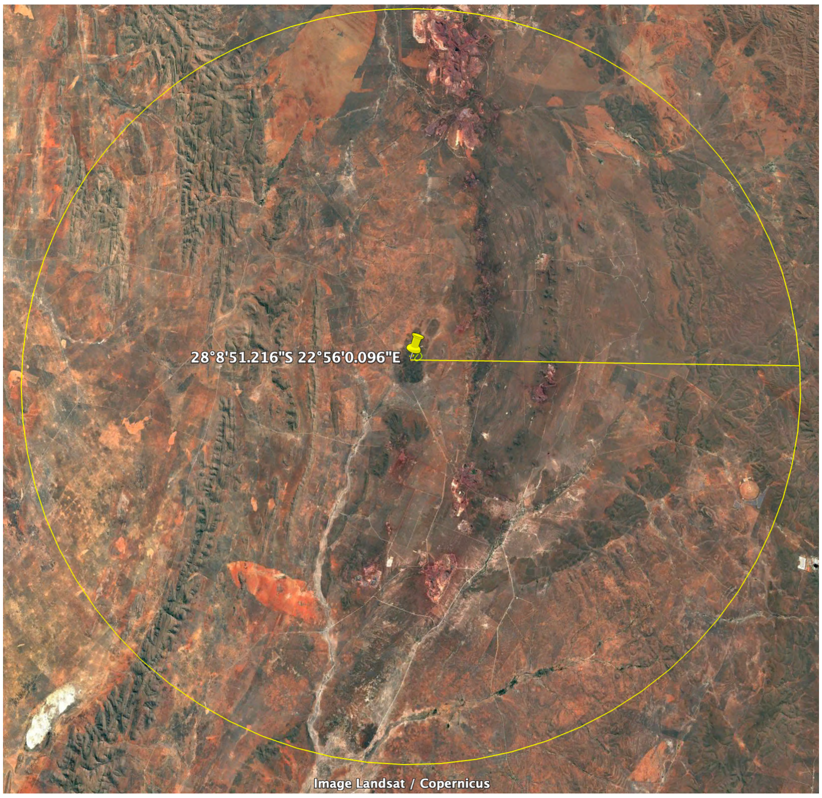

Figure 8: Satellite Map Showing the Area 50 km surrounding the Makganyene Mining Site

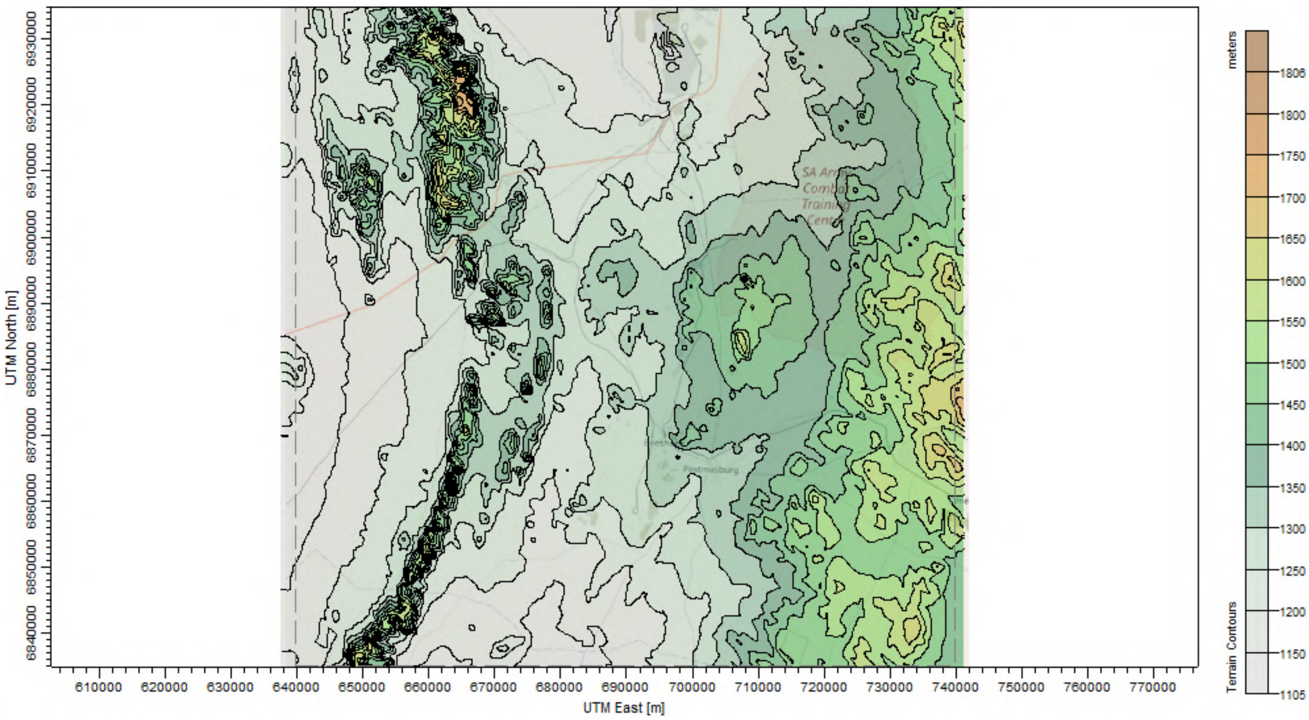

Figure 9: Topographical Map Showing the Area 50 km surrounding the Makganyene Mining Site

7.1.2. Geophysical and Elevation Data

Land use in the 3 km surrounding the site has more than 35 % vegetation coverage. Thus, the area was determined to be rural, as per Section 6.3 of the *Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa,* 2014 (referred to hereafter as the Code of Practice).[8] Shuttle Radar Topography Mission (SRTM) 1 Version 3 (30-metre resolution) elevation data was obtained from WebGIS.

[8] Contained in the Regulations Regarding Air Dispersion Modelling (G.N.R. 533 of 2014)

7.2. Emissions Characterisation: Emissions Inventory and Source Parameters

Section 3.3 of the Code of Practice states that minimum emissions standards (MESs) should be used as the basis for emissions inventories when conducting air dispersion modelling for licensing purposes. However, the Makganyene mining site is not classified as an air quality Listed Activity in terms of G.N. 893 of 2013, as amended and does not include boilers, dryers, or any unit operations that are typically subject to MESs. Therefore, the use of MESs is not applicable to this project.

Instead, the emissions inventory has been developed based on anticipated fugitive dust emissions from open pit mining activities, stockpiles, screening and primary crushing operations, and designated haul roads. These emission sources are characterised as area (e.g., for mining, crushing and stockpiles) or line sources (e.g., for haul roads) in the AERMOD dispersion model. The emission rates from the identified emission sources were estimated using standard emission factors and site-specific activity data where available.

7.2.1. Emissions from Stockpile Area Sources

Fugitive emissions from stockpile area sources are not subject to any MESs. Therefore, emission factors were used to estimate PM emissions from the stockpiles. It was assumed that no NO_x and SO_2 emissions are released from the stockpile area sources.

At the Makganyene site, fugitive PM_{10} and $PM_{2.5}$ emissions from stockpiles were estimated based on two primary mechanisms: wind erosion and material loading/drop operations.

To estimate PM emissions from wind erosion, emission factors from the *NPI Emission Estimation Technique Manual for Mining*[9] were applied. As the manual provides emission factors only for total suspended particulates (TSP) and PM_{10}, it was conservatively assumed that $PM_{2.5}$ emissions are half of PM_{10} emissions, a commonly accepted assumption in the absence of site-specific data.

Emissions from material loading and offloading were calculated using the following equation obtained from the *US EPA AP42 13.2.4 Aggregate Handling and Storage Piles:*[11]:

$$E = k\,(0.0016)\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where,

E = emissions factor (kg/tonne)

k = particle size multiplier (0.74 for PM_{30}, 0.35 for PM_{10}, 0.053 for $PM_{2.5}$)

U = average wind speed (m/s)

M = material moisture content (%)

[9] Page 12, https://cwm.unitar.org/publications/publications/cbl/prtr/pdf/cat5/Australia_mining.pdf

[11] https://www.epa.gov/sites/default/files/2020-10/documents/13.2.4_aggregate_handling_and_storage_piles.pdf

Waste Rock Surface Stockpile Area Source

Waste rock generated during the development and operational phases of Pits 1 and 2 will be deposited in the waste rock surface stockpile, as outlined in yellow in Figure 10. The total allocated area for this stockpile is approximately 606 000 m^2 (60.6 ha).

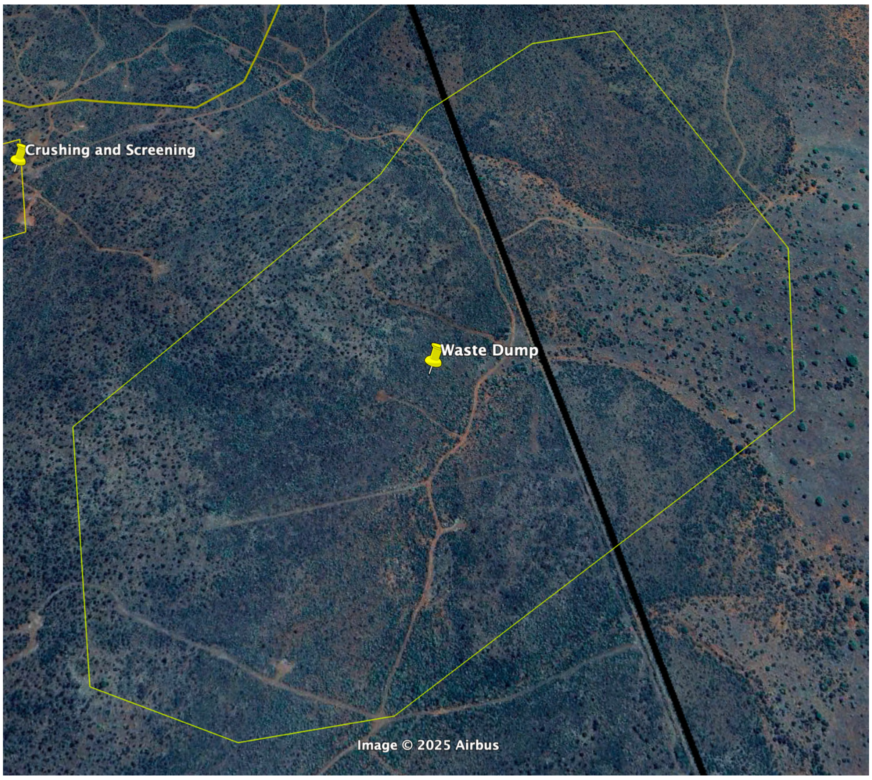

Figure 10: Waste Rock Surface Stockpile (Waste Dump) Perimeter Indicated in Yellow

Wind erosion emission rates were calculated using emission factors (kg/ha/hr) and the surface area of the stockpile. Table 1 presents the estimated emissions for PM_{10} and $PM_{2.5}$:

Table 1: Emission Rate Calculation for Waste Rock Stockpile Wind Erosion

Pollutant	Emission Factor (kg/ha/hr)	Area (ha)	Emission Rate (g/s)
PM_{10}	0.2	60.6	3.367
$PM_{2.5}$	0.1		1.683

Emissions from material loading were estimated based on the total quantity of waste rock handled each month, as provided in the anticipated production schedule. It was assumed that emissions from loading were evenly distributed over the operating time of the site. Additionally, a moisture content of 3 % was assumed for the waste rock material, which is consistent with known dry bulk handling conditions in arid mining regions of South Africa.[14] Historical monthly mean wind speeds were sourced from Weatherspark for Postmasburg, the nearest available weather station to the proposed project site.[15]

The following emissions were calculated:

Table 2: Emission Rate Calculation for Material Loading onto the Waste Rock Stockpile

Pollutant	Wind Speed (m/s)	Moisture (%)	Material Handled (tonnes/month)	Emission Rate (g/s)
PM_{10}	4.27	3.0	1 415 964.1	0.411
$PM_{2.5}$				0.0622

Total fugitive particulate emissions were calculated by summing the contributions from wind erosion and material loading, as shown in Table 3.

Table 3: Emission Rate Calculation for Total Fugitive PM Emissions from the Waste Rock Stockpile

Pollutant	Emission Rate from Wind Erosion (g/s)	Emission Rate from Loading (g/s)	Total Fugitive Emissions (g/s)
PM_{10}	3.367	0.411	3.778
$PM_{2.5}$	1.683	0.062	1.746

[14] Yang, D., Zhang, F., & Wang, J. (2024). Research and Application of High Water Content in Iron Ore. Proceedings of the 2024 6th International Conference on Civil Engineering, Environment Resources and Energy Materials (CCESEM 2024). doi: 10.2991/978-94-6463-606-2_53

[15] Wind speed data sourced from Weatherspark, based on NASA's MERRA-2 reanalysis model. MERRA-2 reconstructs global atmospheric conditions using integrated satellite and surface observations on a 50 km grid. Available at: https://weatherspark.com/y/89141/Average-Weather-in-Postmasburg-Northern-Cape-South-Africa-Year-Round

Ore Stockpile

Ore from the on-site crushing and screening facility will be transported by trucks to the ore stockpile for temporary storage prior to off-site processing. The ore stockpile area is indicated below in Figure 11 as the "stockpile area" and has an allocated surface area of 89 407 m^2 (8.94ha).

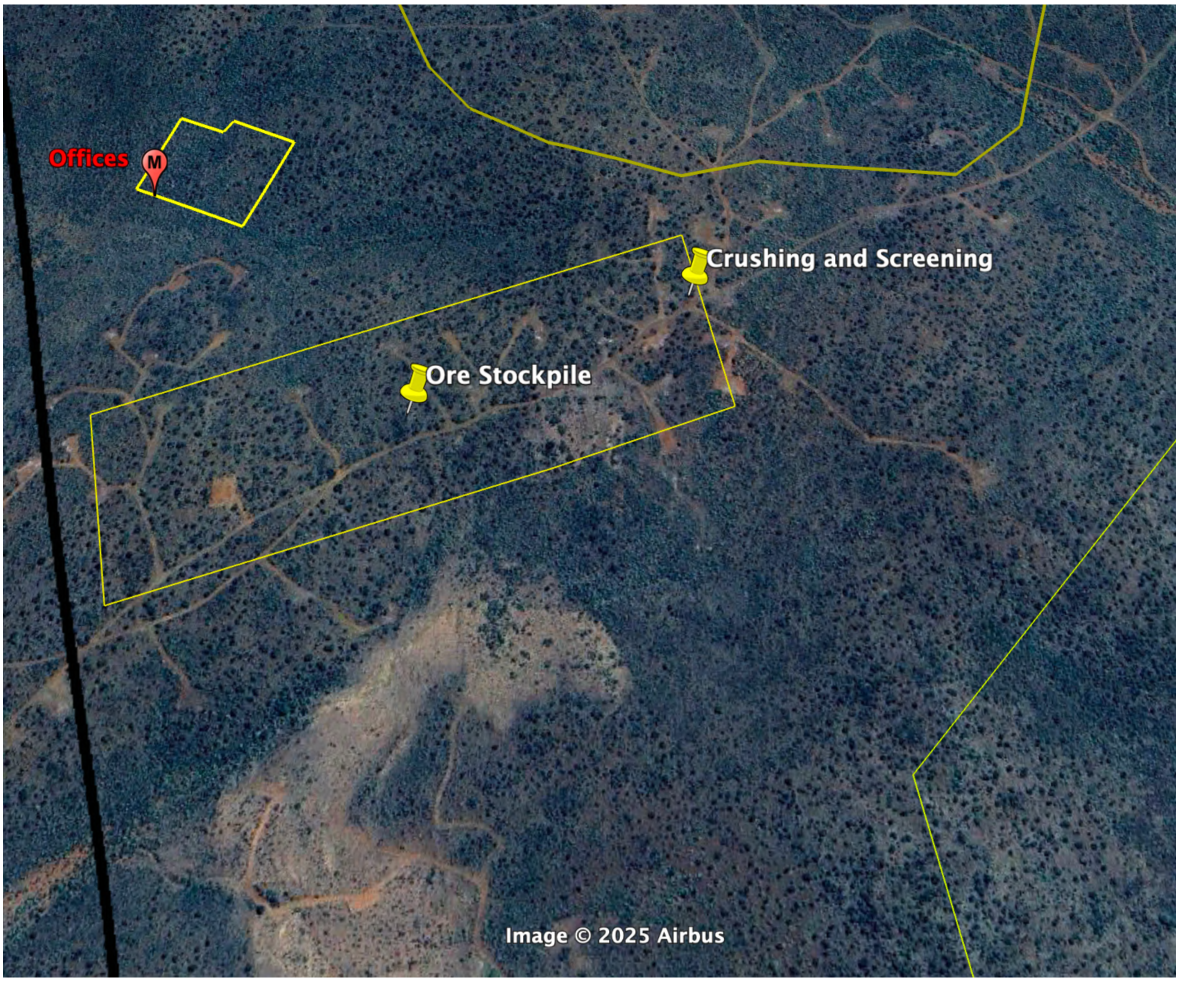

Figure 11: Ore Stockpile Perimeter Indicated in Yellow

Fugitive particulate emission rates from wind erosion were calculated using standard emission factors and are summarized in Table 4.

Table 4: Emission Rate Calculation for Ore Stockpile Wind Erosion

Pollutant	Emission Factor (kg/ha/h)	Area (ha)	Emission Rate (g/s)
PM_{10}	0.2	8.94	0.497
$PM_{2.5}$	0.1		0.248

PM emissions from the loading and unloading of ore are accounted for within the emissions factors for the crushing and screening facility, which is located within the same allocated area as outlined above in Figure 11.

7.2.2. Emissions from the Crushing and Screening Facility

In the absence of local modelling guidelines for crushing operations, PM emissions from the on-site crushing and screening facility were estimated using emission factors sourced from the *Guidance on Emission Factors for the Mining Industry*, published by the Nevada Division of Environmental Protection (NDEP) Bureau of Air Pollution Control.[16]

The applied emission factors are specific to primary crushing operations and include contributions from associated material handling activities such as loading, dumping, conveyor transfer points, and screening. These factors reflect average emission rates based on controlled and uncontrolled conditions and are widely accepted for use in regulatory and permitting contexts.

For dispersion modelling purposes, the crushing and screening circuit, the jaw crusher and its supporting equipment (conveyers, grizzly feeders, screens, structures, etc.) was represented as an area source in AERMOD.

It was assumed that all ore that is sent to the ore stockpile passes through the crushing and screening circuit. As such, emissions rates were based off the total predicted tonnes of ore to be mined at the proposed site throughout the reporting period, in accordance with the client's anticipated production schedule.

The following emissions were calculated:

Table 5: Emission Rate Calculation for Primary Crushing and Screening

Pollutant	Moisture (%)	Material Handled (tonnes/hr)	Emission Factor (g PM/tonne ore)	Emissions Rate (g/s)
PM_{10}	3.0	258.64	25	1.80
$PM_{2.5}$			3.79	0.27

The crushing and screening facility was modelled as a 5 m x 10 m area source, based on the typical area of a primary jaw crusher and supporting equipment (grizzly feeders, conveyers, and screens). A release height of 4.5 m was used, accounting for the crushers height (typically 3.5 m) and an additional 1 m to ensure a conservative estimate.

[16] Nevada Division of Environmental Protection – Bureau of Air Pollution Control (2017). *Guidance on Emission Factors for the Mining Industry*, Carson City, NV.

7.2.3. Emissions from Open Pit Mining Activities

In the absence of local modelling guidelines for particulate emissions from open-pit mining, PM emissions from Pits 1 and 2 were estimated using the standardised methodology developed by Huertas et al. (2012), which provides a structured approach for quantifying PM_{10} emissions from individual mining activities.[17] While these guidelines contain only emission factors for total suspended particulates (TSP) and PM_{10}, it was assumed that $PM_{2.5}$ emissions are half of PM_{10} emissions, which is a common assumption.

Open Pits 1 and 2 were modelled as area sources at their respective maximum allocated surface areas. The emissions inventory accounts for fugitive dust emissions from blasting, truck-based material handling, and wind erosion over the exposed pit areas.

Phase 1 Open Pit - Area Source

The fully developed surface area of Pit 1 under Phase 1 of operations is 267 000 m^2 (26.7 ha), as indicated in Figure 12.

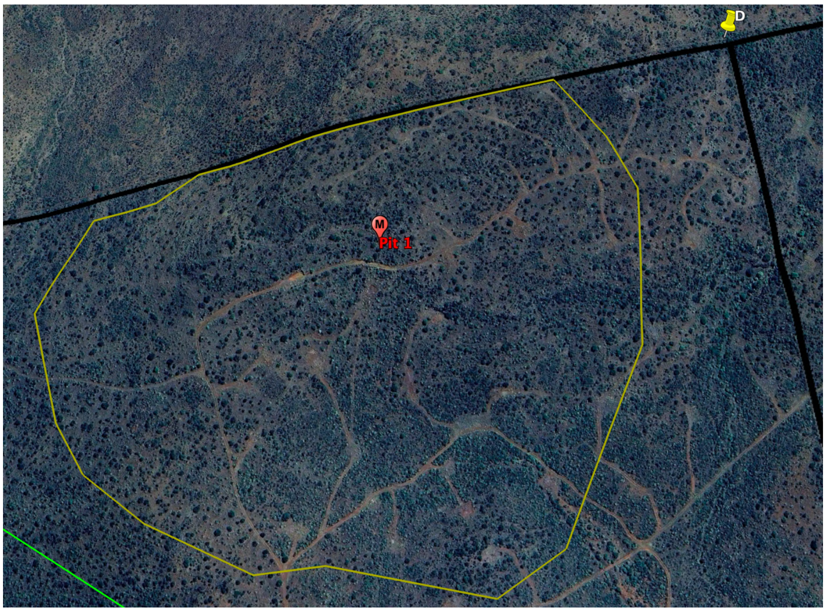

Figure 12: Phase 1 Pit Indicated in Yellow

a. Blasting Emissions

Emission factors for blasting were derived from the following equations obtained from the *US EPA AP42 Section 11.9 Western Surface Coal Mining*:[9]

$$\frac{kgPM_{10}}{blast} = 0.52(0.00022)A^{1.5}$$

$$\frac{kg\ PM_{2.5}}{blast} = 0.03(0.00022)A^{1.5}$$

[17] https://www3.epa.gov/ttn/chief/ap42/ch11/final/c11s09.pdf

Where 'A' is the blasting area (m^2) at a depth of less than 21 m. For conservatism, it was assumed that the entire allocated area of Pit 1 would be subject to blasting at a depth less than 21 m and 'A' was set to 2 025 m^2, which is the area of a standard blast in an open-pit mine.

Blasting was assumed to occur once a day on weekdays (5 days a week) over a 1 156-days reporting period, resulting in 413 blasts events per pit (i.e., half the total number of 826). The emission rate was calculated by multiplying the emission factor per blast by the blasting frequency (blasts per day) and converting to emission rates (g/s).

Table 6: Parameters and Assumptions from Blasting and Drilling in Pit 1

Parameter	Value
Drill hole Diameter	200 mm
Burden and spacing	5 m
Disturbed Area per Blast	2 025 m^2
Total number of blasting activities in reporting period (1 156 days)	413 blasts
Blasting Frequency (blasts/day)	0.357

Therefore, using the parameters provided in Table 6 and the provided equation, the following emission rates from blasting at Pit 1 were determined.

Table 7: Emission Rates for Pit 1 Blasting Activities

Pollutant	Emission Factor (kg/blast)	Blasting Frequency (blasts/day)	Emission Rate (g/s)
PM_{10}	10.42	0.357	0.0431
$PM_{2.5}$	5.212		0.0216

b. Wind Erosion Emissions

To calculate PM emissions from wind erosion, emission factors from the *NPI Emission Estimation Technique Manual for Mining*[18] were used. While this manual contains only emission factors for total suspended particulates (TSP) and PM_{10}, it was assumed that $PM_{2.5}$ emissions are half of PM_{10} emissions, which is a common assumption.

The area of the fully developed pit (26.7 ha) was used in the air dispersion model for conservatism.

[18] Page 12, https://cwm.unitar.org/publications/publications/cbl/prtr/pdf/cat5/Australia_mining.pdf

Table 8: Emission Rate Calculation for Wind Erosion Within Pit 1

Pollutant	Emission Factor (kg/ha/hr)	Area (ha)	Emission Rate (g/s)
PM_{10}	0.2	26.7	1.483
$PM_{2.5}$	0.1		0.742

Historical monthly mean wind speeds were sourced from Weatherspark for the town of Postmasburg, the nearest available weather station to the proposed project site.[19]

c. Material Handling Emissions

A moisture content of 3% was assumed for the waste rock material, consistent with typical dry bulk handling conditions in arid mining regions of South Africa.[20] It was further assumed that all oversize material processed each month was loaded onto the stockpile during that same month, and that emissions from loading activities were evenly distributed over the operating time of the facility.

The monthly quantity of waste rock handled was based on the total predicted tonnes of waste rock to be mined over the reporting period, as provided by the client in the anticipated production schedule. To estimate emissions from loading/drop operations within the boundary of Pit 1, the emission factor equation from the *US EPA AP42 13.2.4 Aggregate Handling and Storage Piles*[21] was applied.

Table 9: Emission Rate Calculation for Waste Rock Loading onto the Stockpile

Pollutant	Wind Speed (m/s)	Moisture (%)	Material Handled (tonnes/month)	Emission Rate (g/s)
PM_{10}	4.27	3.0	801 097	0.233
$PM_{2.5}$				0.0352

d. Total Fugitive Emissions from Pit 1

Total fugitive PM_{10} and $PM_{2.5}$ emissions from Pit 1 were calculated by summing the emission rates from blasting and drilling (Table 7), wind erosion (Table 8) and material handling (Table 9).

Table 10: Emission Rate Calculation for Total Fugitive PM Emissions from Pit 1

Pollutant	Emission Rate from Blasting and Drilling (g/s)	Emission Rate from Wind Erosion (g/s)	Emission Rate from Loading (g/s)	Total Fugitive Emissions (g/s)
PM_{10}	0.0431	1.48	0.233	1.76
$PM_{2.5}$	0.0216	0.742	0.0352	0.798

[19] Wind speed data sourced from Weatherspark, based on NASA's MERRA-2 reanalysis model. MERRA-2 reconstructs global atmospheric conditions using integrated satellite and surface observations on a 50 km grid. Available at: https://weatherspark.com/y/89141/Average-Weather-in-Postmasburg-Northern-Cape-South-Africa-Year-Round

[20] Yang, D., Zhang, F., & Wang, J. (2024). Research and Application of High Water Content in Iron Ore. Proceedings of the 2024 6th International Conference on Civil Engineering, Environment Resources and Energy Materials (CCESEM 2024). doi: 10.2991/978-94-6463-606-2_53

[21] https://www.epa.gov/sites/default/files/2020-10/documents/13.2.4_aggregate_handling_and_storage_piles.pdf

Phase 2 Open Pit Area Source

The open pit area source under phase 2 of operations will have a final surface area of 85 800 m^2 (8.58 ha) and is outlined in Figure 13 below.

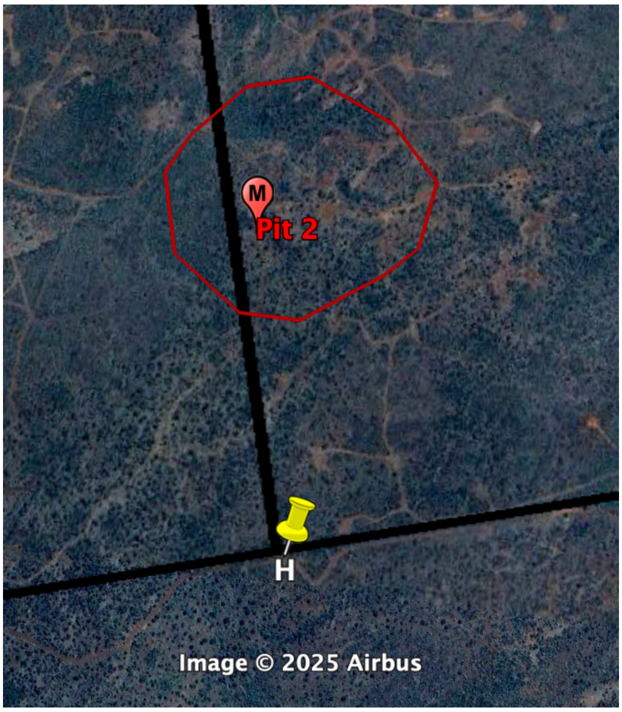

Figure 13: Phase 2 Pit Indicated in Red

a. Blasting Emissions

The same methodology that was used to determine the emissions from blasting at Pit 1 was applied to Pit 2, and the following emission rates were calculated.

Table 11: Emission Rates for Pit 2 Blasting Activities

Pollutant	Emission Factor (kg/blast)	Blasting Frequency (blasts/day)	Emission Rate (g/s)
PM_{10}	10.42	0.357	0.0431
$PM_{2.5}$	5.212		0.0216

b. Wind Erosion Emissions

To calculate PM emissions from wind erosion, emission factors from the *NPI Emission Estimation Technique Manual for Mining*[22] were once again used.

The area of the fully developed pit (8.58 ha) was used in the air dispersion model for conservatism.

Table 12: Emission Rate Calculation for Wind Erosion Within Pit 2

Pollutant	Emission Factor (kg/ha/hr)	Area (ha)	Emission Rate (g/s)
PM_{10}	0.2	8.58	0.477
$PM_{2.5}$	0.1		0.238

Historical monthly mean wind speeds were sourced from Weatherspark for the town of Postmasburg, the nearest available weather station to the proposed project site.

c. Material Handling Emissions

The same methodology and assumptions that were used to estimate the emissions from material handling at Pit 1 was applied to Pit 2, and the following emission rates were calculated:

Table 13: Emission Rate Calculation for Waste Rock Loading onto the Stockpile

Pollutant	Wind Speed (m/s)	Moisture (%)	Material Handled (tonnes/month)	Emission Rate (g/s)
PM_{10}	4.27	3.0	801 097	0.233
$PM_{2.5}$				0.0352

d. Total Fugitive Emissions from Pit 2

Total fugitive PM_{10} and $PM_{2.5}$ emissions from Pit 2 were calculated by summing the emission rates from blasting and drilling (Table 11), wind erosion (Table 12) and material handling (Table 13).

Table 14: Emission Rate Calculation for Total Fugitive PM Emissions from Pit 2

Pollutant	Emission Rate from Blasting and Drilling (g/s)	Emission Rate from Wind Erosion (g/s)	Emission Rate from Loading (g/s)	Total Fugitive Emissions (g/s)
PM_{10}	0.0431	0.477	0.233	0.752
$PM_{2.5}$	0.0216	0.238	0.0352	0.295

[22] Page 12, https://cwm.unitar.org/publications/publications/cbl/prtr/pdf/cat5/Australia_mining.pdf

7.2.4. Fugitive Dust from Trucks

Trucks travelling on-site, including the transport of ore, waste rock, and crushed material, have the potential to generate fugitive dust through re-entrainment of particles on unpaved roads. To estimate these emissions, key transport routes were identified and modelled as line sources in AERMOD.

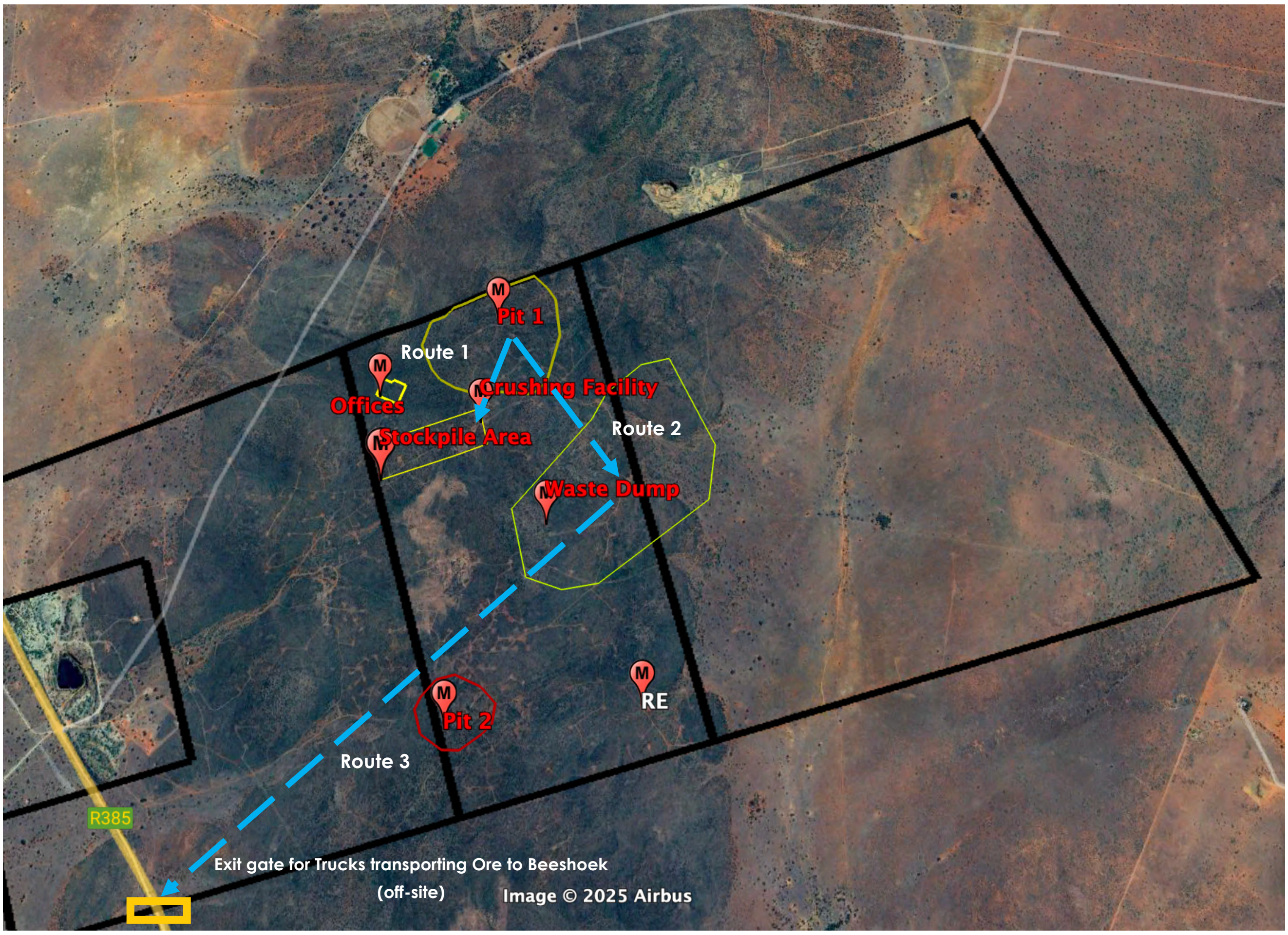

Figure 14: Predicted Truck Transport Routes at Makganyene Mine

Based on the site layout, the following three transport routes were included in the dispersion modelling:

- **Route 1 (LS1):** Transport of ore from the open pits to the crushing and screening facility/ ore stockpile.
- **Route 2 (LS2):** Transport of waste rock from the open pits to the waste rock stockpile
- **Route 3 (LS3):** Transport of crushed ore from the ore stockpile to the main gate (assumed to connect to the R385 at the southern boundary for off-site transport to the Beeshoek Mine)

In the absence of local modelling guidelines, the *Santa Barbara County Modelling Guidelines for Air Quality Impact Assessments (2025)* were consulted. These guidelines recommend modelling unpaved roadways as line sources, which is consistent with the US EPA guidance for modelling emissions from unpaved roads.

Fugitive dust emissions factors from unpaved roads were calculated using the following equation from the *US EPA AP-42 Section 13.2.2: Unpaved Roads*:

$$EF_i = k * \left(\frac{s}{12}\right)^a * \left(\frac{W}{2.72}\right)^b$$

Where:

- EF_i: Emissions factor for pollutant i (kg/VKT)
- S: Surface silt content (%). Assumed to be 6 %
- W: Average vehicle mass (metric tonnes). Assumed to be 36 tonnes (as per client specifications)
- k, a, and b: Empirical constants (Table 15)

Table 15: Constants Used in Emissions Factor Equation

Pollutant	k (g/VKT)	a	b
PM_{10}	422.85	0.9	0.45
$PM_{2.5}$	42.285	0.9	0.45

To incorporate the effects of precipitation and control measures (e.g. watering or chemical suppressants), emissions were adjusted using the following equation:

$$E_i = VKT * EF_i * \left(\frac{365 - P}{365}\right) * \left(1 - \frac{CE}{100}\right)$$

Where:

- E_i: Daily emissions of pollutant i (kg)
- VKT: Vehicle kilometres travelled per day
- P: Annual precipitation days exceeding 0.2 mm of rainfall per year, or snow and frozen days. Assumed to be 89.3 days (based on MeteoBlue weather service data for Potmasburg)
- CE: Control efficiency of the dust suppression method(s) (%)

Table 16: Dust Control Methods and Efficiencies (USEPA, 2006; WRAP, 2004; MRI, 2001)

Dust Control Activity	Control Efficiency
Watering twice per day	55 %
Watering more than twice a day	70 %
Chemical suppressants	80 %

Representatives from Assmang confirmed that all internal roads would be sprayed twice a day using water trucks. Accordingly, a control efficiency of 55 % was applied to LS1 and LS2. Furthermore, the use of chemical suppressants on LS3 was proposed, and a control efficiency of 80 % was applied.

Daily vehicle kilometres travelled (VKT) was calculated based on monthly haulage requirements, truck capacity (36 tonne) and trip frequency. For example, the daily VKT for Route 1 was calculated as follows:

$$VKT_{LS1} = \frac{0.7214\ km}{vehicle} \cdot 2\ trips \cdot roundup\left(\frac{186\ 220.47\ tonnes\ haulage\ per\ month}{36\ tonnes\ per\ truck} \cdot \frac{1}{30\ days\ per\ month}\right)$$

$$= 248.9\ total\ km\ per\ day$$

Since the transport routes remain unchanged across both scenarios, the same distances were applied in both Scenarios 1 and 2. Additionally, the emissions from Pit 2 were not modelled separately, as only one pit is assumed to be operational at any given time. It was therefore assumed that the transport distances from Pit 2 to the waste rock and ore stockpiles are equivalent to those from Pit 1. Further, all line sources were modelled with a 7.2 m road width and a release height if 3.4 m, representative of emissions from heavy-duty trucks.

The calculated fugitive emissions used in Scenarios 1 and 2 are summarised in Table 17 and Table 18, respectively.

Table 17: Estimated Fugitive PM Emissions from On-Site Trucking - Scenario 1

Line Source Modelled	One Way Distance (km)	Control Efficiency (%)	Pollutant	Haulage (tonne per year)	Distance Travelled (km/day)	Emissions (g/s)
Line Source 1	0.72	55	PM_{10}	186 220.47	248.88	0.679
			$PM_{2.5}$			0.0679
Line Source 2	0.78	55	PM_{10}	1 415 974.11	2 052.92	5.599
			$PM_{2.5}$			0.560
Line Source 3	2.29	80	PM_{10}	186 220.47	790.40	0.958
			$PM_{2.5}$			0.0958

For Scenario 2, chemical suppressants were also assumed for Route 2 to reduce the high emissions observed in Scenario 1.

Table 18: Estimated Fugitive PM Emissions from On-Site Trucking - Scenario 2

Line Source Modelled	One Way Distance (km)	Control Efficiency (%)	Pollutant	Haulage (tonne per year)	Distance Travelled (km/day)	Emissions (g/s)
Line Source 1	0.72	55	PM_{10}	186 220.47	248.88	0.679
			$PM_{2.5}$			0.0679
Line Source 2	0.78	80	PM_{10}	1 415 974.11	2 052.92	2.488
			$PM_{2.5}$			0.2488
Line Source 3	2.29	80	PM_{10}	186 220.47	790.40	0.958
			$PM_{2.5}$			0.0958

7.2.5 Dust Mitigation Control Efficiencies for Area Sources

To assess the effect of implementing dust control measures at the proposed Makganyene mining site, control efficiencies were sourced from the *WRAP Fugitive Dust Handbook*.[28] This handbook is a recognised reference for estimating emissions reductions from various fugitive dust sources in mining and industrial operations.

Table 19 summarises the selected dust control measures and associated PM_{10} control efficiencies. Due to limited data availability, the same control efficiencies were conservatively applied to $PM_{2.5}$ emissions.

Table 19: Control Measures and Associated PM_{10} Emission Reductions (WRAP, 2006)

Control Measure	PM_{10} Emissions Control Efficiency (%)
Watering of stockpiles and covering during wind events	90
Three-sided enclosures built around stockpiles with 50 % porosity	75
Application of chemical suppressants to exposed surfaces	84
Gravel cover over exposed areas	84

In Scenario 2, a 75 % control efficiency was applied to the area sources, including the waste rock stockpile, ore stockpile and the open pits (Pits 1 and 2), to simulate the effect of installing three-sided enclosures for wind protection. The emissions rates calculated after applying the relevant control efficiencies in Scenario 2 are summarised in Section 7.5.2.

7.3. Meteorological Data

Pre-processed on-site and upper air WRF-MMIF meteorological data for a period of three full calendar years (2022, 2023, and 2024) was purchased from Lakes Environmental. The WRF model is recommended for use in the Code of Practice. The base station elevation is 1 286.47 metres. The data was pre-processed using AERMET View Version 22112. No missing hours or calm periods were noted.

[28] WRAP. 2006. *Fugitive Dust Handbook*. Western Regional Air Partnership (WRAP), prepared by ENVIRON International Corporation. Available at: https://www.env.nm.gov/wp-content/uploads/sites/2/2017/02/WRAP_FDHandbook_Rev_06.pdf

7.4. Ambient Impact Analysis

7.4.1. National Ambient Air Quality Standards

South Africa's National Ambient Air Quality Standards were promulgated in G.N. 1210 of 2009, with further standards for $PM_{2.5}$ promulgated in G.N. 486 of 2012. The following standards are applicable to PM_{10} and $PM_{2.5}$:

Table 20: PM_{10} NAAQS

Averaging Period	Concentration (µg/m³)	Frequency of Exceedance	Compliance Date
24 hours	120	4	Immediate – 31 December 2014
	75	4	1 January 2015
1 year	50	0	Immediate – 31 December 2014
	40	0	1 January 2015
The reference method for the determination of the particulate matter fraction of suspended particulate matter shall be EN 12341			

Table 21: $PM_{2.5}$ NAAQS

Averaging Period	Concentration (µg/m³)	Frequency of Exceedance	Compliance Date
24 hours	65	4	Immediate – 31 December 2015
	40	4	1 January 2016 – 31 December 2029
	25	4	1 January 2030
1 year	25	0	Immediate – 31 December 2015
	20	0	1 January 2016 – 31 December 2029
	15	0	1 January 2030
The reference method for the determination of $PM_{2.5}$ fraction of suspended particulate matter shall be EN 14907			

For PM_{10} and $PM_{2.5}$, daily average and annual average standards are specified. 4 exceedances of the daily average standard are permitted in each calendar year.

7.4.2. Background Concentrations

Ambient air quality monitoring data was sourced from the South African Air Quality Information System (SAAQIS). Table 22 below shows the nearest monitoring station from which data could be sourced and the distance between the station and the proposed site.

Table 22: Ambient Air Quality Monitoring Stations

Station	Distance and Direction from Makganyene	Parameters Monitored
Kanana-NAQI	392 km NNE	PM_{10}, $PM_{2.5}$

Given the substantial distance (approximately 392 km) between the Kanana-NAQI station and the proposed project site, as well as differences in environmental context and land use, the monitoring data from this station is not considered representative of ambient conditions at the Makganyene site. As such, background concentrations have not been included in the dispersion modelling assessment, and only non-cumulative results are reported as part of the results for both scenarios.

This is consistent with the guidance provided in the *National Framework for Air Quality Management in the Republic of South Africa*, which states that background concentrations should be included "where representative data are available,"[29] and the *Guideline for Air Dispersion Modelling* (2012), which emphasises the use of representative and locally relevant background data in air quality assessments.[30]

The air dispersion modelling results for this assessment thus reflect the incremental impact of emissions from the identified activities at the proposed site, without distortion from unrelated baseline data.

[29] Department of Forestry, Fisheries and the Environment (DFFE). 2018. *National Framework for Air Quality Management in the Republic of South Africa – 3rd Edition*. Government Gazette No. 42883, Notice 1335 of 2019. Section 5.2.2.

[30] Department of Forestry, Fisheries and the Environment (DFFE). 2012. *Guideline for Air Dispersion Modelling*. Government Gazette No. 35981, Notice 1035 of 2012. Section 6.5.1.

7.5. Modelling Procedure

7.5.1. Model Used

Based on Section 2.1.2 of the Code Practice, a Level 2 assessment was used, and the AERMOD model was chosen. The model was conducted using the AERMOD View Version 11.01.1 interface and AERMET View Version 11.0.1 pre-processor.

An elevated terrain height setting was chosen as the default setting for AERMOD. Surface characteristics in the pre-processed meteorological data were obtained from an MMIF-generated AERSURFACE output file.

7.5.2. Modelled Emissions

Two dispersion modelling scenarios were developed for the proposed Makganyene mining site to assess the potential impact of particulate matter (PM_{10} and $PM_{2.5}$) emissions on ambient air quality.

In accordance with the Code of Practice, if the results that are predicted by the air dispersion model that uses MES emission rates exceed the NAAQS, then the facility's design should be reviewed. The facility's design includes that of the abatement equipment, as seen in the excerpt in Figure 15 below.

> local sources and regional background. If the sum of background and predicted concentrations are (C_B + C_P) is more than the NAAQS, the applicant must review the design of the facility (including pollution control equipment) to ensure compliance with NAAQS. Compliance assessments must

Figure 15: Excerpt from the *Regulations Code of Practice*

1. **Scenario 1 – Baseline Emissions with Proposed Dust Mitigation Measures:**

   This scenario represents a conservative baseline case in which only the dust control measures proposed by the client are modelled. These include:

   - Spraying water on all haul roads twice per day
   - Application of a chemical dust suppressant on Route 3 (the haul road to the main gate).

   The relevant control efficiencies were applied to the identified line sources, as outlined in Section 7.2.4. Emissions were estimated for all major dust-generating activities, including open pit operations, haul roads, screening, crushing, and wind erosion from stockpiles and waste dumps.

   This scenario provides a worst-case estimate of potential air quality impacts based on the current dust mitigation measures to be used on site.

2. **Scenario 2 – Enhanced Dust Mitigation Measures:**

   This scenario evaluates the potential reduction in emissions that could be achieved through the implementation of additional dust control measures beyond those included in Scenario 1. These enhancements include:

- Installation of windbreaks or three-sided enclosures around the ore stockpile, waste rock dump and open pits to reduce wind-blown dust, with associated control efficiencies sourced from the *WRAP Fugitive Dust Handbook.*[31]
- Application of a chemical dust suppressant in addition to water spraying on Route 2, in response to the high PM emissions predicted in Scenario 1 for this route.

The control efficiencies applied to the relevant line and area sources in this scenario are given in Table 16 and Table 19, respectively.

The purpose of modelling both scenarios is to compare the expected air quality impacts under unmitigated and mitigated conditions and to support informed decision-making regarding dust control strategies at the site.

[31] WRAP. 2006. *Fugitive Dust Handbook*. Western Regional Air Partnership (WRAP), prepared by ENVIRON International Corporation. Available at: https://www.env.nm.gov/wp-content/uploads/sites/2/2017/02/WRAP_FDHandbook_Rev_06.pdf

Scenario 1: Unmitigated Stockpile Emissions:

The following emission rates were modelled for the identified area and line sources at the proposed site:

Source ID	Source Description	Source Type	Source Location	Source Parameters	Pollutant	Emission Rate (g/s)
AS1	Waste Dump	Area POLY	X: 690444.26 Y: 6885174.91	Base Elevation: 1 350.91 m Release Height: 0 m Area: 606 000 m²	PM_{10} $PM_{2.5}$	3.778 1.746
AS2	Ore Stockpile	Area POLY	X: 689838.09 Y: 6885324.12	Base Elevation: 1 329.34 m Release Height: 0 m Area: 89 400 m²	PM_{10} $PM_{2.5}$	0.497 0.248
AS3	Open Pit 1	Area POLY	X: 691049.98 Y: 6886441.79	Base Elevation: 1 363.06 m Release Height: 0 m Area: 267 000 m²	PM_{10} $PM_{2.5}$	1.759 0.798
AS4	Open Pit 2	Area POLY	X: 690127.11 Y: 6884108.58	Base Elevation: 1 335.11 m Release Height: 0 m Area: 85 800 m²	PM_{10} $PM_{2.5}$	0.752 0.295
AS5	Crushing Facility	Area	X: 690277.53 Y: 6885588.66	Base Elevation: 1347.84 m Release Height: 0 m Area: 100 m²	PM_{10} $PM_{2.5}$	1.796 0.272
LS1	Route 1	Line	X: 690803.47 Y: 6886105.86	Base Elevation: 1 350.03 m Release Height: 3.4 m Length: 721.4 m Width: 7.2 m	PM_{10} $PM_{2.5}$	0.679 0.0679
LS2	Route 2	Line	X: 690815.26 Y: 6886090.85	Base Elevation: 1 350.03 m Release Height: 3.4 m Length: 782.9 m Width: 7.2 m	PM_{10} $PM_{2.5}$	5.599 0.560
LS3	Route 3	Line	X: 690074.27 Y: 6885411.35	Base Elevation: 1 350.03 m Release Height: 3.4 m Length: 2 291 m Width: 7.2 m	PM_{10} $PM_{2.5}$	0.958 0.0958

Scenario 2: Proposed Dust Mitigation for Stockpiles:

The following emission rates were modelled for the identified area and line sources at the proposed site:

Source ID	Source Description	Source Type	Source Location	Source Parameters	Pollutant	Emission Rate (g/s)
AS1	Waste Dump	Area POLY	X: 690444.26 Y: 6885174.91	Base Elevation: 1 350.91 m Release Height: 0 m Area: 606 000 m^2	PM_{10} $PM_{2.5}$	0.944 0.436
AS2	Ore Stockpile	Area POLY	X: 689838.09 Y: 6885324.12	Base Elevation: 1 329.34 m Release Height: 0 m Area: 89 400 m^2	PM_{10} $PM_{2.5}$	0.124 0.0621
AS3	Open Pit 1	Area POLY	X: 691049.98 Y: 6886441.79	Base Elevation: 1 363.06 m Release Height: 0 m Area: 267 000 m^2	PM_{10} $PM_{2.5}$	0.440 0.200
AS4	Open Pit 2	Area POLY	X: 690127.11 Y: 6884108.58	Base Elevation: 1 335.11 m Release Height: 0 m Area: 85 800 m^2	PM_{10} $PM_{2.5}$	0.188 0.0738
AS5	Crushing Facility	Area	X: 690277.53 Y: 6885588.66	Base Elevation: 1347.84 m Release Height: 0 m Area: 100 m^2	PM_{10} $PM_{2.5}$	1.796 0.272
LS1	Route 1	Line	X: 690803.47 Y: 6886105.86	Base Elevation: 1 350.03 m Release Height: 3.4 m Length: 721.4 m Width: 7.2 m	PM_{10} $PM_{2.5}$	0.679 0.0679
LS2	Route 2	Line	X: 690815.26 Y: 6886090.85	Base Elevation: 1 350.03 m Release Height: 3.4 m Length: 782.9 m Width: 7.2 m	PM_{10} $PM_{2.5}$	2.488 0.249
LS3	Route 3	Line	X: 690074.27 Y: 6885411.35	Base Elevation: 1 350.03 m Release Height: 3.4 m Length: 2 291 m Width: 7.2 m	PM_{10} $PM_{2.5}$	0.958 0.0958

7.5.3. Receptors

Two sets of receptors were used in this model:

1. A cartesian plant boundary (indicated in red on the following maps). Intermediate receptors were placed at 50-metre intervals along the boundary of the site (indicated by green markers). The plant boundary essentially acts as a set of receptors for the surrounding land users and members of the public. The maximum concentrations at and close to the plant boundary were assessed.
2. A uniform cartesian grid with 50-metre spacing up to 10 km from the site (shown by the blue markers and is the area of maximum impact) and 100-metre spacing beyond this (indicated by the grey grid).

Sensitive receptors are usually placed in areas where the occupants are more susceptible to the adverse effects of exposure to air pollutants. Sensitive receptors often include, but are not limited to, hospitals, schools, daycare facilities, and elderly housing. In this study, no sensitive receptors were placed, as the surrounding land use is limited to agricultural and mining activities, and there are no known sensitive land uses within the vicinity of the site.

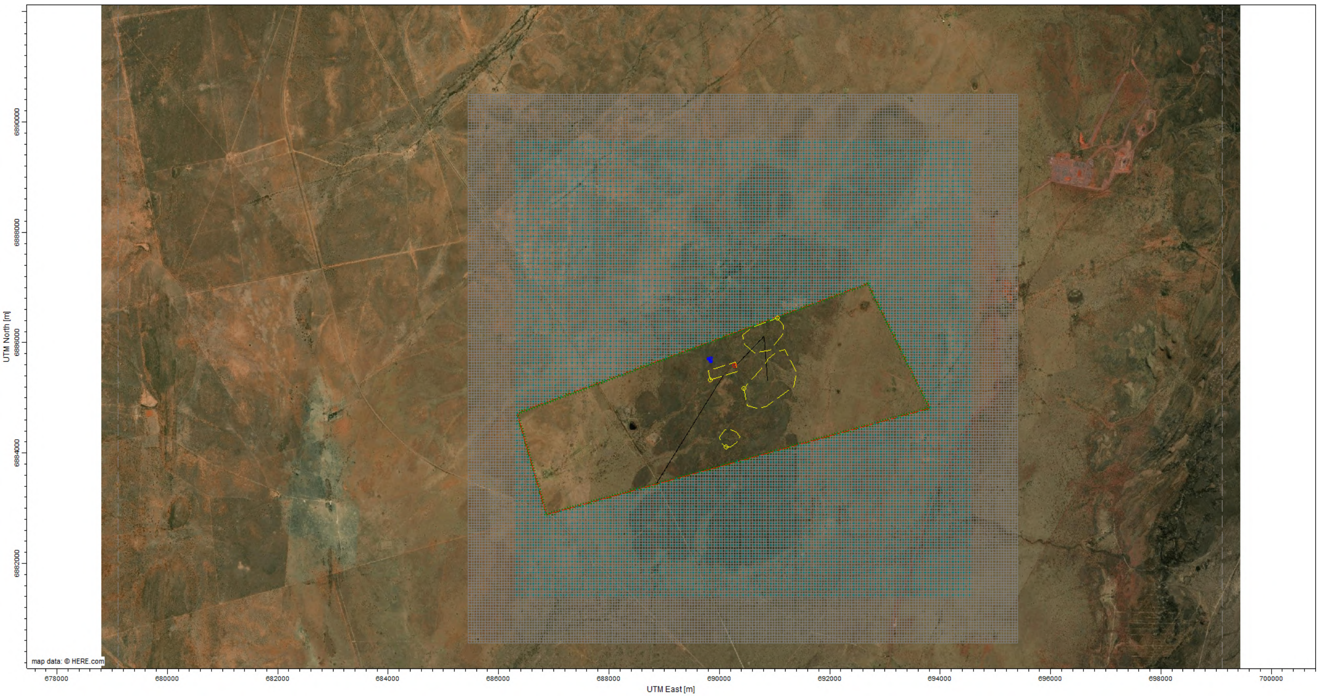

Figure 16: Receptor Map

Due to the large spatial extent of the Makganyene mining site, the receptors are not easily visible in Figure 16. Thus, Figure 17 depicts a magnified section of the receptor map.

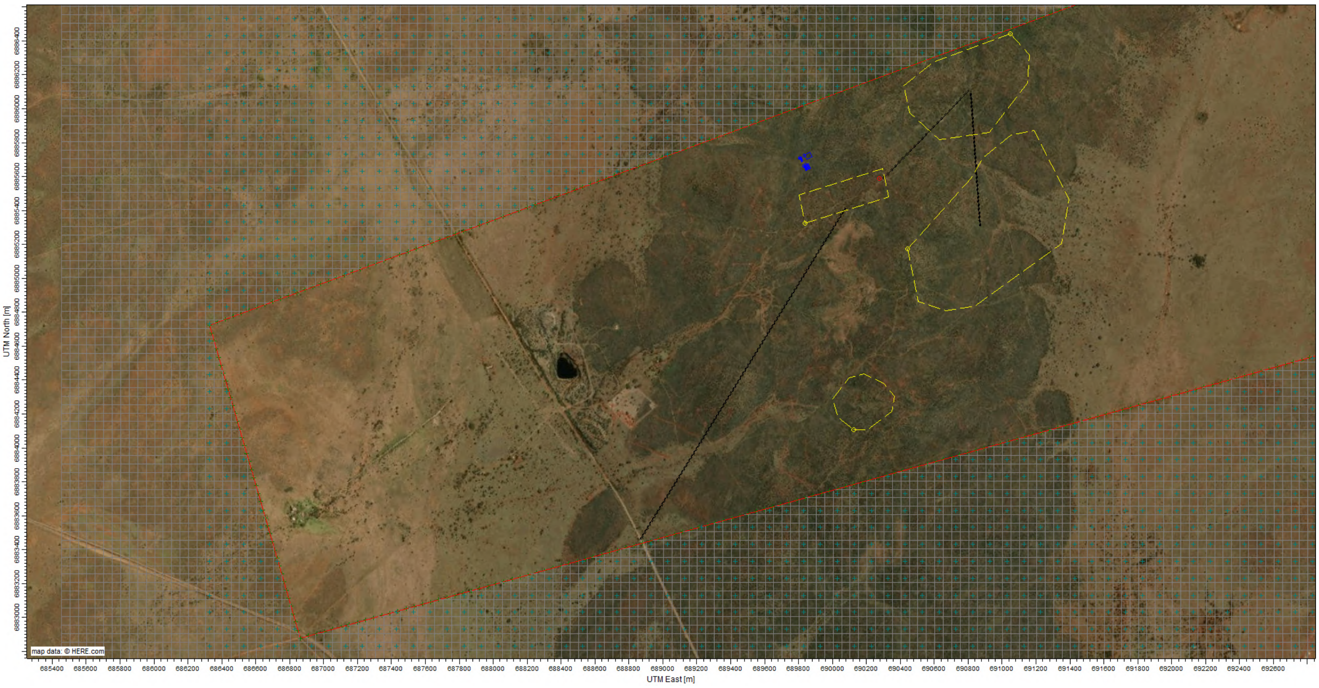

Figure 17: Magnified Section of Receptor Map

7.6. Results

As per the Code of Practice, all short-term averages (24 hours or less) were presented as 99th percentile concentrations.

In the three-year period, there were 1 096 days. The 99th percentile values for the daily average values for PM_{10} and $PM_{2.5}$ are thus the 11th highest value recorded (1 096 x 0.01 = 10.96).

For PM_{10} and $PM_{2.5}$ the maximum predicted ground-level concentrations from the proposed Makganyene mining activities were assessed against the National Ambient Air Quality Standards (NAAQS). Background concentrations were not included in the assessment due to the absence of representative monitoring data, as discussed in Section 7.4.2, and therefore cumulative concentrations were not determined. The results from the air dispersion model thus isolate the incremental impact of the proposed activities of the Makganyene site on the ambient air quality in the region.

No results inside of the plant boundary were assessed, in accordance with Section 5.2 of the Code of Practice, as these are subject to occupational air quality standards and not the NAAQS.

The maximum concentrations near the fence line were assessed and these are presented in the following sections.

7.6.1. Scenario 1

PM_{10}

Table 23: Non-Cumulative PM_{10} Results – Scenario 1

Ave. Period	Parameter	Max. Fence Line and Surrounds	NAAQS (µg/m³)
Daily	**Concentration (µg/m³)**	413.6	75
	Elevation	1 349.13 m	
	Location (UTM)	X: 690503.75 m Y: 6886405.76 m	
	Date	2023/11/09	
Annual	**Concentration (µg/m³)**	69.69	40
	Elevation	1 366.84 m	
	Location (UTM)	X: 690868.35 m Y: 6886405.05 m	
	Date/Hour	-	

The dispersion model predicts that, under Scenario 1, ambient PM_{10} concentrations at the site fenceline as a result of the Makganyene facility alone will exceed both the daily NAAQS of 75 µg/m³ and the annual NAAQS of 40 µg/m³. These exceedances highlight the need to consider additional dust mitigation strategies at the proposed site.

However, it's important to note that the assessment conservatively assumed that the maximum possible surface areas of the pits would be exposed throughout the entire operational period of the mine. In practice, only portions of the pits will be active at any given time, and actual emissions are therefore likely to be lower than those predicted.

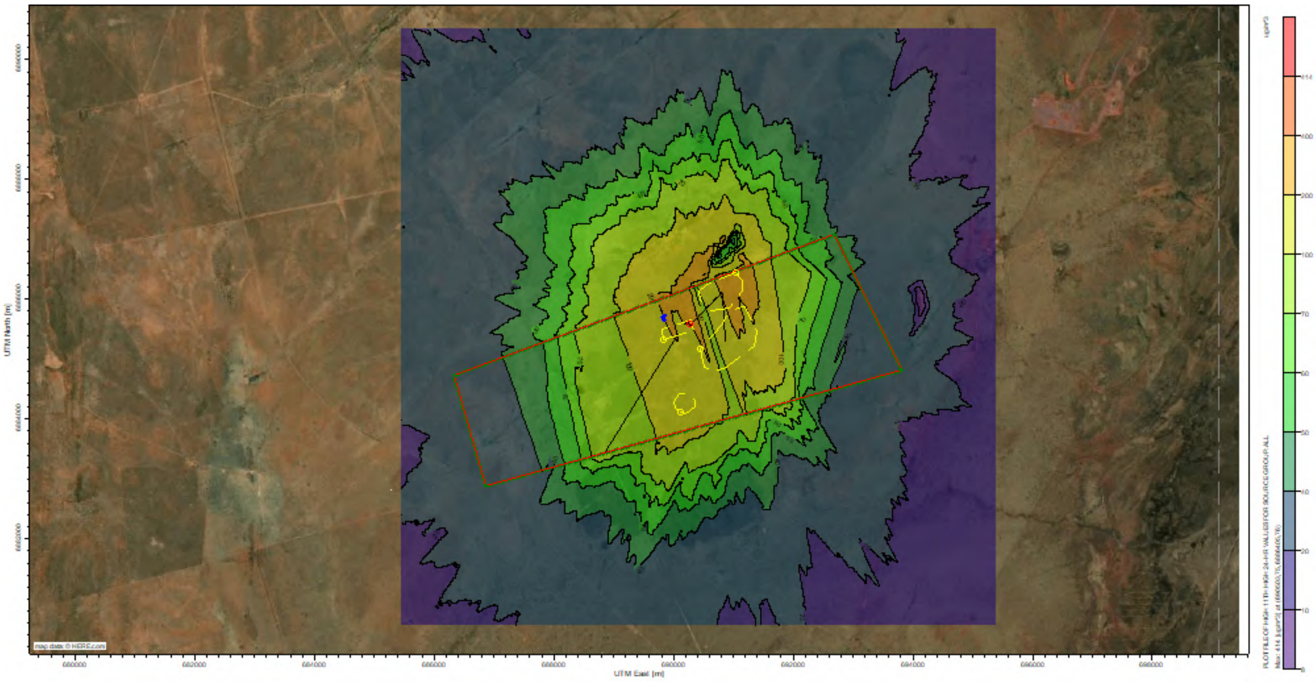

Figure 18: Isopleths of *Daily* PM_{10} Concentrations

Figure 18 shows that the highest daily ambient PM_{10} concentration (413.6 µg/m³) occurs along the northern border of the proposed site, as indicated by the red isopleth. Exceedances of the daily PM_{10} NAAQS are primarily concentrated around the waste rock stockpile. The red, orange, yellow, and light green isopleths denote areas in which exceedances of the daily PM_{10} NAAQS are predicted, while the dark green and blue isopleths indicate concentrations that are below the NAAQS.

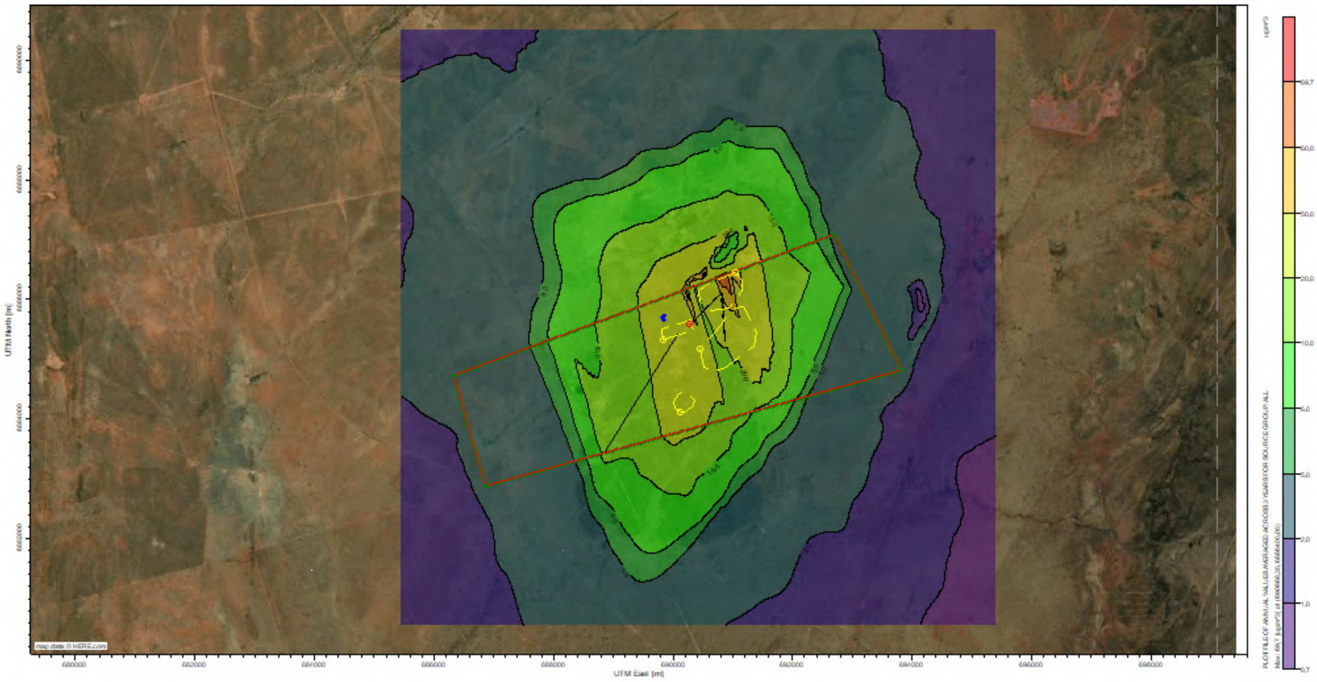

Figure 19: Isopleths of *Annual* PM_{10} Concentrations

Figure 19 shows that the highest predicted annual ambient PM_{10} concentration (69.69 µg/m^3) occurs along the northern border of the proposed site, near the waste rock stockpile, as indicated by the red isopleth. The red, orange, and yellow, isopleths denote areas in which exceedances of the annual PM_{10} NAAQS are predicted, while the green and blue isopleths indicate concentrations that are below the NAAQS.

$PM_{2.5}$

Table 24: Non-Cumulative $PM_{2.5}$ Results – Scenario 1

Ave. Period	Parameter	Max Fence Line and Surrounds	NAAQS (µg/m³)
Daily	**Concentration (µg/m³)**	101.83	40
	Location (UTM)	X: 690868.35 m Y: 6886405.05 m	
	Elevation	1 366.84 m	
	Date/Hour	2024/10/29, 24	
Annual	**Concentration (µg/m³)**	24.97	20
	Location (UTM)	X: 690868.35 m Y: 6886405.05 m	
	Elevation	1 366.84 m	
	Date/Hour	-	

The model predicts that, under Scenario 1, ambient $PM_{2.5}$ concentrations at the site fenceline as a result of the Makganyene facility alone will exceed both the daily NAAQS of 40 µg/m³ and the annual NAAQS of 20 µg/m³. These exceedances highlight the need to consider additional dust mitigation strategies at the proposed site.

However, again it's important to note that the assessment conservatively assumed that the maximum possible surface areas of the pits would be exposed throughout the entire operational period of the mine. In practice, only portions of the pits will be active at any given time, and actual emissions are therefore likely to be lower than those predicted.

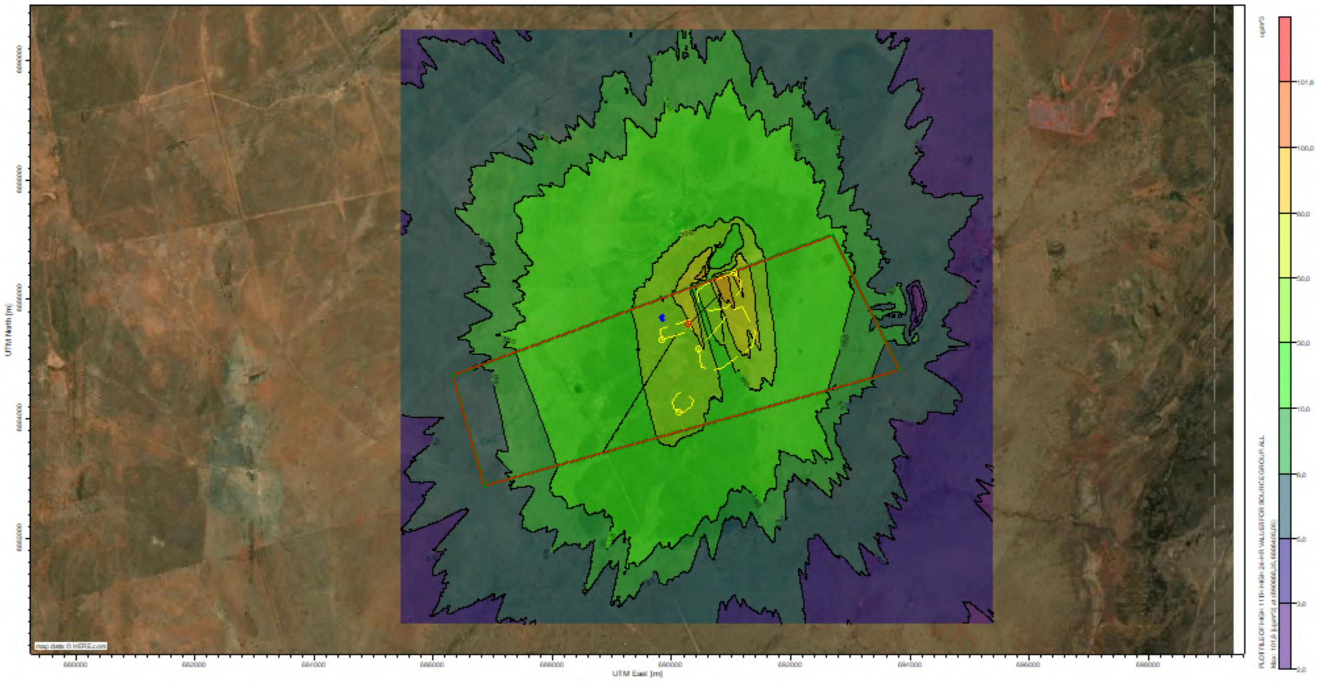

Figure 20: Isopleths of *Daily* PM2.5 Concentrations

Figure 20 shows that the highest daily ambient PM2.5 concentration (101.83 µg/m³) occurs along the northern border of the proposed site, as indicated by the orange isopleth. The areas in which exceedances are predicted are located around the waste dump of the proposed facility. The red, orange, and yellow isopleths denote areas in which exceedances of the daily PM2.5 NAAQS of 40 µg/m³ are predicted, while the green and blue isopleths indicate concentrations that are below the NAAQS.

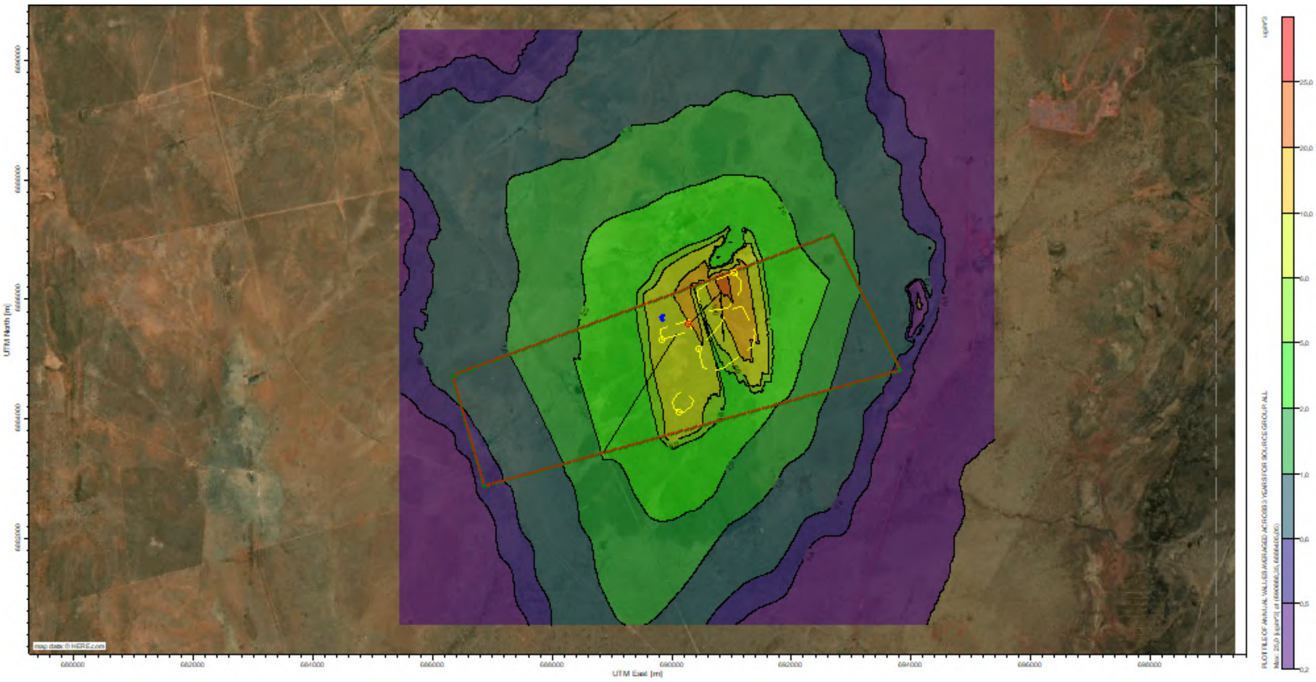

Figure 21: Isopleths of *Annual* $PM_{2.5}$ Concentrations

Figure 21 shows that the highest annual ambient $PM_{2.5}$ concentration (24.97 µg/m³) occurs along the northern border of the proposed site, near the waste rock stockpile, as indicated by the red isopleth. The red and orange isopleths denote areas in which exceedances of the annual $PM_{2.5}$ NAAQS of 20 µg/m³ are predicted, while the green and blue isopleths indicate concentrations that are below the NAAQS.

7.6.2. Scenario 2

PM_{10}

Table 25: Non-Cumulative PM_{10} Results – Scenario 2

Ave. Period	Parameter	Max. Fence Line and Surrounds	NAAQS (µg/m³)
Daily	**Concentration (µg/m³)**	191.48	75
	Elevation	1 350.80 m	
	Location (UTM)	X: 690212.86 m Y: 6886162.50 m	
	Date	2023/04/04, 24	
Annual	**Concentration (µg/m³)**	34.58	40
	Elevation	1 350.80 m	
	Location (UTM)	X: 690212.86 m Y: 6886162.50 m	
	Date/Hour	-	

In Scenario 2, which includes additional dust mitigation measures, namely the windbreaks around the stockpiles and open pits, as well as chemical dust suppressants on the haul route between the pits and waste stockpile, the model predicts exceedances of the daily PM_{10} NAAQS of 75 µg/m³ at the site fenceline. However, no exceedances of the annual PM_{10} NAAQS of 40 µg/m³ are predicted in this scenario, indicating that the implementation of the proposed dust mitigation strategies offers a meaningful reduction in long-term ambient PM_{10} concentrations.

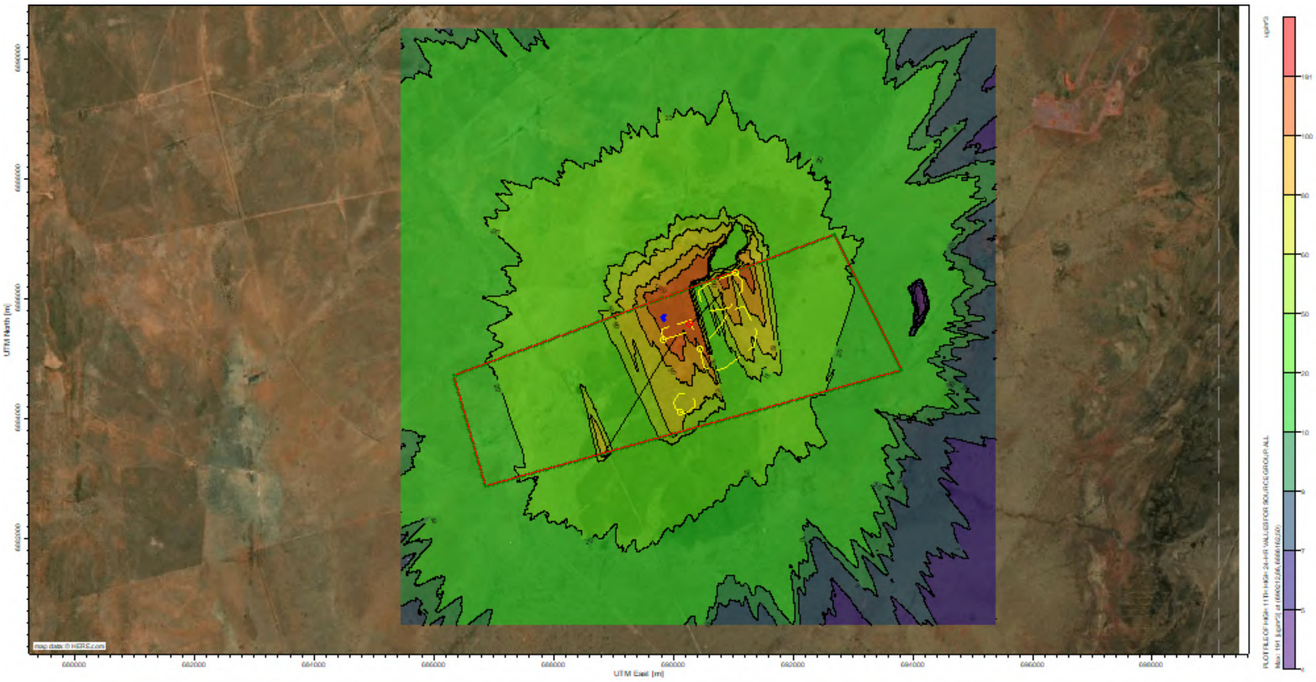

Figure 22: Isopleths of *Daily* PM_{10} Concentrations

Figure 22 shows that the highest daily ambient PM_{10} concentration (191.48 µg/m³) occurs along the northern border of the proposed site, as indicated by the red isopleth. The areas in which exceedances are predicted are located around the waste dump and the ore stockpile of the proposed facility. The red, orange, and yellow isopleths denote areas in which exceedances of the daily PM_{10} NAAQS of 75 µg/m³ are predicted, while the green and blue isopleths indicate concentrations that are below the NAAQS.

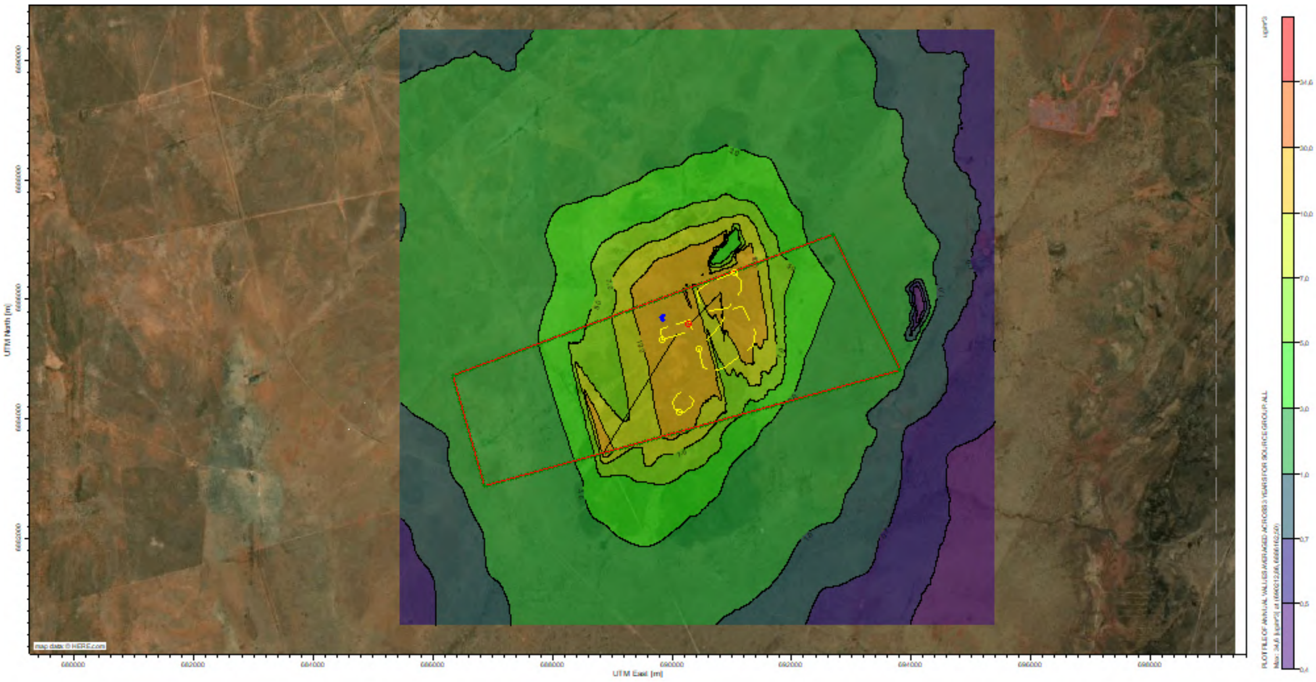

Figure 23: Isopleths of *Annual* PM_{10} Concentrations

Figure 23 shows that the highest annual ambient PM_{10} concentration (34.58 µg/m^3) occurs along the northern border of the proposed site, as indicated by the orange isopleth. The highest predicted concentrations occur in and around the waste dump. No exceedances in the annual NAAQS are predicted by the model, and all isopleths shown indicate annual ambient PM_{10} concentrations that are below the NAAQS.

$PM_{2.5}$

Table 26: Non-Cumulative $PM_{2.5}$ Results – Scenario 2

Ave. Period	Parameter	Max Fence Line and Surrounds	NAAQS (µg/m³)
Daily	**Concentration (µg/m³)**	32.22	40
	Location (UTM)	X: 690503.75 m Y: 6886405.76 m	
	Elevation	1349.13 m	
	Date/Hour	2022/04/26, 24	
Annual	**Concentration (µg/m³)**	6.92	20
	Location (UTM)	X: 690868.35 m Y: 6886405.05 m	
	Elevation	1 366.84 m	
	Date/Hour	-	

The Scenario 2 model predicts no exceedances of the $PM_{2.5}$ daily and annual NAAQS of 40 µg/m³ and 20 µg/m³, respectively, at the fenceline, indicating that the proposed dust mitigation strategies are effective in reducing ambient $PM_{2.5}$ concentrations around the proposed site.

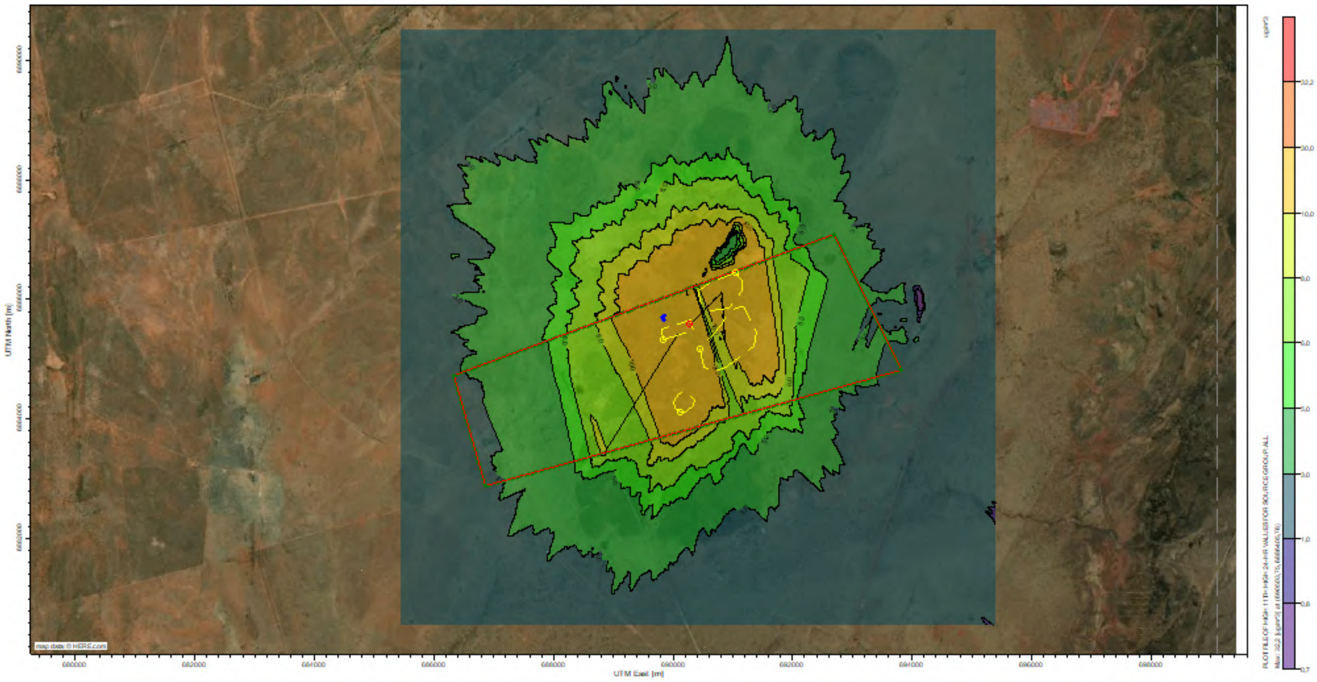

Figure 24: Isopleths of *Daily* $PM_{2.5}$ Concentrations

Figure 24 shows that the highest daily ambient $PM_{2.5}$ concentration (32.22 µg/m³) occurs along the northern border of the proposed site, as indicated by the orange isopleth. The highest predicted concentrations occur around the vicinity of the waste stockpile. However, no exceedances of the daily NAAQS of 40 µg/m³ are predicted by the model, and all isopleths shown remain within compliance levels.

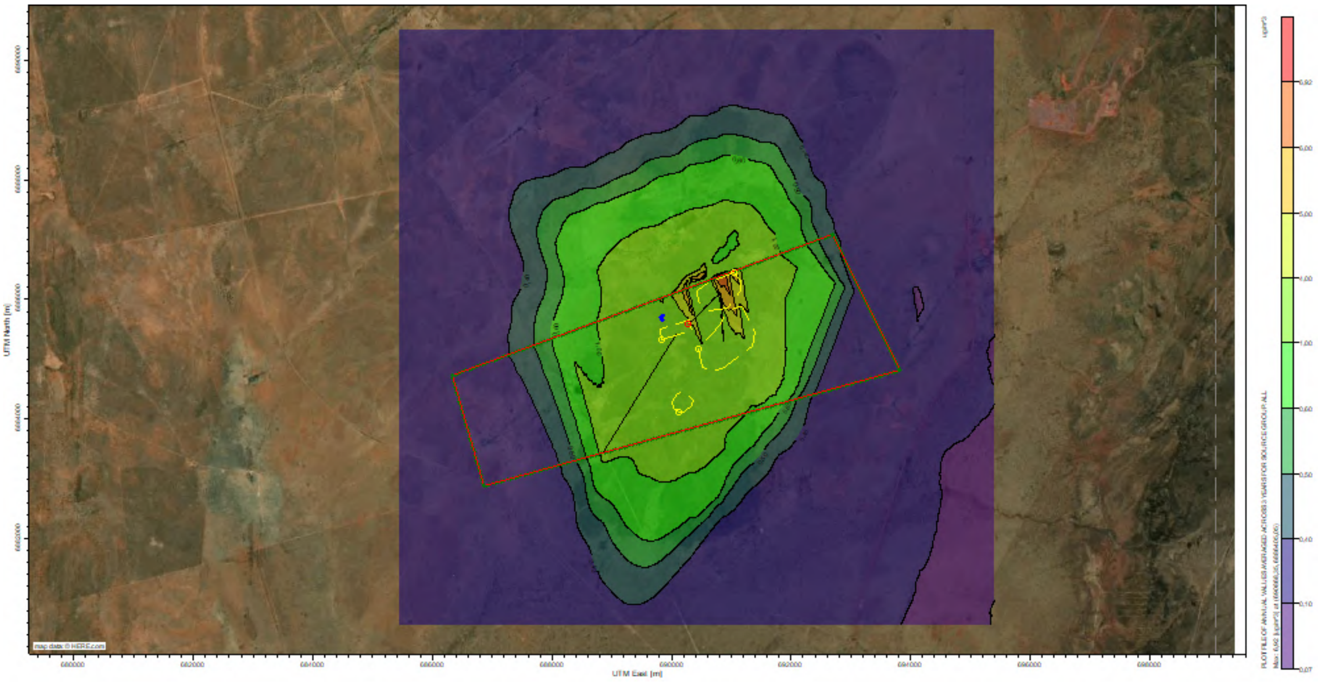

Figure 25: Isopleths of *Annual* $PM_{2.5}$ Concentrations

Figure 25 shows that the highest annual ambient $PM_{2.5}$ concentration (6.92 µg/m³) occurs along the northern border of the proposed site, as indicated by the red and orange isopleths. The highest predicted concentrations occur around the vicinity of the waste stockpile. However, no exceedances of the annual NAAQS of 20 µg/m³ are predicted, and all isopleths shown remain within compliant levels.

7.7. Air Dispersion Modelling Conclusions

Air dispersion modelling was conducted for the proposed Makganyene mining project to assess the potential impact of fugitive particulate emissions (PM_{10} and $PM_{2.5}$) on ambient air quality as a result of the proposed facility. Two modelling scenarios were developed:

- **Scenario 1** reflects baseline conditions, incorporating only the dust mitigation measures currently proposed by the client.
- **Scenario 2** evaluates the potential benefits of additional dust mitigation measures, including windbreaks around stockpiles and open pits, and the use of chemical dust suppressants on high-traffic haul roads.

The modelling results from Scenario 1 indicate that both the daily and annual NAAQS for PM_{10} and $PM_{2.5}$ would be exceeded at locations along the northern fence line of the site, particularly in the vicinity of the waste stockpile and ore stockpile. These exceedances highlight the need for additional dust control measures to ensure compliance during the operational phase of the mine. However, it's important to note that the assessment conservatively assumed that the maximum possible surface areas of the pits would be exposed throughout the entire operational period of the mine. In practice, only portions of the pits will be active at any given time, and actual emissions are therefore likely to be lower than those predicted.

In Scenario 2, the implementation of additional dust mitigation measures results in notable improvement in predicted ambient PM concentrations. All $PM_{2.5}$ concentrations remain below both the daily and annual NAAQS, and the predicted annual PM_{10} concentrations also comply with the applicable standard. While the daily PM_{10} NAAQS is still exceeded, the extent and magnitude of the daily exceedance is significantly reduced compared to Scenario 1.

Based on the results of the dispersion modelling, the implementation of additional dust control measures, such as windbreaks and chemical suppressants, would significantly reduce the predicted ambient concentration of PM at the proposed site. However, it should be noted that these measures were assessed in isolation of operational, technical and economic feasibility considerations. Furthermore, the model adopts conservative assumptions, including the maximum surface area of the open pits for the entire operational life of the mine, which may overstate actual emissions experienced during the operational phase of the mine.

8. Complaints

None.

9. Current or Planned Air Quality Management Interventions

None.

10. Compliance and Enforcement History

None.

11. Appendix A: Report Details

Reporting Conducted by:	Yellow Tree Advisory Unit B7 & B9 Westlake Square Westlake Western Cape 7945
Report Compiled by:	Denham Lailvaux (BEng, Chemical)
Report Reviewed by:	Sasha Kasperski (MEng, Chemical)
Report Compiled for:	Greenmined Environmental 106 Baker Square, Block 1, Paardevlei De Beers Avenue Somerset West 7130

12. Appendix B: Air Dispersion Modelling Study Reporting Requirements[33]

Chapter 1: Facility and modellers' information		Submitted Yes/No	Comments, References
1.1	**Project identification information requirements**		
	• Applicant	Y	6
	• Physical address of facility	Y	7
	• Air Emissions License reference number (if applicable)	Y	8
	• Environmental authorisation reference number (if applicable)	NA	NA
	• Modelling contractor(s), when applicable	Y	64
1.2	**Project background**		
	• Purpose(s) and objectives of the air dispersion modelling under consideration.	Y	5
	• General descriptive narrative of the plant processes and proposed new source or modification.	Y	9
1.3	**Project location requirements**		
1.3.1	Detailed scaled layout plan of proposed project area including the following:		
	• UTM coordinates of facility property lines, including fence	Y	14
	• Property lines, including fence lines	Y	14
	• Roads and railroads that pass-through property line	Y	14
	• Location and dimensions of buildings and/or structures (on or off property) which could cause downwash	Y	14
1.3.2	**Area map(s) that include the following:**		
	• Map of adjacent area (10 km radius from proposed source) indicating the following	Y	16
	° Latitude/Longitude on horizontal and vertical axis		
	° Nearby known pollution sources		
	° Schools and hospitals within 10km of facility boundary		
	° Topographic features		
	° Any proposed off-site or on-site meteorological monitoring stations		
	° Roads and railroads		
	• Regional map that includes the following	Y	16
	° UTM coordinates		
	° Modelled Facility		
	° Topography features within 50 km		
	° Known pollution sources within 50 km		
	° Any proposed off-site meteorological monitoring stations		
1.4	**Land use determination in modelling domain**		
	• Urban	Y	19
	• Rural/agricultural	Y	19

[33] Section 7.2.2 Code of Practice

Chapter 1: Facility and modellers' information		Submitted Yes/No	Comments, References
1.5	**Elevation data (DEM) and resolution** • Discuss DEM data utilised	Y	19
Chapter 2. Emissions characterisation		**Submitted Yes/No**	**Comments, References**
2.1	**Emissions characteristics** • Include fugitive and secondary emissions when applicable • Emission unit descriptions and capacities (including proposed emission controls) • New structures or modifications to existing structures as a result of project	Y Y Y	20 20 20
2.2	**Operating scenarios for emission units** • Operating conditions simulated in the modelling study ° Upset conditions ° Normal ° Start-up ° Standby ° Shut-down	Y	42
2.3	**Emissions and source parameter table(s)** • List all identifiable emissions • Include parameter table(s) for each operating scenario of each emission unit, which may include, but not be limited to the following: ° Operating scenario(s) ° Source location (UTM Coordinates) ° Point source parameters ° Area source parameters ° Volume source parameters • Include proposed emissions (and supporting calculations) for all identifiable emissions	Y Y	42 42 42
Chapter 3: Meteorological data		**Submitted Yes/No**	**Comments, References**
3.1	**Surface data discussions must include:** • Off-site ° Source of data ° Description of station (location, tower height, etc.) ° Period of record ° Demonstrate temporal and spatial representativeness	NA	NA

Chapter 3: Meteorological data		Submitted Yes/No	Comments, References
	◦ Seasonal wind-rose(s) ◦ 3-year of representative off-site data ◦ Evaluate if off-site data complies with regulatory Code of Practice ◦ Program and version used to process data ◦ Method used to replace missing hours ◦ Method used to handle calm periods • On-site ◦ Description of station (location, tower height, etc.) ◦ Period of record ◦ Demonstrate spatial representativeness ◦ Minimum 1-year of representative on-site data ◦ Evaluate if off-site data complies with regulatory Code of Practice ◦ Program and version used to process data ◦ Method used to replace missing hours ◦ Method used to handle calm periods	NA	NA
3.2	**Discuss upper air data utilised** • Discuss upper air data utilised from the most representative station. • Explain why it is most representative.	 NA NA	 NA NA
Chapter 4: Ambient impact analysis and ambient levels		**Submitted Yes/No**	**Comments, References**
4.1	**Standards Levels** • National Ambient Air Quality Standards	Y	35
4.2	**Background Concentrations** • Specify background values used including supporting documentation	Y	36
Chapter 5: Modelling Procedures		**Submitted Yes/No**	**Comments, References**
5.1	**Model used in the Study Assessment level proposed** • Assessment level proposed and justification • Dispersion model used. • Supporting models and input programs • Version of models and input programs	 Y Y Y Y	 37 37 37 37
5.2	**Specify modelled emissions** • Pollutants • Scenarios and emissions that will be modelled • Conversion factor utilised for converting NO_x to NO_2	 Y Y NA	42 42 42 NA
5.3	**Specify setting utilised within the model(s), which may include:** • Recommended settings utilised within model • Terrain settings (simple flat/simple elevated/complex) • Land characteristics (Bowen ratio, surface albedo, surface roughness)	 Y Y Y	 37 37 37

Chapter 5: Modelling Procedures		Submitted Yes/No	Comments, References
5.4	**Describe the receptors grids utilised within the analysis**		
	• Property line resolution	Y	41
	• Fine grid resolution	Y	41
	• Medium grid resolution(s)	Y	41
	• Course grid resolution	Y	41
	• Figures that show locations of receptors relative to modelled facility and terrain features.	Y	41
Chapter 6: Ambient impact results documentation		**Submitted Yes/No**	**Comments, References**
6	At a minimum, the Ambient Air Quality Standards results are to be documented as follows:		
6.1	**Table(s) of modelling results including**		
	1. Pollutant	Y	43
	2. Averaging time	Y	43
	3. Operating scenario	Y	43
	4. Maximum modelled concentration	Y	43
	5. Receptor location of maximum impact (coordinates)	Y	43
	6. Receptor elevation	Y	43
	7. Date of maximum impact	Y	43
	8. Grid resolution at maximum impact	Y	43
	9. Name of output e-file(s) where data was taken from.	N	e-Files available on request
6.2	**Figure(s) showing source impact area including**		
	1. UTM coordinates on horizontal and vertical axis	Y	43
	2. Modelled facility	Y	14
	• Boundary		
	• Buildings		
	• Emission points		
	3. Topography features	Y	16
	4. Isopleths of impact concentrations	Y	43
	5. Location and value of maximum impact	Y	43
	6. Location and value of maximum cumulative impact.	Y	43
Chapter 7: Ambient impact supporting documentation		**Submitted Yes/No**	**Comments, References**
7.1	All warning and informational messages within modelling output files must be explained and evaluated.	NA	NA
7.2	Required electronic files to be submitted with report	All files available on request	
	1. Input & output files for models		
	2. Input & output files for pre-processors		
	3. Input & output files for post-processors		
	4. Digital terrain files		

	5. Plot files Final report		
7.3	Report shall include a list and description of electronic files	All files available on request	
7.4	Report shall include a discussion on deviations from the modelling protocol	NA	NA

13. Appendix C: Curriculum Vitae of Project Team

DENHAM LAILVAUX

JUNIOR ENVIRONMENTAL ENGINEER | YELLOW TREE

EXPERIENCE

JUNIOR ENVIRONMENTAL ENGINEER • YELLOW TREE • DECEMBER 2024 – PRESENT

- Greenhouse gas (GHG) emissions inventory development and reporting in terms of the National Greenhouse Gas Emissions Reporting Regulations on behalf of 26 companies.
- Carbon tax payment eligibility and tax liability assessments - assessed companies' carbon tax obligations under the Carbon Tax Act, ensuring compliance and identifying tax efficiency opportunities.
- Scope 1, 2 and 3 carbon footprint development in terms of the GHG Protocol and IPCC Guidelines for fuel combustion activities, air conditioning and refrigerant use, agricultural activities, and waste activities.
- Atmospheric Impact Reports (AIRs), including Level 1 and 2 air dispersion modelling for the sugar milling industry.
- Annual reporting for Atmospheric Emission Licence compliance for numerous industries.

JUNIOR METALLURGIST • NORTHAM PLATINUM • DECEMBER 2023 – NOVEMBER 2024

- Design, planning, and overseeing of various process optimization and research projects at a high capacity MF2 concentrator for recovery of PGMs and Cr_2O_3.
- As a junior engineer, carried out multiple research projects and was involved in commissioning new projects on site:
  - Commissioned an Alfa Laval Decanter Centrifuge for dewatering of tailings to reduce the environmental risk of the tailings dam due to the amount of water being deposited (>525 wet ton/ hr)
  - Lab scale testing for optimisation of depressant dosage to plant and testing of alternative depressants to improve plant recovery and concentrate grade.
  - Co-led a plant-scale trial run of a new co- collector to investigate its effect on flotation recovery.
  - Commissioned an industry- first chrome flotation plant for recovery of fine Cr_2O_3 from tailings (project handover phase)

EDUCATION

BENG CHEMICAL ENGINEERING • 2023 • UNIVERSITY OF STELLENBOSCH

Dean's merit award for final year project and design project.

Member of Golden Key International Honours Society (awarded to top 15 % in Faculty)

yellowtree
WHERE INTEGRITY & SCIENCE MEET

SASHA KASPERSKI

CHEMICAL ENGINEER | YELLOW TREE

EXPERIENCE

CHEMICAL ENGINEER • YELLOW TREE • MARCH 2022 – PRESENT

- Atmospheric Impact Reports (AIRs) including Level 1 and 2 air dispersion modelling for, amongst others, glass manufacturing facilities, precious metal refining facilities, lead processing facilities, and battery manufacturing facilities.
- Stack emissions sampling for NEM:AQA Section 21 Listed Activities and Section 23 Controlled Emitters, data analysis, report writing, client liaison and client feedback.
- Greenhouse gas (GHG) emissions inventory development and reporting in terms of the National Greenhouse Gas Emissions Reporting Regulations
- Carbon tax payment eligibility and tax liability assessments in terms of the Carbon Tax Act.
- Scope 1, 2 and 3 carbon footprint development in terms of the GHG Protocol, IPCC Guidelines, and ISO 14064-1.
- Scope 1, 2 and 3 carbon footprint verifications according to ISO 14064-3.
- Voluntary carbon budget applications.
- Technical information-sharing presentations to various industries and authorities on GHG reporting and the Carbon Tax Act.

EDUCATION

401 GHG VERIFICATION FOR INVENTORIES AND PROJECTS • 2023 • GHG MANAGEMENT INSTITUTE

Achieved 86 % in final examination. The course material focused on GHG verification approaches such as ISO 14064 Part 3 and the UNFCCC Clean Development Mechanism (CDM) Validation and Verification Manual.

MENG CHEMICAL ENGINEERING • 2023 • UNIVERSITY OF STELLENBOSCH

Master's degree in Chemical Engineering

BOILER SUPERVISION AND MANAGEMENT COURSE • 2022 • JOHN THOMPSON

The course material included information related to boiler construction, design & controls; boiler efficiency; steam generation; steam utilisation; water treatment; fuel selection; trouble shooting; and cost saving.

BENG CHEMICAL ENGINEERING • 2019 • UNIVERSITY OF STELLENBOSCH

Honours degree in Chemical Engineering

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yellowtree ADVISORY