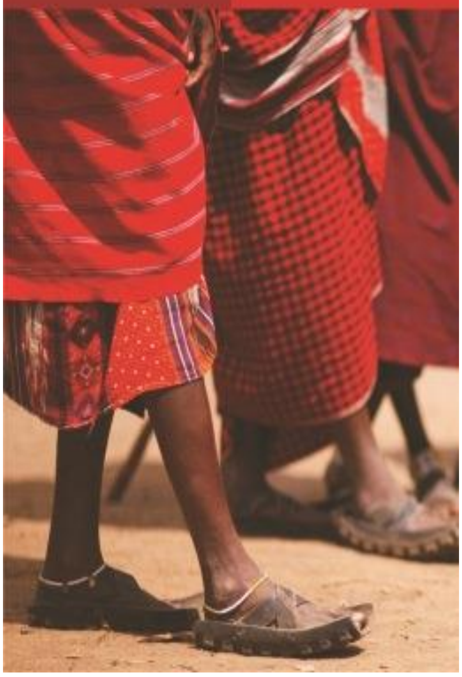

DIGBY WELLS ENVIRONMENTAL

Environmental Regulatory Processes relating to the Thubilisha, Trichardtsfontein and Vaalkop Mining Right Areas, Mpumalanga

Air Quality Impact Assessment Report

Project Number:

SAS3869

Prepared for:

Sasol Mining (Pty) Ltd

August 2017

Digby Wells and Associates (South Africa) (Pty) Ltd
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This document has been prepared by Digby Wells Environmental.

Report Type:	**Air Quality Impact Assessment Report**
Project Name:	**Environmental Regulatory Processes relating to the Thubilisha, Trichardtsfontein and Vaalkop Mining Right Areas, Mpumalanga**
Project Code:	**SAS3869**

Name	Responsibility	Signature	Date
Matthew Ojelede	Report Writer		August 2017
Renee van Aardt	Report Reviewer		August 2017

EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) was appointed by Sasol Mining (Pty) Ltd as the independent environmental consultant to undertake a Section 102 process in accordance with the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA). A number of specialist studies have been requested, including an Air Quality Impact Assessment (AQIA) study. This report presents findings from the Air Quality study and made recommendations to ameliorate impacts.

This study adopted the Occupational Exposure Limits (OELs) gazetted in the Mine Health and Safety Act of Mine Health and Safety Act (MHSA), 1996 (Act No. 29 0f 1996) of October 2006. The MHSA requires that the levels of these pollutants be lower than the gazetted concentrations. Adopted these limits represent a worst-case scenario, with the emissions rates applied at 100% of the South African OEL and no mitigation measures were in place. An AQIA was undertaken to determine the impacts associated with the proposed construction and operation of the ventilation shaft and associated facilities. Pollutants quantified and evaluated in the assessment included dust fallout, fine particulate matter (PM_{10} and $PM_{2.5}$) as well as gaseous pollutants (SO_2, NO_2 and CO).

The predicted ground level concentrations (GLC) of pollutants assessed show that emissions associated with the short averaging periods can lead to exceedances once the ventilation shafts are operational. In terms of spatial impacts based on the isopleths generated from the model revealed that the zones of exceedances are confined to the vicinity of the vent, some 20 m to 40 m away from the ventilation shaft.

Despite these exceedances, the zones of impact occur predominantly within the Project boundary (at a radius of 20 m to 40 m) from the ventilation shaft. However, the GLC predicted at the surrounding receptors are below the South African standard. Results of the dispersion modelling exercise, coupled with the impact assessment ratings conducted show that impacts will be negligible. The operation of the ventilation shafts will not pose a risk to the environment and exposed receptors.

In conclusion, if the ventilation shafts and associated facilities are operated with mitigation measures in place i.e. enclosure of crusher, fitting of dust extraction system and water spray, use of selective catalytic technology and gas scrubbers at the vent upcast, predicted particulate and gaseous emissions anticipated will have negligible impacts on the ambient air quality of the Project area.

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LIST OF ABBREVIATIONS

APPA	Atmospheric Pollution Prevention Act
AQIA	Air Quality Impact Assessment
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMPRs	Environmental Management Programme Reports
GLC	Ground Level Concentration
GN	Government Notice

km	Kilometre
km2	Kilometre squared
MM5	Mesoscale model - Fifth generation
MHSA	Mine Health and Safety Act
NAAQS	National Ambient Air Quality Standard
NDCR	National Dust Control Regulation
NEMAQA	The National Environmental Management: Air Quality Act
PM_{10}	Particulate Matter less than 10 microns in diameter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
OEL	Occupational Exposure Limit
TCTS	Twistdraai Colliery: Thubelisha Shaft (TCTS)
TSP	Total Suspended Particulates
USEPA	United States Environment Protection Agency
WHO	World Health Organisation

1 Introduction

Digby Wells Environmental (hereafter Digby Wells) was appointed by Sasol Mining (Pty) Ltd (hereafter Sasol) as the independent environmental consultant to undertake a Section 102 process in accordance with the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA). A number of specialist studies have been requested, including an Air Quality Impact Assessment (AQIA) Study.

Sasol holds mining rights for the Twistdraai Colliery: Thubelisha Shaft (TCTS) and the Vaalkop mining area (Ref: MP30/5/1/2/2/138MR) Further to this, the mining right for the Trichardtsfontein Mine (Ref: MP30/5/1/2/2/10056MR) was ceded from Glencore Operations South Africa (Pty) Ltd in accordance with Section 11 of the Mineral and Petroleum Resources Development Act, 2002 (No. 28 of 2002) (MPRDA) to Sasol. To ensure the mines operate in a more efficient and effective manner Sasol embarked on a consolidation of all amended Environmental Management Programme Reports (EMPRs) into one merged EMPR.

1.1 Project Description

The Project which includes the TCTS, Trichardtsfontein Mine and Vaalkop is located between the town of Trichardt and Bethal in Mpumalanga Province. Due to the depth of the resource (i.e. between 30 m to 215 m below surface), underground mining will be used to access the ore body. Sasol is currently mining TCTS and proposes to start mining Trichardtsfontein within the next few years. Vaalkop mining area although, a priority to Sasol will only begin mining in 2032. It is proposed that Sasol will construct two ventilation shafts on TCTS and two ventilation shafts on Trichardtsfontein

It is expected that there will be dolerite intrusions and a dyke development section will be deployed for the purpose of mining through these and preparing new mining sections. Any overburden material extracted will be stockpiled and used to rehabilitate the shafts once mining is completed.

1.2 Terms of Reference

Digby Wells was appointed by Sasol to assess potential impacts associated with the consolidation Project footprint and additional infrastructure. The Terms of Reference (ToR) encompasses a completion of an AQIA report. As part of the ToR, the following was required:

- Emissions inventory of pollution sources at the mine;
- Development of a dispersion model to understand the dispersal pollutant across the Project area; and
- Compilation of an Air Quality Impact Assessment report.

In addition, Digby Wells was required to provide recommendations regarding appropriate monitoring programme and action plans tailored to needs of the Project.

1.3 Aims and Objectives

The overall aim of the AQIA study was to establish the impacts on air quality due to the Project and ancillary activities. To achieve this aim, the following tasks were undertaken:

- To appraise all sources of pollution within the Project area;
- To predicted ground level concentration (GLC) of pollutants from the Project;
- To appraise the predicted GLC against current South African standards protective of the environment and human health; and
- To appraise impacts on sensitive receptors in the vicinity of the Project.

2 Specialist Details

Matthew Ojelede completed his B.Sc. (Hons) degree at the University of Benin; an M.Sc. in Environmental Science (Wits University) and a Ph.D. in Environmental Management from the University of Johannesburg. He has been in the Atmospheric Research field since 2005 and now actively involved in atmospheric dispersion modeling and emissions inventories compilation. He has authored and co-authored several research articles in peer reviewed journals and compiled dispersion modeling impact assessments reports. A curriculum vitae (CV) and declaration of independence is attached in Appendix A.

3 Legal Context and Health Implications of Pollutants

3.1 South African Standards

Guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to minimum ambient levels of pollutants that are known or likely to be hazardous to human health and wellbeing World Health Organization (WHO, 2000). Once the guidelines are adopted as standards, they become legally enforceable. These standards prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified time period in a defined area. If the air quality guidelines/standards are exceeded, the ambient air quality is poor and the potential for health effects is greatest.

The prevailing legislation in the Republic of South Africa with regards to the Air Quality field is the National Environment Management: Air Quality Act (Act No. 39 of 2004) (NEM: AQA). The NEM: AQA repealed the Atmospheric Pollution Prevention Act (45 of 1965) (APPA) and various other laws dealing with air pollution.

According to NEM: AQA, the Department of Environmental Affairs) (DEA), the provincial environmental departments and local authorities (district and local municipalities) are separately and jointly responsible for the implementation and enforcement of various aspects of the Act. Each of these spheres of government is obliged to appoint an air quality officer and to co-operate with each other and co-ordinate their activities through mechanisms provided for in the National Environment Management Act, 1998 (Act 107 of 1998) (NEMA).

The purpose of NEM: AQA is to set norms and standards that relate to:

- Institutional frameworks, roles and responsibilities;
- Air quality management planning;
- Air quality monitoring and information management;
- Air quality management measures; and
- General compliance and enforcement.

Amongst other things, it is intended that the setting of norms and standards will achieve the following:

- The protection, restoration and enhancement of air quality in South Africa;
- Increased public participation in the protection of air quality and improved public access to relevant and meaningful information about air quality; and
- The reduction of risks to human health and the prevention of the degradation of air quality.

The Minister of Water and Environmental Affairs, released on the 01 November 2013 the National Dust Control Regulation, in terms of Section 53, read with Section 32 of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) (NEMAQA) National Dust Control Regulation, the National DEA published the acceptable dust fallout limits for residential and non-residential areas.

The New National Dust Regulation (NDCR) fallout standard is given in the Table 3-1 below.

Table 3-1: Acceptable dust fall standards (NEMAQA - NDCR, 2013)

Restriction Areas	Dust fall rate (mg/m^2/day, 30-days average)	Permitted Frequency of exceeding dust fall rate
Residential Area	< 600	Two within a year, not sequential months
Non-Residential Area	< 1200	Two within a year, not sequential months

Any person who conducts any activity in such a way as to give rise to dust in quantities and concentrations that may exceed the dustfall standard (Table 3-1) set out in regulation 3 must, upon receipt of a notice from an air quality officer, implement a dustfall monitoring programme (NEMAQA-NDCR, 2013).

In the National Dust Control Regulation, terms like target, action and alert thresholds have been omitted. Another notable observation was the reduction of the *margin of tolerance* from the usual three to two incidences within a year (NEMAQA-NDCR, 2013). The National Dust Control Regulation actually adopted a more stringent approach than the previous standard, and would require dedicated mitigation plans now that it is in force.

Also, the DEA has established National Ambient Air Quality Standards for PM_{10} (Table 3-2) and particulate matter of aerodynamic diameter less than 2.5 µm since June 2012 (GN 486: 2012) as depicted in Table 3-3.

Table 3-2: National Ambient Air Quality Standards (2009)

National Ambient Air Quality Standards for Sulfur Dioxide (SO_2)				
AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
10 Minutes	500	191	526	Immediate
1 hour	350	134	88	Immediate
24 hours	125	48	4	Immediate
1 year	50	19	0	Immediate
The reference method for the analysis of SO_2 shall be ISO 6767.				

National Ambient Air Quality Standards for Nitrogen Dioxide (NO_2)				
AVERAGING PERIOD	**LIMIT VALUE (µg/m³)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
1 hour	200	106	88	Immediate
1 year	40	21	0	Immediate
The reference method for the analysis of NO_2 shall be ISO 7996.				

National Ambient Air Quality Standards for Particulate Matter (PM_{10})			
AVERAGING PERIOD	**LIMIT VALUE (µg/m³)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
24 hour	75	4	1 January 2015
1 year	40	0	1 January 2015
The reference method for the determination of the PM_{10} fraction of suspended particulate matter shall be EN 12341.			

National Ambient Air Quality Standards for Ozone (O_3)				
AVERAGING PERIOD	**LIMIT VALUE (µg/m³)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
8 hours (running)	120	61	11	Immediate
The reference method for the analysis of ozone shall be the UV photometric method as described in SANS 13964.				

National Ambient Air Quality Standards for Benzene (C_6H_6)				
AVERAGING PERIOD	**LIMIT VALUE (µg/m³)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
1 year	5	1.6	0	1 January 2015
The reference methods for the sampling and analysis of benzene shall either be EPA Compendium method TO-14 A or method TO-17.				

National Ambient Air Quality Standard for Lead (Pb)				
AVERAGING PERIOD	**LIMIT VALUE (µg/m³)**	**LIMIT VALUE (ppb)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
1 year	0.5		0	Immediate
The reference method for the analysis of lead shall be ISO 9855.				

National Ambient Air Quality Standards for Carbon Monoxide (CO)				
AVERAGING PERIOD	LIMIT VALUE (mg/m^3)	LIMIT VALUE (ppm)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
1 hour	30	26	88	Immediate
8 hour (calculated on 1 hourly averages)	10	8.7	11	Immediate
The reference method for analysis of CO shall be ISO 4224.				

Table 3-3: Established National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$) (2012)

National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$)			
AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
24 hours	40	0	1 January 2016 – 31 December 2029
24 hours	25	0	01 January 2030
1 year	20	0	1 January 2016 – 31 December 2029
1 year	15	0	01 January 2030
The reference method for the determination of PM2.5 fraction of suspended particulate matter shall be EN 14907.			

3.2 Health Implications of Pollutants

The main pollutants of concern identified as a result of the operational phase of the Project encompass particulate matter (PM) classified by their aerodynamic properties into coarse particles – PM_{10} and $PM_{2.5}$. PM_{10} - represents particulate matter with an aerodynamic diameter of less than 10 µm and fine particles $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm), Sulfur Dioxide (SO2), Carbon Monoxide (CO), and Nitrogen Dioxide (NO2) (Fenger, 2002, Harrison and van Grieken, 1998).

These emissions result from the use of a wide range of mine machinery underground, i.e. the use of the continuous miner, operation of the underground conveyor belt connecting the production sections and an underground coal handling facility.

3.2.1 Particulate Matter

In terms of health effects, particulate air pollution is associated with complaints of the respiratory system (WHO, 2000). PM size is relevant in terms of health because it controls where in the respiratory system a given particle is deposited. Fine particles are thought to be more damaging to human health than coarse particles as larger particles are less respirable in that they do not penetrate deep into the lungs compared to smaller particles (Manahan, 1991). Larger particles are deposited into the extra-thoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

The range of adverse health effects of PM is broad, involving respiratory and cardiovascular systems in children and adults. Both short- and long-term exposures lead to adverse health effects. Very young children, probably including unborn babies, are particularly sensitive to the adverse effects of PM. The evidence is sufficient to infer a causal relationship between exposure to PM and deaths from respiratory diseases in the post-neonatal period. Adverse effects of PM on lung development include reversible deficits of lung function as well as chronically reduced lung growth rate and long-term lung function deficit. The available evidence is also sufficient to assume a causal relationship between exposure to PM and aggravation of asthma, as well as cough and bronchitis symptoms. Daily mortality and hospital admissions have been linked with short term variation of PM levels. Increased mortality from cardiovascular and respiratory diseases and from lung cancer has been observed in residents of more polluted areas.

Based on existing evidence of adverse health effects at lower concentrations, WHO revised the Air Quality Guidelines (AQG) for PM (WHO, 2005). For $PM_{2.5}$, the new AQG values are 10 µg/m^3 for the annual average and 25 µg/m^3 for the 24-hour mean (not to be exceeded for more than 3 days/year). The corresponding annual and daily guidelines for PM_{10} were set as 20 µg/m^3 and 50 µg/m^3.

Ambient PM_{10} concentrations are a good approximation of population exposure to PM from outdoor sources. Numerous epidemiological studies conducted in Europe and in other parts of the world have shown adverse health effects of exposure to PM_{10} and $PM_{2.5}$ at concentrations that are currently observed in Europe and the rest of the world. WHO estimated that approximately 700 annual deaths from acute respiratory infections in children aged 0–4 years could be attributed to PM_{10} exposure in the WHO European Region in the late 1990s alone. Population health effects of exposure to PM in adults are dominated by mortality associated with long-time exposure to fine PM ($PM_{2.5}$). Short-term and long-term health effects associated with exposure to particulate matter are presented in Table 3-4.

3.2.1.1 Short-Term Exposure

Recent studies suggest that short-term exposure to particulate matter is associated with health effects, even at low concentrations of exposure. Various studies undertaken during the 1980s and early 1990s have looked at the relationship between daily fluctuations in particulate matter and mortality at low levels of exposure. Pope *et al* (1992) studied daily mortality in relation to PM_{10} concentrations in Utah Valley during the period 1985 - 1989. A maximum daily average concentration of 365 µg/m^3 was recorded with effects on mortality observed at concentrations of < 100 µg/m^3. The increase in total daily mortality was 13% per 100 µg/m^3 increase in the 24 hour average. Studies by Schwartz (1993) in Birmingham recorded daily concentrations of 163 µg/m^3 and noted that an increase in daily mortality was experienced with an increase in PM_{10} concentrations. Relative risks for chronic lung disease and cardiovascular deaths were higher than deaths from other causes.

However, in the past, daily particulate concentrations were in the range 100 – 1000 µg/m^3 whereas in more recent times, daily concentrations are between 10 – 100 µg/m^3. Overall, exposure-response can be described as curvilinear, with small absolute changes in exposure at the low end of the curve having similar effects on mortality to large absolute changes at the high end (WHO, 2000; 2002).

Morbidity effects associated with short-term exposure to fine PM include increases in lower respiratory symptoms, medication use and small reductions in lung function. Pope and Dockery (1992) studied panels of children in Utah Valley in winter during the period 1990 – 1991. Daily PM_{10} concentrations ranged between 7 – 251 µg/m^3. Peak Expiratory flow was decreased and respiratory symptoms increased when PM_{10} concentrations increased. Pope and Kanner (1993) utilised lung function data obtained from smokers with mild to moderate chronic obstructive pulmonary disease in Salt Lake City. The estimated effect was a 2% decline in Forced Expiratory Volume over one second for each 100 µg/m^3 increase in the daily PM_{10} average.

3.2.1.2 Long-Term Exposure

Long-term exposure to low concentrations (~10 µg/m^3) of PM is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000; 2002).

Studies have indicated an association between lung function and chronic respiratory disease and airborne particles. Older studies by Chestnut *et al* (1991) found that Forced Vital Capacity decreases with increasing annual average particulate levels with an apparent threshold at 60 µg/m^3. Using chronic respiratory disease data, Schwartz (1993) determined that the risk of chronic bronchitis increased with increasing particulate concentrations, with no apparent threshold.

Few studies have been undertaken documenting the morbidity effects of long-term exposure to PM (Table 3-4). Recently, the Harvard Six Cities Study showed increased respiratory illness rates among children exposed to increasing PM, sulphate and hydrogen ion concentrations. Relative risk estimates suggest an 11% increase in cough and bronchitis rates for each 10 µg/m^3 increase in annual average particulate concentrations.

Table 3-4: Short-term and long-term health effects associated with exposure to PM (WHO, 2004)

Pollutant	Short-term exposure	Long-term exposure
Particulate matter	▪ Lung inflammatory reactions ▪ Respiratory symptoms ▪ Adverse effects on the cardiovascular system ▪ Increase in medication usage ▪ Increase in hospital admissions ▪ Increase in mortality	▪ Increase in lower respiratory symptoms ▪ Reduction in lung function in children ▪ Increase in chronic obstructive pulmonary disease ▪ Reduction in lung function in adults ▪ Reduction in life expectancy ▪ Reduction in lung function development

3.2.2 Sulfur dioxide (SO_2)

Sulfur dioxide (SO_2) forms part of the entire group of sulfur oxides (SO_x), and constitutes the component of greatest concern. Emissions that lead to high concentrations of SO_2 generally also lead to the formation of other SO_x. In the context of this project, sources of SO_2 emissions from the use of heavy equipment underground burning fuel with sulfur content vented through the ventilation upcast to keep the underground working safe for personnel. SO_2 can have adverse effect public health and the environment (Alberta Health & Wellness, 2006).

Short-term exposures to SO_2 can result in difficulties for the human respiratory system, making breathing difficult. Children, the elderly, and those who suffer from asthma are particularly sensitive to effects of SO_2.

SO_x can react with other compounds in the atmosphere to form small particles. These particles contribute to particulate matter (PM) pollution: particles may penetrate deeply into sensitive parts of the lungs and cause additional health problems. At high concentrations, gaseous SO_2 can harm trees and plants by damaging foliage and decreasing growth. SO_2 and other sulfur oxides can contribute to acid rain which can harm sensitive ecosystems.

3.2.3 Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a nasty-smelling gas. Some nitrogen dioxide is formed naturally in the atmosphere by lightning and some is produced by plants, soil and water. However, only about 1% of the total amount of nitrogen dioxide found in our cities' air is formed this way.

In terms of this Project, nitrogen dioxide will arise mainly the ventilation upcast to the ambient environment. Exposure to elevated levels of nitrogen dioxide present the likelihood of respiratory problems. This pollutant inflames the lining of the lungs, reducing immunity to lung infections – exacerbating the occurrence of wheezing, coughing, colds, flu and bronchitis (Kraft et al, 2005).

Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. Children with asthma and older people with heart disease are most at risk.

3.2.4 Carbon Dioxide (CO)

Carbon monoxide (CO), a poisonous, colourless, odourless and tasteless gas is known to be widely associated with incomplete combustion of material containing carbon such as gasoline, kerosene, oil, propane, coal, or wood.

Carbon monoxide is harmful when breathed because it displaces oxygen in the blood and deprives the heart, brain, and other vital organs of oxygen. Exposure to high concentrations of CO can result in loss of consciousness and suffocation. Prior to the aforementioned, tightness across the chest, headache, fatigue, dizziness, drowsiness, or nausea is common symptoms. Symptoms vary widely from person to person. CO poisoning may occur sooner in those most susceptible: young children, elderly people, people with lung or heart disease, people at high altitudes, or those who already have elevated CO blood levels, such as smokers.

The Occupational Safety and Health Administration (OSHA) standards prohibit worker exposure to more than 50 parts of the gas per million parts of air averaged during an 8-hour time period (OSHA's Safety and Health Program Management Guidelines, 2006).

4 Methodology

4.1 Baseline Environment

4.1.1 Receptors

Receptor locations and distances from the project area are based on visual observation on Google Earth Imagery. Receptors are located to the southwest and western sections of the Project area. These include Trichardt, Secunda and unnamed informal settlement. The Project area and coal reserve are located within the Highveld East Magisterial District, the Gert Sibande District Municipality and the Govan Mbeki Local Municipality. The Thubelisha Project is situated within a region that is characterised by coal mining activities and cultivation which includes maize cropping and grazing.

According to the United States Environmental Protection Agency (2016), a sensitive receptor encompasses but not limited to "*hospitals, schools, daycare facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to toxic chemicals, pesticides, and other pollutants*". Human settlement where involuntary exposure is likely to occur is not exempted. From the above, significant buffer exists between the project infrastructure and possible human settlements in the area (Table 4-1).

Table 4-1: Sensitive Receptors in the Vicinity of the Proposed Project Area

Sensitive Receptor	Receptor Type	Average distance from the Ventilation Shafts
Secunda	Residential	12 km
Trichardt	Residential	10 km

4.1.2 Meteorology

Ambient air quality in this region of South Africa is strongly influenced by regional atmospheric movements, together with local climatic and meteorological conditions.

There are distinct summer and winter weather patterns that affect the dispersal of pollutants in the atmosphere. In summer, unstable atmospheric conditions result in mixing of the atmosphere and rapid dispersion of pollutants. Summer rainfall also aids in removing pollutants through wet deposition. Precipitation reduces wind erosion potential by increasing the moisture content of exposed surface materials–this represents an effective mechanism for suppressing wind-blown dust. Rain-days are defined as days experiencing 0.1 mm or more rainfall.

In contrast, winter is characterised by atmospheric stability caused by a persistent high-pressure system over South Africa. This dominant high-pressure system results in subsidence, causing clear skies and a pronounced temperature inversion over interior of South Africa. This inversion layer traps pollutants from near surface sources in the lower atmosphere, which results in reduced dispersion and poorer air quality. Preston-Whyte and Tyson (1988) described the atmospheric conditions in the winter months as highly unfavourable for the dispersion of atmospheric pollutants. Emissions from elevated sources, such as from tall stacks, remain stratified in the mid-troposphere and have a reduced probability of reaching the surface with high concentrations near the source.

In the absence of site specific meteorological records, three years' worth of hourly weather MM5 modelled meteorological data (2014-2016) from Lakes Environmental Software was analysed and used to generate wind rose plots and determine the local prevailing weather conditions. This dataset, from the Pennsylvania State University / National Center for Atmospheric Research (PSU/NCAR) meso-scale model is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict meso-scale atmospheric circulation. This data, obtained for a point (26.441558 S, 29.329617 E) in the proposed project area, has been tested extensively and has been found to be accurate. Generally, a data set of greater than 90% completeness is required for that month/year to be considered representative of the assessed area.

Dispersion of atmospheric pollutants is a function of the prevailing wind characteristics at any site. The vertical dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness (Cowherd *et al*, 1998; Cowherd *et al*, 2010).

The amount of particulate matter generated by wind is highly dependent upon the wind speed. Below the wind speed threshold for a specific particle type, no particulate matter is liberated, while above the threshold, particulate matter liberation tends to increase with wind speed. The amount of particulate matter generated by wind is dependent also on the surface properties, for example, whether the material is crusted, the fraction of erodible particles, and the particle size distribution (Fryrear et al., 1991).

Wind roses generally comprises of 16 spokes which represent the frequencies and the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and different categories. The figures at the bottom of the legend represent the frequency at which calms occurred (periods with wind speed <0.5 m/s).

The spatial and annual variability in the wind field for the proposed Project area is evident in Figure 4-1. The dominant winds are blowing from North of Northwest (10.4%) and Northwest (9.9%) respectively. Secondary winds were coming from the north (8.9%), northeast (8.6%) and east northeast (8.3%). Calm conditions (wind speeds <0.5 m/s) occurred 6.3% of the time.

There is some diurnal variation in the meteorological data shown in Figure 4-2. The predominant wind direction is northeast and north with 14.9% and 13.4% respectively, north northwest (12.8%) and north (11.6%) in the morning, northwest in the afternoon (16.3%) and northwest (10.2%) in the evening.

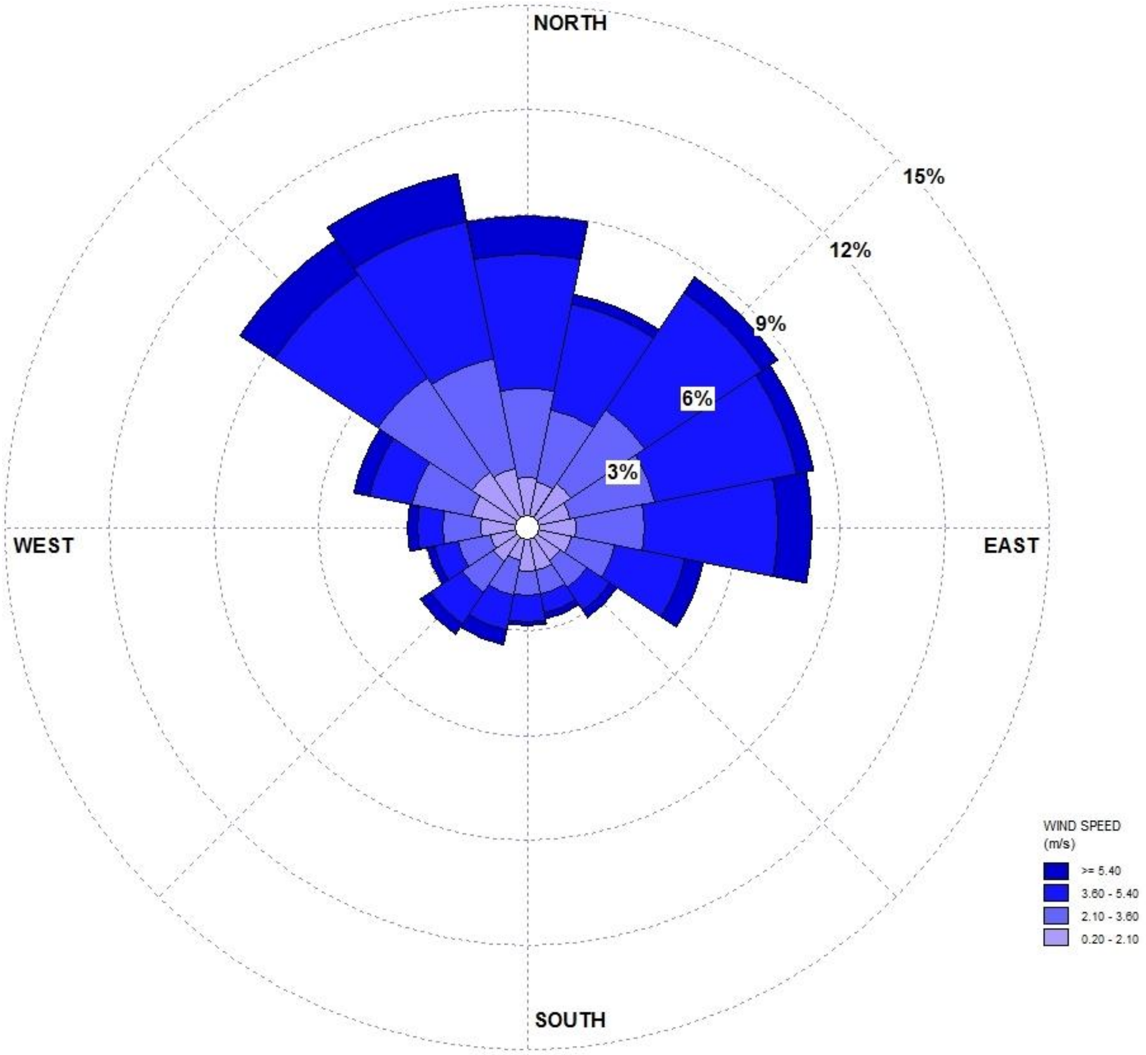

Figure 4-1: Surface Wind Rose at the Proposed Project Site

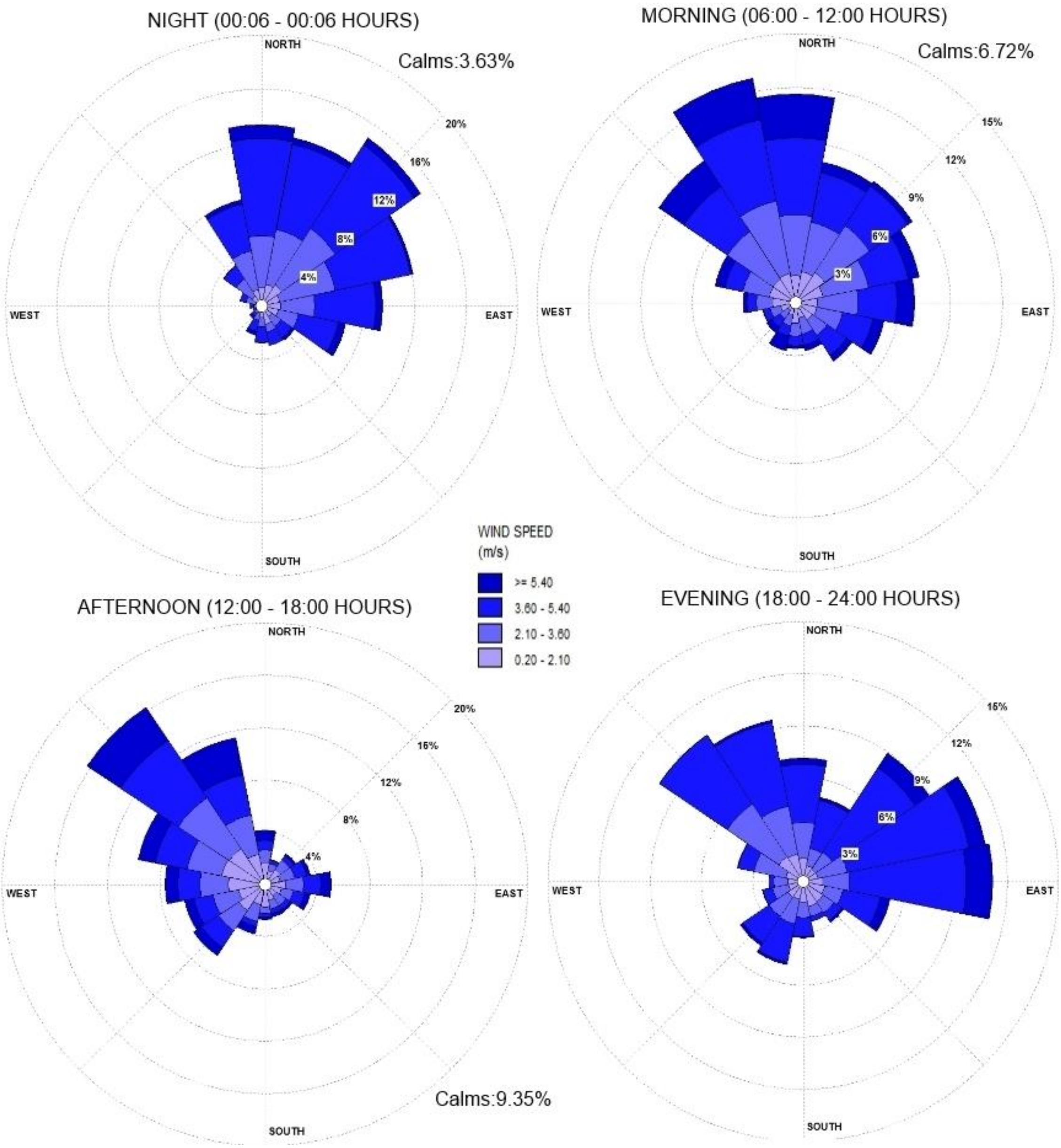

Figure 4-2: Diurnal variations of wind at night-time: 00:00 – 06:00 (top left), morning 06:00 – 12:00 (top right), afternoon 12:00 – 18:00 (bottom left) and evening 18:00 – 00:00 (bottom right)

The seasonal variability in wind direction is depicted in Figure 4-3. The seasonal signature show winds from the northwest and north-northwest dominating in autumn, winter and spring, except summer when winds from northeast and east northeast dominated. The wind class frequency distribution per sector is given in Figure 4-4 and Table 4-2.

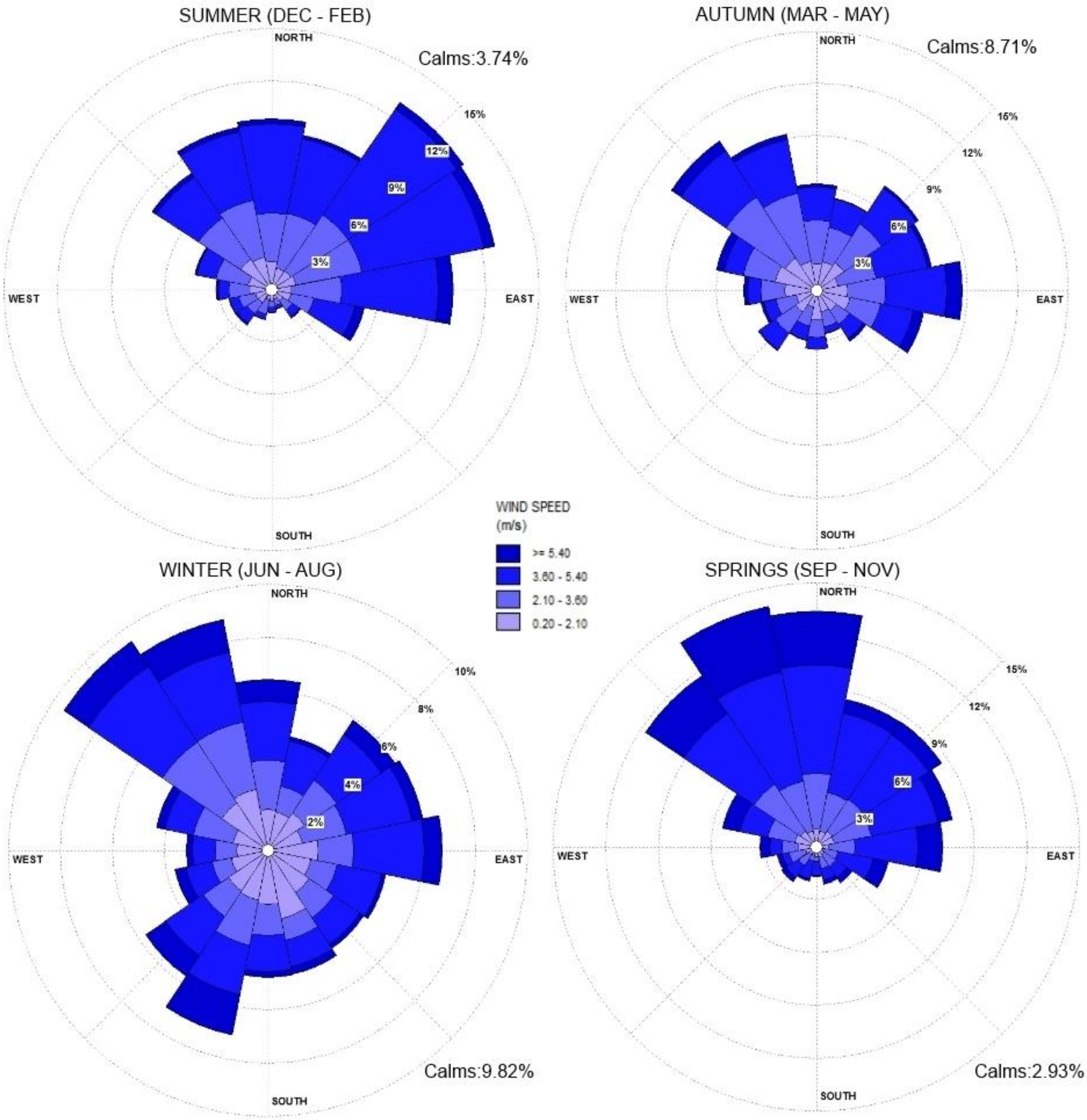

Figure 4-3: Seasonal variability of winds in summer (December – February); autumn (March – May); winter (June – August) and spring (September – November)

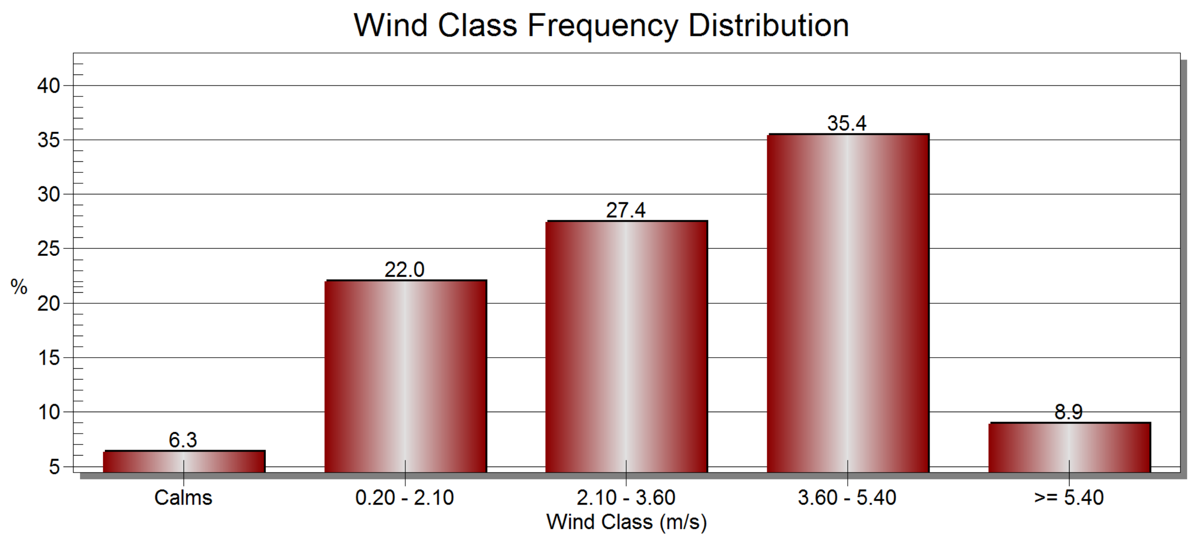

Figure 4-4: Wind Class Frequency Distribution

Table 4-2: Wind Class Frequency Distribution

	Directions (m/s)	0.20 - 2.10	2.10 - 3.60	3.60 - 5.40	5.40 - 8.80	>= 8.80	Total (%)
1	N	1.46	2.54	3.85	1.08	8.92	1.46
2	NNE	1.35	2.11	3.06	0.32	6.84	1.35
3	NE	1.53	2.53	4.05	0.55	8.65	1.53
4	ENE	1.28	2.47	4.11	0.53	8.39	1.28
5	E	1.41	1.97	3.82	0.97	8.17	1.41
6	ESE	1.31	1.27	2.01	0.56	5.16	1.31
7	SE	1.16	0.89	0.83	0.23	3.11	1.16
8	SSE	1.27	0.69	0.56	0.16	2.68	1.27
9	S	1.26	0.69	0.79	0.09	2.82	1.26
10	SSW	0.99	1.02	1.02	0.43	3.46	0.99
11	SW	1.21	1.03	1.09	0.37	3.70	1.21
12	WSW	1.08	0.97	0.68	0.22	2.96	1.08
13	W	1.35	1.09	0.73	0.30	3.47	1.35
14	WNW	1.64	1.72	1.24	0.48	5.08	1.64
15	NW	1.92	3.24	3.57	1.19	9.91	1.92
16	NNW	1.74	3.19	4.01	1.43	10.37	1.74
	Sub-Total	21.95	27.41	35.43	8.90	93.69	21.95
	Calms					6.31	
	Missing/Incomplete						0
	Total						**100**

4.1.3 Wind Speed

One of the factors that favour the suspension and resuspension of loose particulates in the atmosphere is the intensity of the wind speed regime. Wind speed greater than 5.4 m/s leads to erosion of loose dust PM and the degree of dispersion across the landscape (Table 4-3 and Figure 4-5). Figure 4-5 shows that wind speed greater than 5.4 m/s occur every month with increases observed from the months of June to October. Although average wind speed is generally below 5.4 m/s, it can be seen from Table 4-3 that the potential is there for wind erosion to occur each month. In total, 30 days in a year recorded wind speed greater than 5.4 m/s (~ 3 days in a month).

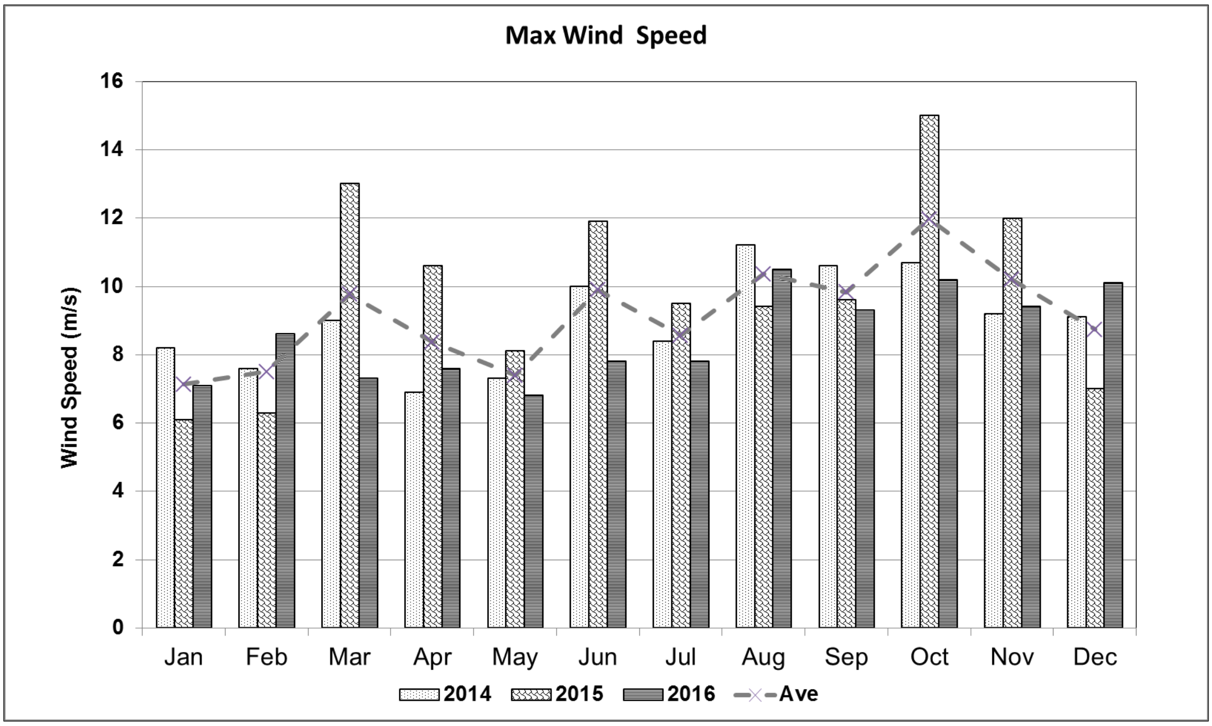

Figure 4-5: Monthly Maximum Wind Speed

Table 4-3: Monthly Wind Speed Records

Wind Speed (m/s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	8	9	13	11	8	12	10	11	11	15	12	10	11
Monthly Ave	3	3	3	3	3	3	3	3	4	4	4	4	3

4.1.4 Temperature

The monthly maximum and average temperature for the Project area is given in Table 4-4, and represented graphically in Figure 4-6. The maximum temperatures were observed from October to February with the month of January recording the highest temperature of 31°C. The monthly averages ranged from 9°C in June to 20°C in December/January/February. The annual average temperature for the proposed project site is given as 15°C.

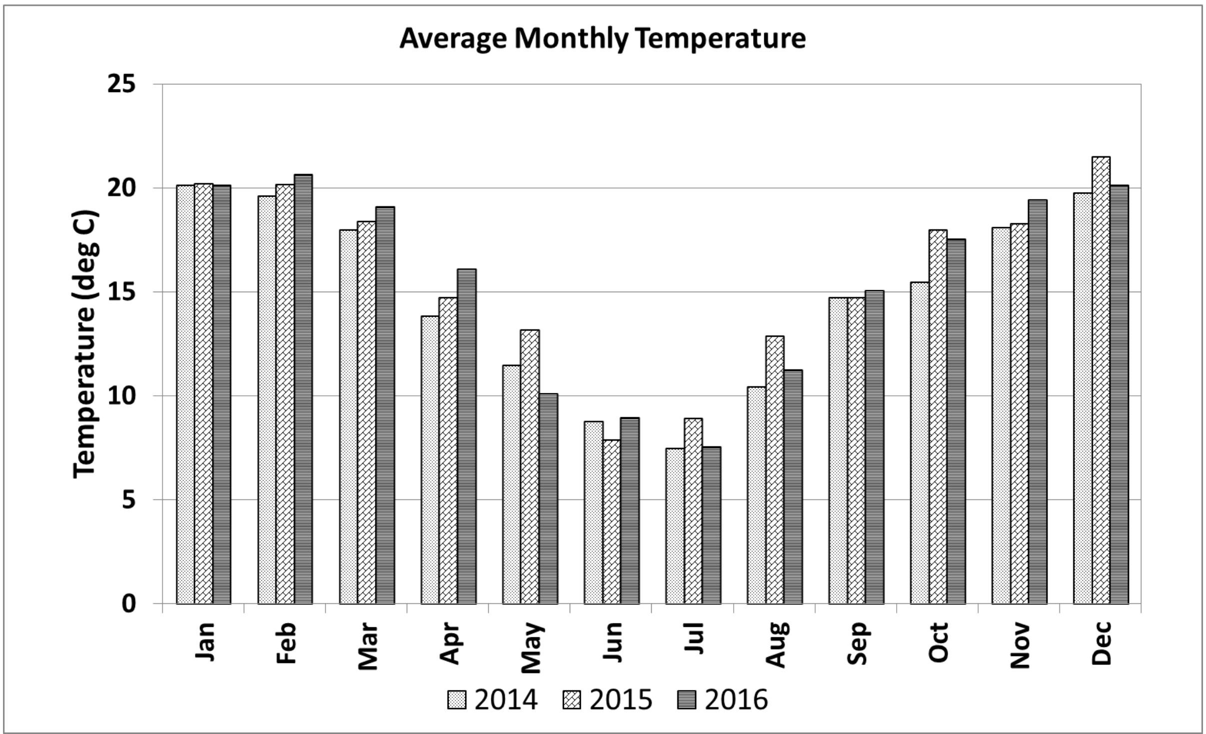

Figure 4-6: Average Monthly Temperature

Table 4-4: Monthly Temperature Records

Temp(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	31	29	28	25	21	18	17	23	25	29	29	30	25
Monthly Ave	20	20	18	15	12	9	8	12	15	17	19	20	15

4.1.5 Precipitation

The total monthly and the average monthly rainfall for the period under review are reported in Table 4-5 for the three-year period (2014-2016). This is represented graphically in Figure 4-7. The highest precipitation of 291 mm observed in March. The lowest recorded precipitation (3 mm) was observed in June. The annual total and average rainfall reached 1302 mm and 842 mm respectively.

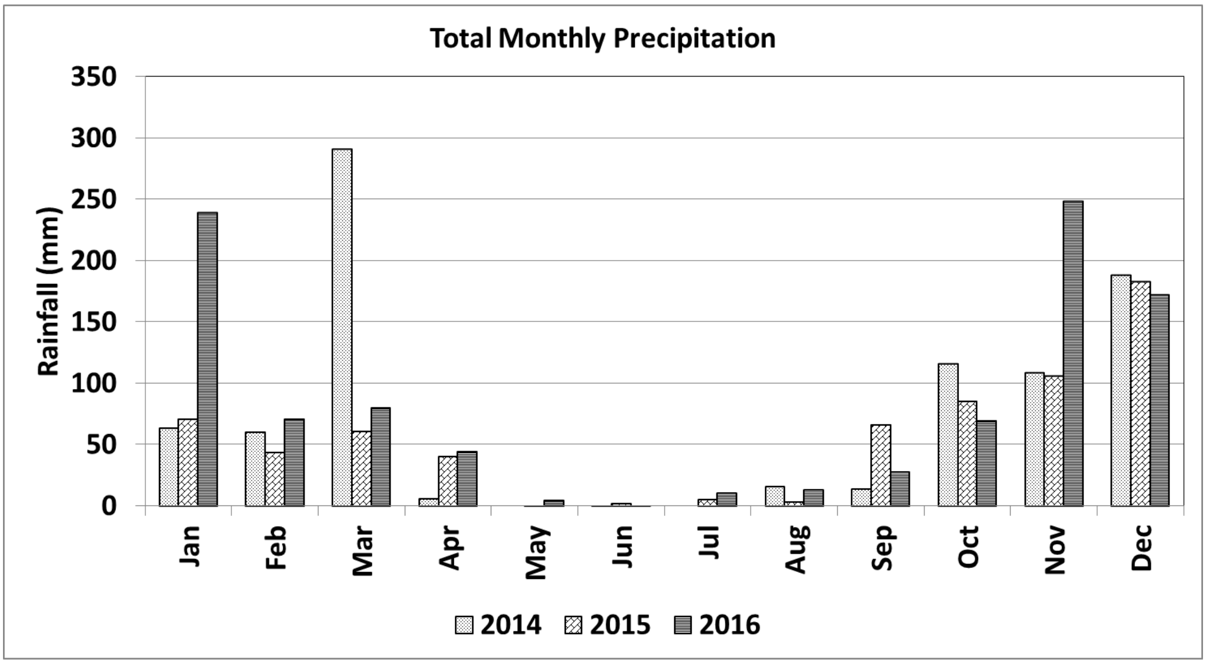

Figure 4-7: Total Monthly Precipitation

Table 4-5: Total Monthly Precipitation Records

Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Tot. Mon Rainfall (Max)	239	72	291	45	5	3	11	17	67	116	249	189	1302
Aver. Mon Rainfall	125	59	144	31	2	1	6	11	36	91	155	182	842

4.1.6 Relative Humidity

The data in Table 4-6 are representative of the relative humidity for the Project area. Each month, there were days with relative humidity reaching 100%. The monthly average ranged between 65% and 75% respectively. The annual average estimated was 70% (Table 4-6 and Figure 4-8).

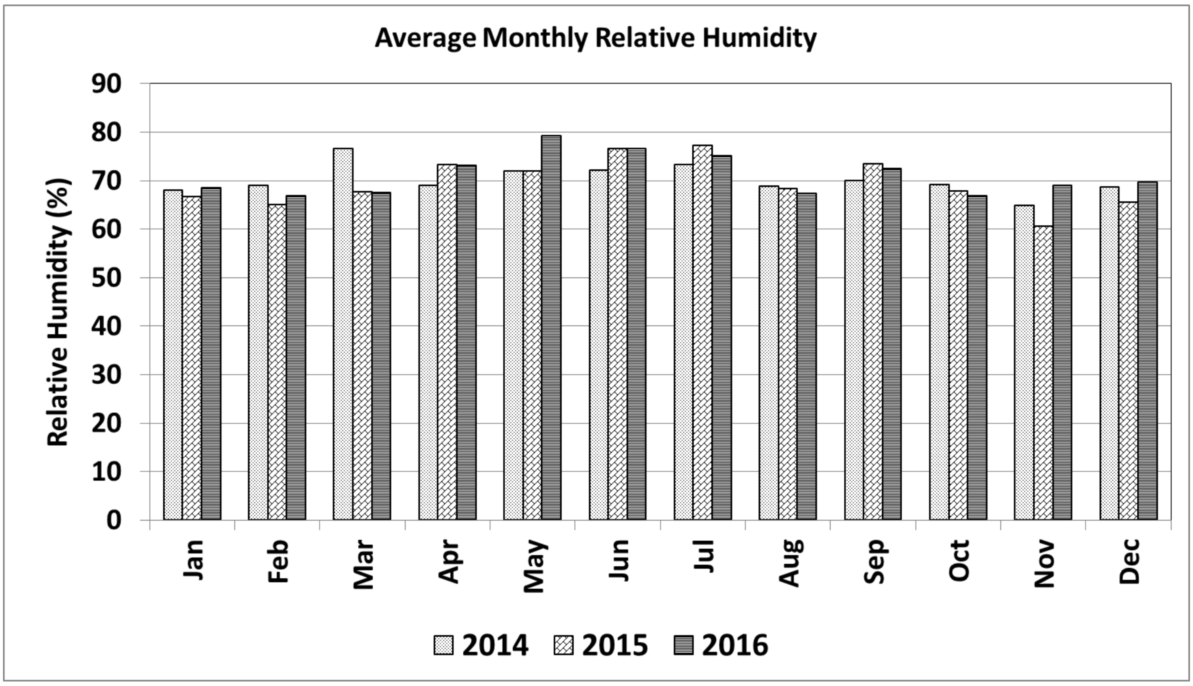

Figure 4-8: Average Monthly Relative Humidity

Table 4-6: Average Monthly Relative Humidity

Relative Humidity (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max	100	100	100	100	100	100	100	100	100	100	100	100	100
Monthly Ave	68	67	71	72	74	75	75	68	72	68	65	68	70

4.2 Air Quality Impact Assessment

4.2.1 Emissions Inventory

Emissions generated from mining activities are often associated with fugitive dust emissions, such as: PM_{10}, $PM_{2.5}$, dust fallout and gaseous emissions such as SO_2, NO_2 and CO mostly from generator sets. Emissions from this Project are likely to be associated with upcast from the ventilation shafts into the ambient atmosphere. Surface emission sources will be limited to the tipping from the incline shaft via conveyor to a bunker, coal crusher and from the surface stockpile area located on the western side of the bunker. The bunker is enclosed, as such emissions from tipping and crushing is considered negligible (as a spray system is present), to further minimise emissions. Emissions inventory took into cognisance emission rates from the two vent shafts (east shaft and south shaft respectively). The emissions rates served as input parameters in a dispersion model environment to predict GLC for the different pollutants assessed. Details of the emissions inventory are discussed below.

The establishment of an emissions inventory forms the basis for any air quality impact assessment. Air pollution emissions may typically be obtained using actual sampling at the point of emission, or estimated from mass and energy balances. Sometimes, emission factors which have been established at similar operations are adopted. Emission factors published by the US-EPA in its AP-42 document "Compilation of Air Pollution Emission Factors (USEPA 1995: 1998) and Australian National Pollutant Inventory "Emission Estimation Technique (EET)" manuals (2012) were employed for estimating emission rates for tipping from the conveyor and from the stockpile.

The ventilation shaft was assessed as a point source emission in the dispersion model environment. The Mine Health and Safety Act, 1996 (Act No. 29 of 1996), aims to ensure the safety of personnel, hence the gazette of the Occupational Exposure Limits (OEL) that should not be exceeded in the work environment. The parameters of the ventilation shafts adopted in this assessment are presented in Table 4-10 below. The South African OELs for the pollutants assessed are presented in Table 4-11 below.

The emissions inventory was conducted considering that the mine is operational for 24 hours/day and 365/year. The various activities associated with the Project are presented in Table 4-7. Activities with negligible implications on ambient air quality will not be assessed.

Table 4-7: Project Activities

Activity No.	Activity
Construction Phase	
1	Site clearance and topsoil removal prior to the commencement of physical construction of the ventilation shaft.
2	Construction of the ventilation shaft.
Operational Phase	
3	Tipping from incline shaft to the bunker
4	Crushing
3	Operation of the ventilation shaft
Decommissioning Phase	
4	Sealing of shaft, rehabilitation and establishment of vegetation

The construction phase is assumed to be short-term (1-year) and potential impacts were assumed to be limited to the vicinity of site activities. The operational phase took cognisance of the proposed mining processes, assuming continuous operation for 24 hours per day, 365 days per year.

Quoting directly from the United States Environmental Protection Agency (USEPA) – AP-42 (2016), …"*air pollutant emission factors are representative values that attempt to relate the quantity of a pollutant released to the ambient air with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages*".

The equation for the estimation of emissions before emission reduction controls are applied is depicted in Equation 1, and once emissions reduction is applied Equation 2 will apply:

$$E = A * EF$$

Equation 1

$$E = A * EF * (1 - \frac{ER}{100})$$

Equation 2

Where:

- E=emission rate
- A=activity rate
- EF=emission factor
- ER=Overall emission reduction efficiency (%)

The basic equations for estimating emission rates employed in the inventory are described in the sections below.

4.2.1.1 Operational Phase

Emission sources associated with operational phase Project encompasses those from the tipping process from inclined shaft to the bunker, and the crushing that followed, including the operation of the two ventilation upcast shafts.

4.2.1.1.1 Tipping

The following equations were used to calculate the total suspended particulates (TSP), PM_{10} and $PM_{2.5}$ emissions associated with loading and offloading of material. Moisture contents of 3.4% for coal and 6.9% for overburden were used. Emission rates for the loading and offloading are calculated using Equations 3 and Equation 4 below.

$$EF_{TSP\,(kg/t)} = k_{TSP} \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}}$$

Equation 3

$$EF_{PM_{10}\,(kg/t)} = k_{PM_{10}} \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}}$$

Equation 4

Where:

- $EF_{TSP(kg/t)}$ = emission factor for total suspended particles (kg/t)
- $EF_{PM_{10}\,(kg/t)}$ = emission factor for PM_{10} (kg/t)
- k_{TSP} = 0.74 for particles less than 30 micrometres aerodynamic diameter
- $k_{PM_{10}}$ = 0.35 for particles less than 10 micrometres aerodynamic diameter
- $U_{(m/s)}$ = mean wind speed (m/s)
- $M_{(\%)}$ = moisture content (% by weight)

4.2.1.1.2 Crushing

Crushing is conducted assuming the ore with moisture greater than 4% by weight, either naturally or by virtue of added water, is considered as a “high moisture” ore. If an ore is “high moisture” at the primary crusher, then it will remain so unless it is dried in the process.

Emissions were quantified using the approach from the NPI emissions factors (NPI, 2012) for coal ore processing. The crushing was assumed for 365 days and the emissions factors are summarized in Table 4-9.

Crushers are used to reduce the size of the ore for ease of processing. In most cases this is a significant source of fugitive dust with large quantities of respirable fractions of dust released into the ambient atmosphere. The crushers will be working for 8760 hours per year. The parameters used in the calculations of the emissions are given below (Table 4-8) and estimated emission Table 4-9.

Table 4-8: Tonnages feed to the Crushers

Source	Tonnes per annum	Moisture content (%)
Crusher	8,000,000	4

Table 4-9: Emissions Factor for the Crushers

Operation/activity	Emission factor			
	High Moisture Content (g/s)		Low Moisture Content (g/s)	
	TSP (a)	PM_{10} (a)	TSP (a)	PM_{10} (a)
Primary crushing	0.01	0.004	0.2	0.02

Source: Reference NPI EET Manual for Mining (NPI, 2012)
The mitigation efficiency adopted was obtained from the NPI EET Manual (NPI, 2012)

Emission rates for crushing was calculated using Equation 5 below

$$EF_{TSP\,(kg/t)} = k_{TSP} \times 0.0016 \times \frac{\left(\frac{U_{(m/s)}}{2.2}\right)^{1.3}}{\left(\frac{M_{(\%)}}{2}\right)^{1.4}}$$

Equation 5

Where:

- $EF_{TSP(kg/t)}$ = emission factor for total suspended particles (kg/t)
- k_{TSP} = 0.74 for particles less than 30 micrometres aerodynamic diameter
- $k_{PM_{10}}$ = 0.35 for particles less than 10 micrometres aerodynamic diameter
- $U_{(m/s)}$ = mean wind speed (m/s)
- $M_{(\%)}$ = moisture content (% by weight)

4.2.1.1.3 Point source emissions

Emission from the ventilation upcast was assessed as a point source, encompassing pollutants such as: PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO respectively based on the South African OELs (worst case scenario) published in the Mine Health and Safety Act (MHSA), 1996 (Act No. 29 0f 1996) in October 2006. The parameters of the ventilation shafts are specified in Table 4-10 and the OEL adopted for the different pollutants are presented in Table 4-11.

Table 4-10: Parameters adopted for the Ventilation Shafts

Source	Diameter (m)	Release Height (m) (1)	Volumetric Flow rate (m^3/s)	Exit Velocity (m/s) (2)	Exit temperature (K) (3)
Up cast shaft 1	7	4	500.4	13	298
Up cast shaft 2	7	4	500.4	13	298

Table 4-11: MHSA OEL (2006)

Pollutant	Occupational Limit	Occupational Limit	Emissions Rate
	(ppm)	(mg/Nm^3)	(g/s)
CO	30	35	17.5
NO_2	3	5	2.5
SO_2	2	5	2.5
PM (PM10)	no standard	10	5.0
PM (PM2.5)		3	1.5

4.2.2 Atmospheric Dispersion Modelling

4.2.2.1 AERMOD Suite of Models

All emission scenarios have been simulated using the USA Environmental Protection Agency's Preferred/Recommended Models: AERMOD modelling system (as of December 9, 2006, AERMOD is fully promulgated as a replacement to ISC3 model). The AERMOD modelling system incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

AERMOD model is capable of providing ground level concentration estimates of various averaging times, for any number of meteorological and emission source configurations (point, area and volume sources for gaseous or particulate emissions), as well dust deposition estimates. Table 4-12 gives an overview of meteorological parameters and basic setup options for the AERMOD model runs.

Table 4-12: Summary of Meteorological and AERMET Parameters used for this Study

Number of grids (spacing)	200 m
Years of analysis	Jan 2014 to Dec 2016
Centre of analysis	26.441558 S, 29.329617 E
Meteorological grid cell resolution	20 km (east-west) x 20 km (south-north)
Station Base Elevation	1606 m
MM5-Processed Grid Cell (Grid Cell Centre)	26.441558 S, 29.329617 E
Anemometer Height	13 m
Surface meteorological stations	1 site at the proposed Trichardt site using data generated by AERMET
Upper air meteorological stations	1 site at the proposed Trichardt site using data generated by AERMET
Simulation	2561 hours (Jan 2014 to Dec 2016)
Sectors	0.28 (generated with the AERMOD Model – when the land use types are specified)
Albedo	
Surface Roughness	0.0725
Bowen Ratio	0.75
Terrain Option	Elevated

Geophysical data required in the in the model, such as land use type and terrain elevation are defined in AERMET and AERMAP respectively. Often, the in-built land use classification type and the terrain heights derived from the 90 m SRTM DEM product are employed. Land use and terrain exact strong influence on wind speed and turbulence, which are key components for dispersion. Additional, AERMOD model system input parameters include: emissions source data, meteorological data and information on the receptor grid.

5 Evaluation of Model Results

Modelling results consist of graphical representation of ground level concentrations (GLC) of pollutants. The graphical representations are shown in Figure 5-1 to Figure 5-8.

Simulations were undertaken to determine the GLC of PM_{10}, $PM_{2.5}$, dust deposition (≥ 30 µm), NO_2, SO_2 and CO.

The daily average concentrations were calculated as the 4th highest value (99th percentile). Annual mean values were shown as the highest values (100th percentile). The predicted hourly, daily and annual GLC for each of the modelled pollutants at selected receptors are summarised in Table 5-1.

5.1 Isopleth Plots and Evaluation of Modelling Results

5.1.1 PM_{10} Predicted Impacts

Isopleth showing 24-hour (daily) GLC of PM_{10} attributed to the proposed operation of the ventilation shafts and associated facilities is presented in Figure 5-1. Exceedance of the South African standards of 75 µg/m³ is confined within the Project boundary, with the exception of some locations at the southern boundary. In terms of spatial impact, much of the area impacted is within the licence area. Therefore, predicted concentrations at the selected receptors are below the South African standard.

The predicted concentrations are the likely additions that the proposed project will add onto the ambient air quality and not cumulative impact from all the existing sources in the area. *It is therefore possible that the highest daily concentration predicted to occur at a certain location may only be true for one day during the entire period.* Once mitigation measures were applied, the zone of exceedances was minimised further.

The predicted annual GLC for PM_{10} were too low to plot (no isopleth displayed). Hence, predicted GLC are within the current South African standard (40 µg/m³) at the Project area.

5.1.2 $PM_{2.5}$ Predicted Impacts

The predicted 24-hour (daily) GLC for $PM_{2.5}$ attributed to the proposed Project is presented in Table 5-1 below. This isopleth plot of GLC without mitigation measures does not exceed the µg/m³ at the Project boundary. Exceedances were within the Project boundary. If mitigation measure were to be applied, the predicted GLC will become negligible.

The annual GLC attributed to the proposed project could not display the associated isopleths because predicted values were very low. Hence, this is not presented and discussed in this report. The predicted zone of exceedance was limited to the Project area boundary.

5.1.3 Dust Deposition

The predicted dust deposition rates anticipated from the proposed operation of the ventilation shafts and associated facilities show that dust levels will be lower than the residential and non-residential limits of 600 mg/m^2/day and 1200 mg/m^2/day within the Project boundary (Figure 5-2). The predicted dust deposition rates at the mine boundary are below 1 200 mg/m^2/day (NDCR 2013) recommended standard for industrial areas. This pollutant will not present a concern during the operational phase of the project (Figure 5-2). Major contributions are coming from tipping from the incline conveyor, crusher and wind erosion of the stockpile to the west of the bunker respectively. The dust deposition rates predicted at the sensitive receptors are below the recommended standard of 600 mg/m^2/day and within compliance.

It should be noted that isopleth plots reflecting monthly averaging periods contain only the highest predicted ground level concentrations for that averaging period, over the entire period for which simulations were undertaken. These isopleths are likely concentrations that the proposed Project would exert on ambient air quality and not cumulative impact from all other sources. *It is therefore possible that even though a high daily concentration is predicted to occur at certain locations, that this may only be true for month during the entire period.*

5.1.4 Predicted Nitrogen Dioxides (NO_2) Concentrations

The hourly and annual South African standards for NO_2 are 200 µg/m^3 and 40 µg/m^3 respectively. The predicted hourly concentration can lead to exceedance of the standard in the vicinity of the vent raise, with potential to go beyond the southern portion of the Project boundary (Figure 5-3) without mitigation measures.

The predicated annual ground level concentrations are very low, lower than the South African standard. Emissions are restricted to the vicinity of the shaft and confined to a very small footprint within the Project area. The predicted GLC at the selected sensitive receptors are presented in Table 5-1.

5.1.5 Predicted Sulfur Dioxides (SO_2) Concentrations

The hourly and 24-hours South African standard for SO_2 of 350 µg/m^3 and the 125 µg/m^3 are predicted to be exceeded in the vicinity of the ventilation shaft vent raise and some metres away (Figure 5-5 and Figure 5-6). Emissions over the short averaging periods can present a problem. However, over a longer averaging period, emissions are observed to be lower and in compliance with the standard. The GLC predicted at the at the Project boundary, and at selected sensitive receptors are generally lower and within compliance. It is worth mentioning that the GLC predicted, represents the worst-case scenario and without mitigation measures in place.

The predicted GLC at the nearest receptors are presented in Table 5-1 and shown to be very low and within compliance.

5.1.6 Predicted Carbon Monoxide (CO) Concentrations

The 1-hour and 8-hours CO South African standards of 30 000 µg/m^3 (30 mg/m^3) and 10 000 µg/m^3 (10 mg/m^3) are used in this report. The predicted carbon monoxide concentrations were very low and below the standard within the mine and restricted to the vicinity of the shaft vent raise. The impacts are limited to the vicinity of the vents. The GLC at the nearby receptors are below the standard and within compliance (Figure 5-7 and Figure 5-8.

Table 5-1: Predicted GLC of PM_{10}, $PM_{2.5}$, NO_2, SO_2 and CO at selected sensitive receptors

Pollutant	Averaging Period	Ambient Air Quality Standard (µg/m^3)	Levels at receptors (µg/m^3)		
			Trichardt	Secunda	Informal Settlement
PM_{10}	24 Hours	75(1)	4.6	2.1	1.7
	Annual	40(1)	0.3	0.2	0.1
$PM_{2.5}$	24 Hours	40(2)	1.4	0.6	0.5
	Annual	20(2)	0.08	0.06	0.04
Dust Deposition (mg/m^2/day)					
Dust Deposition	Monthly	600(3)	4.4	1.5	2.9
Gasses (µg/m^3)					
NO_2	1 Hour	200(1)	15.1	6.7	5.2
	Annual	40(1)	0.09	0.07	0.05
SO_2	1 Hour	350(1)	28.9	8.8	8.4
	24 Hours	125(1)	1.8	0.8	0.6
Gasses (mg/m^3)					
CO	1 Hour	30(1)	0.3	0.1	0.1
	8 Hours	10(1)	0.04	0.02	0.01

(1) National Ambient Air Quality Standards, 2009 (NAAQS)
(2) National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter Less Than 2.5 Microns Meter ($PM_{2.5}$)
(3) National Dust Control Regulation 2013: “Dust fallout Standards”

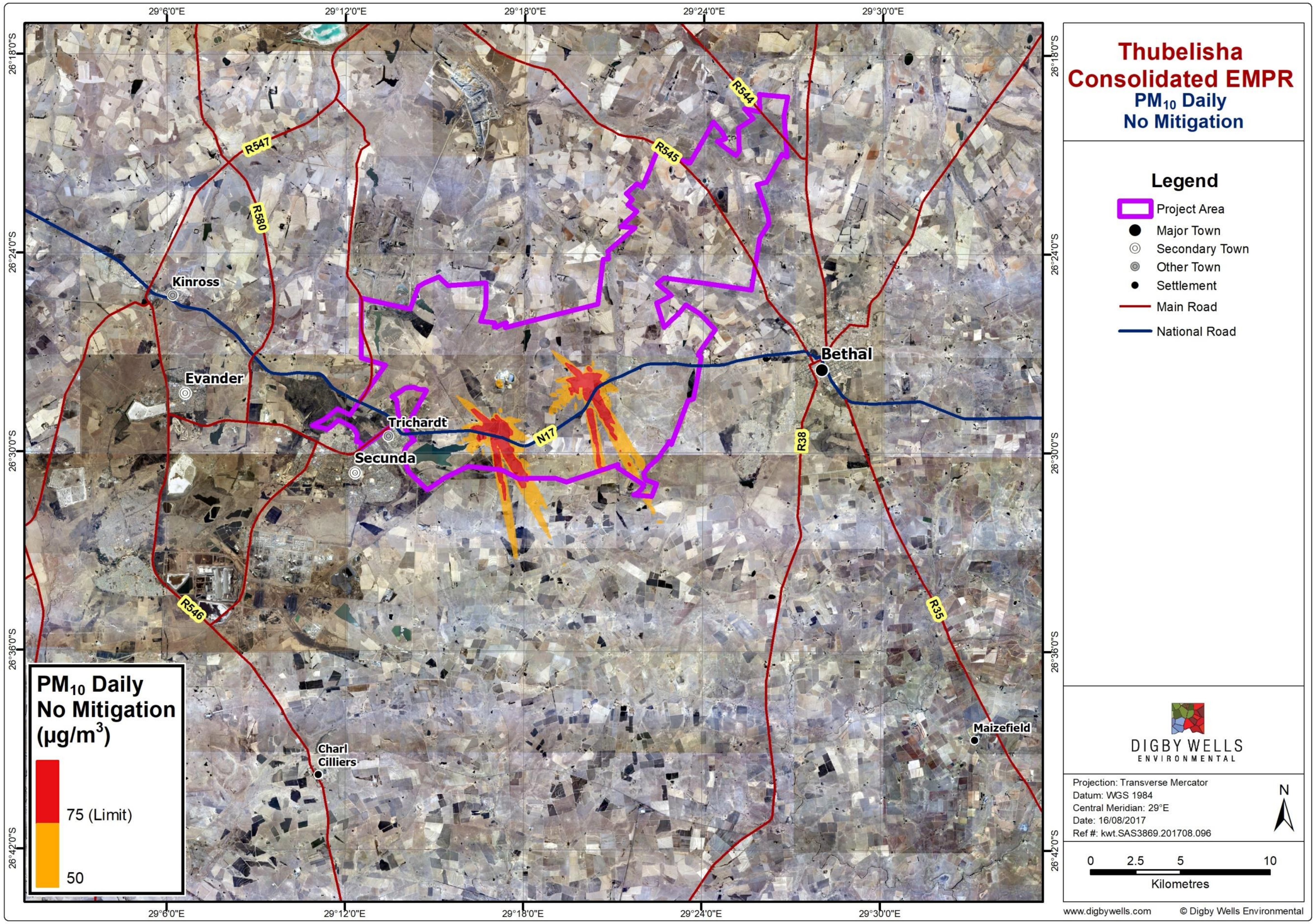

Figure 5-1: Predicted 24-hr average PM_{10} concentrations - No mitigation (µg/m^3)

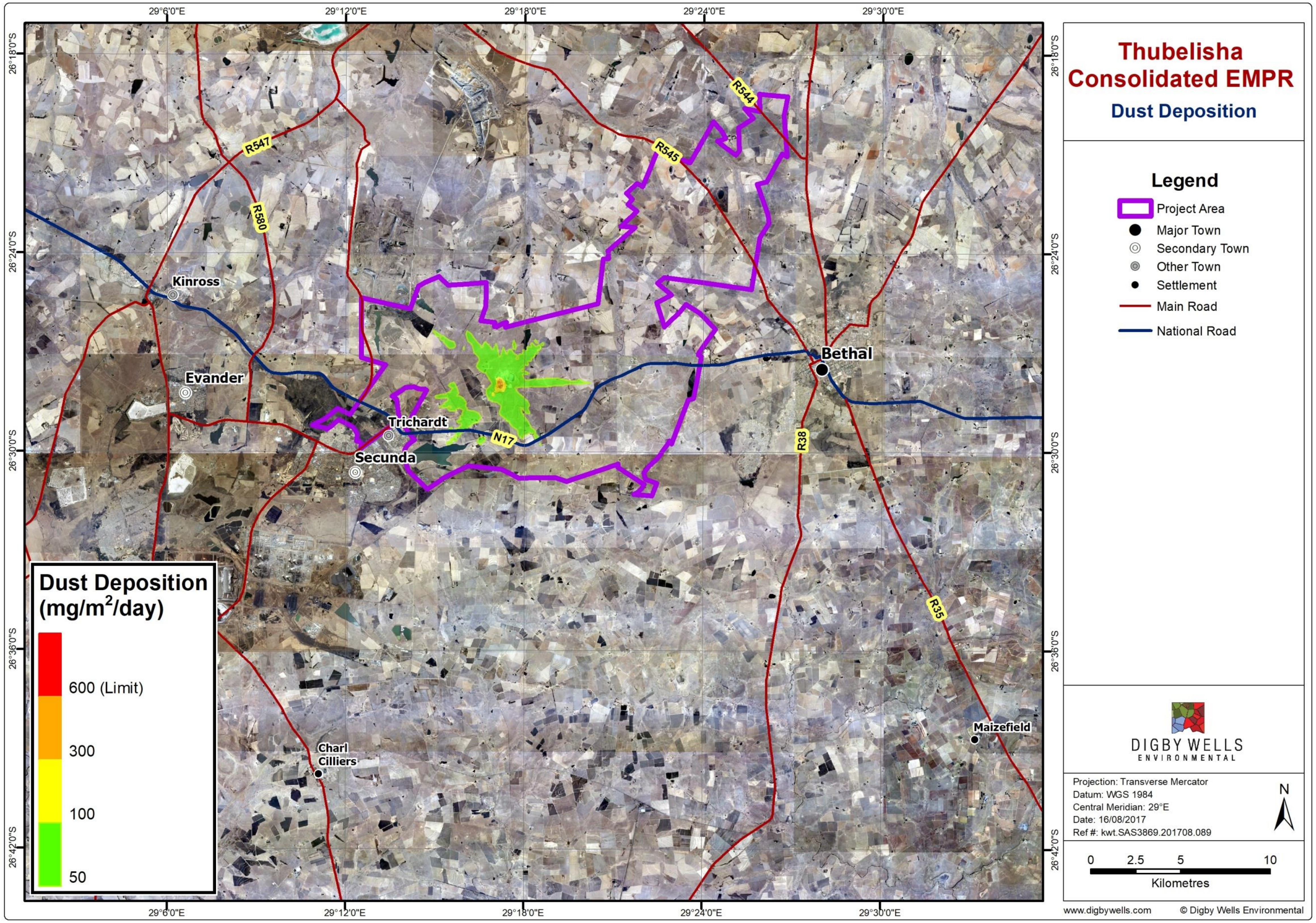

Figure 5-2: Predicted maximum (100th percentile) dust deposition (mg/m²/day) - No mitigation

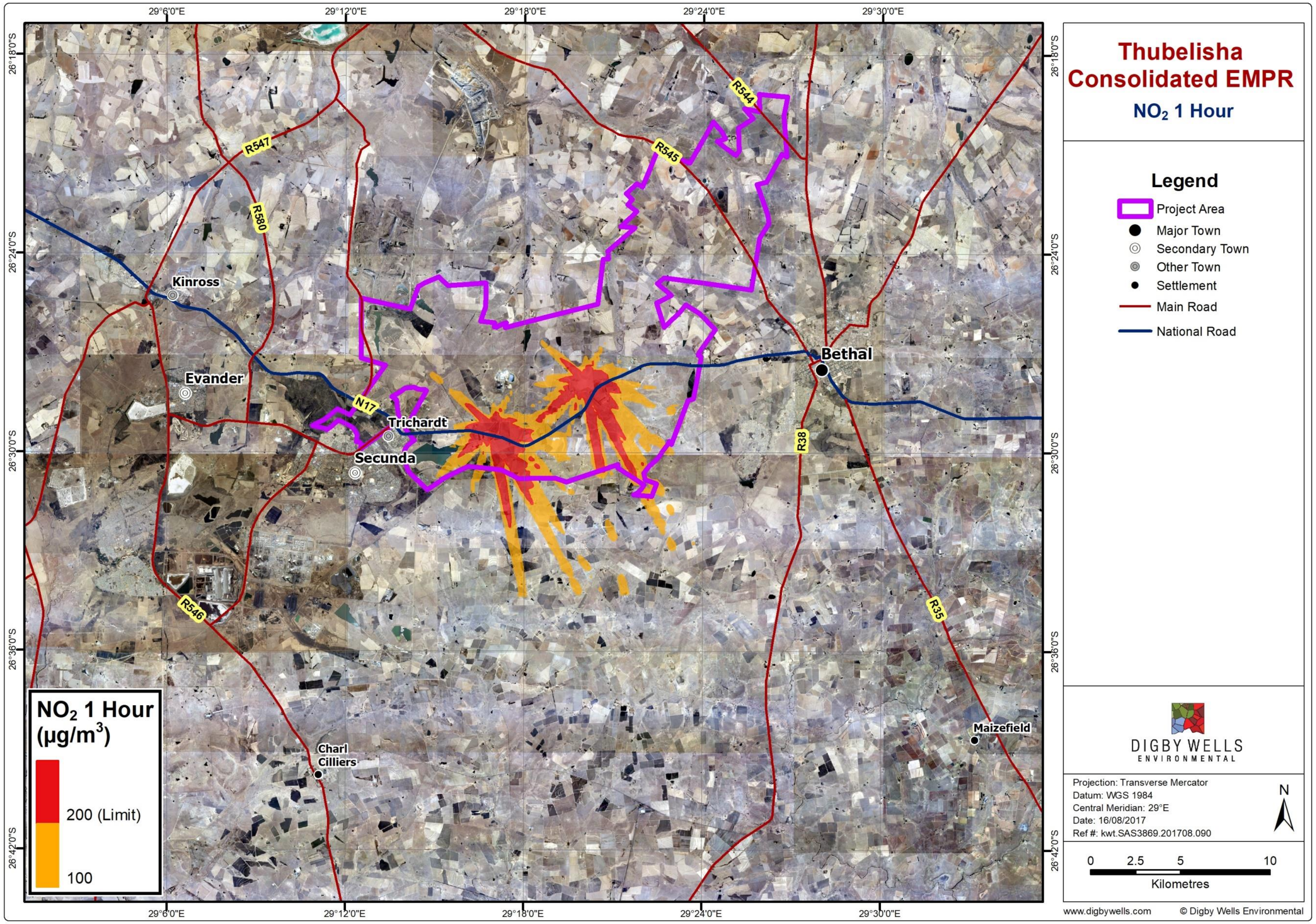

Figure 5-3: Predicted NO_2 1-Hour concentrations (µg/m^3), No mitigation

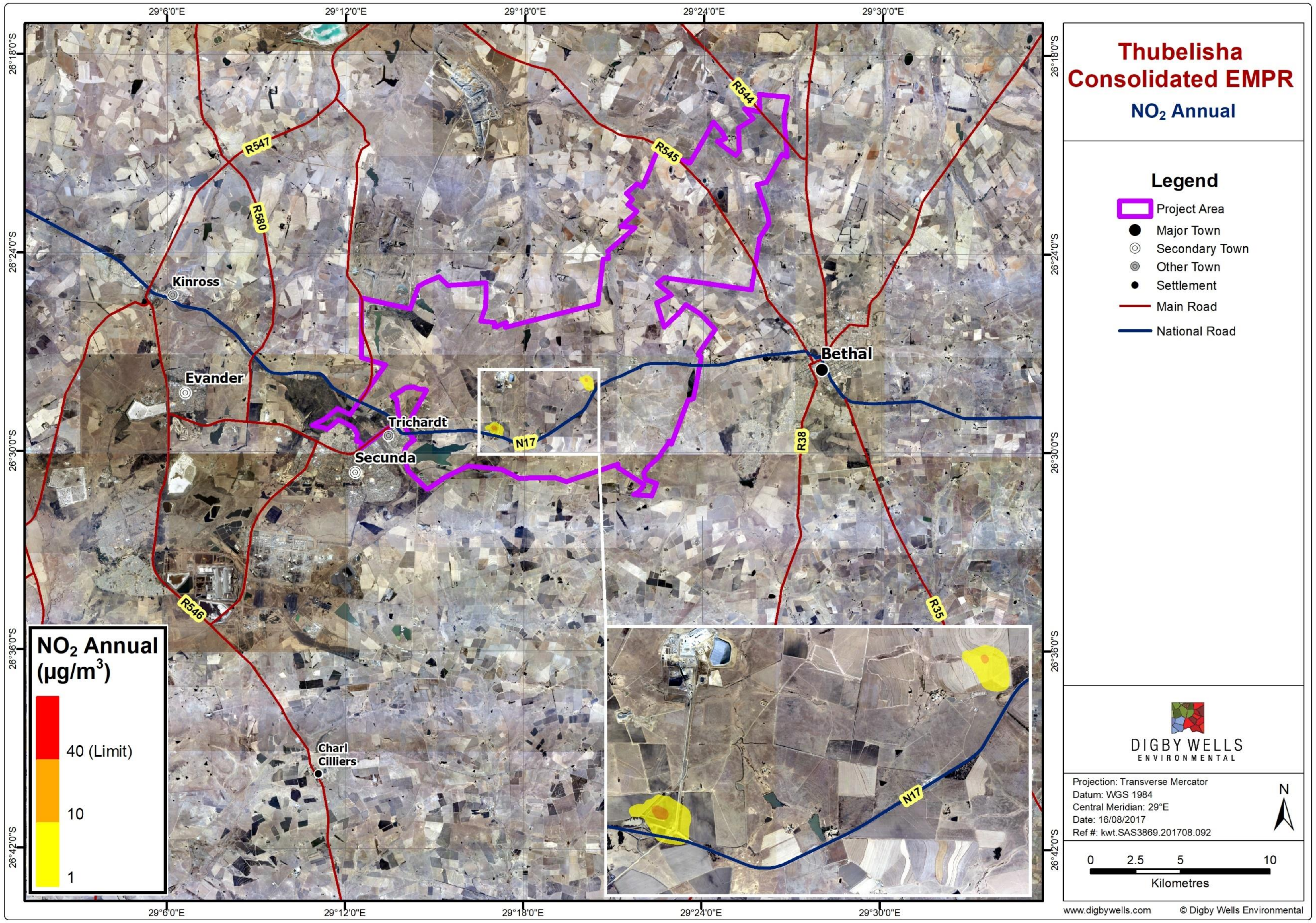

Figure 5-4: Predicted NO_2 Annual concentrations (µg/m³), No mitigation

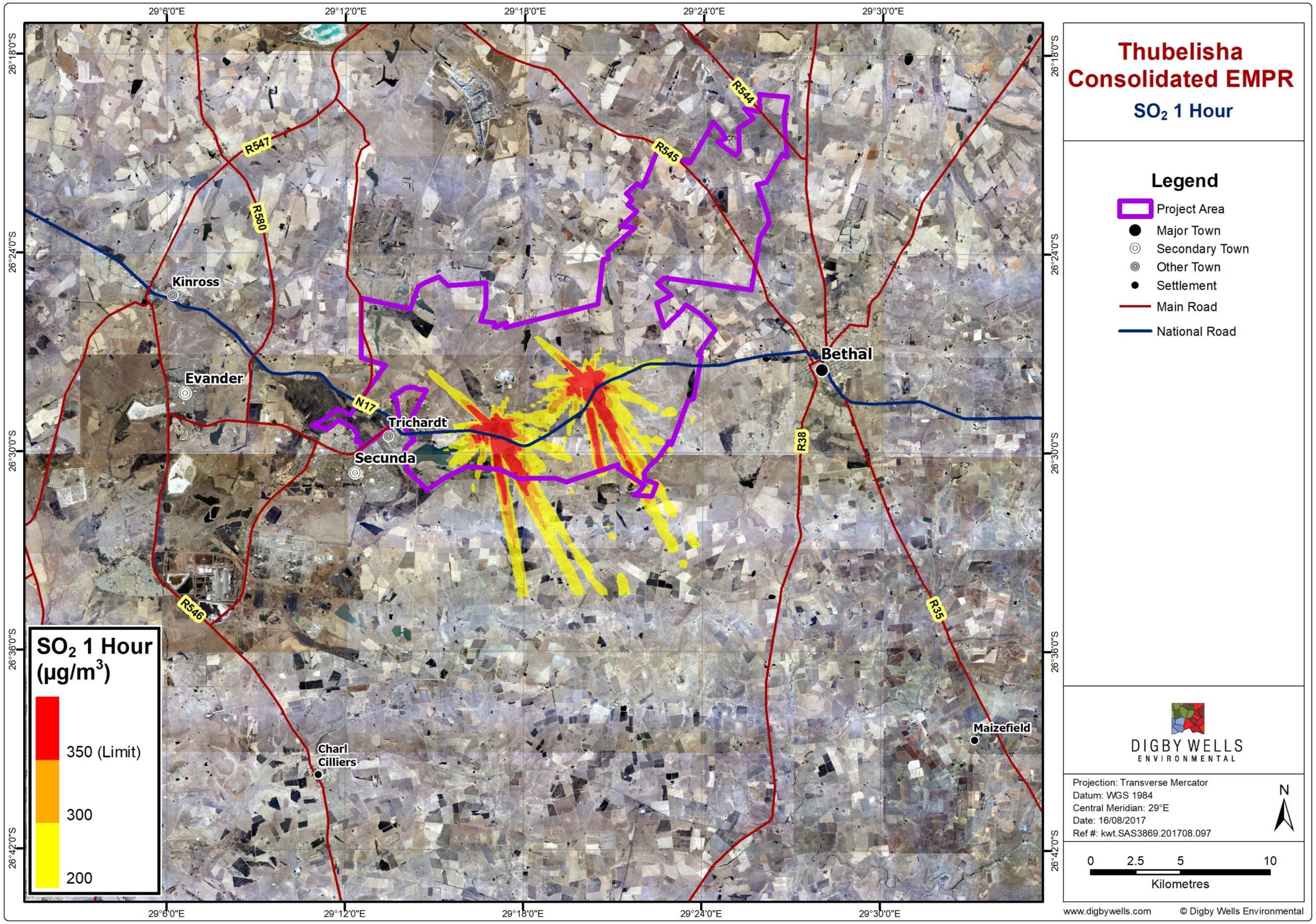

Figure 5-5: Predicted SO_2 1-Hour concentrations (µg/m^3), No mitigation

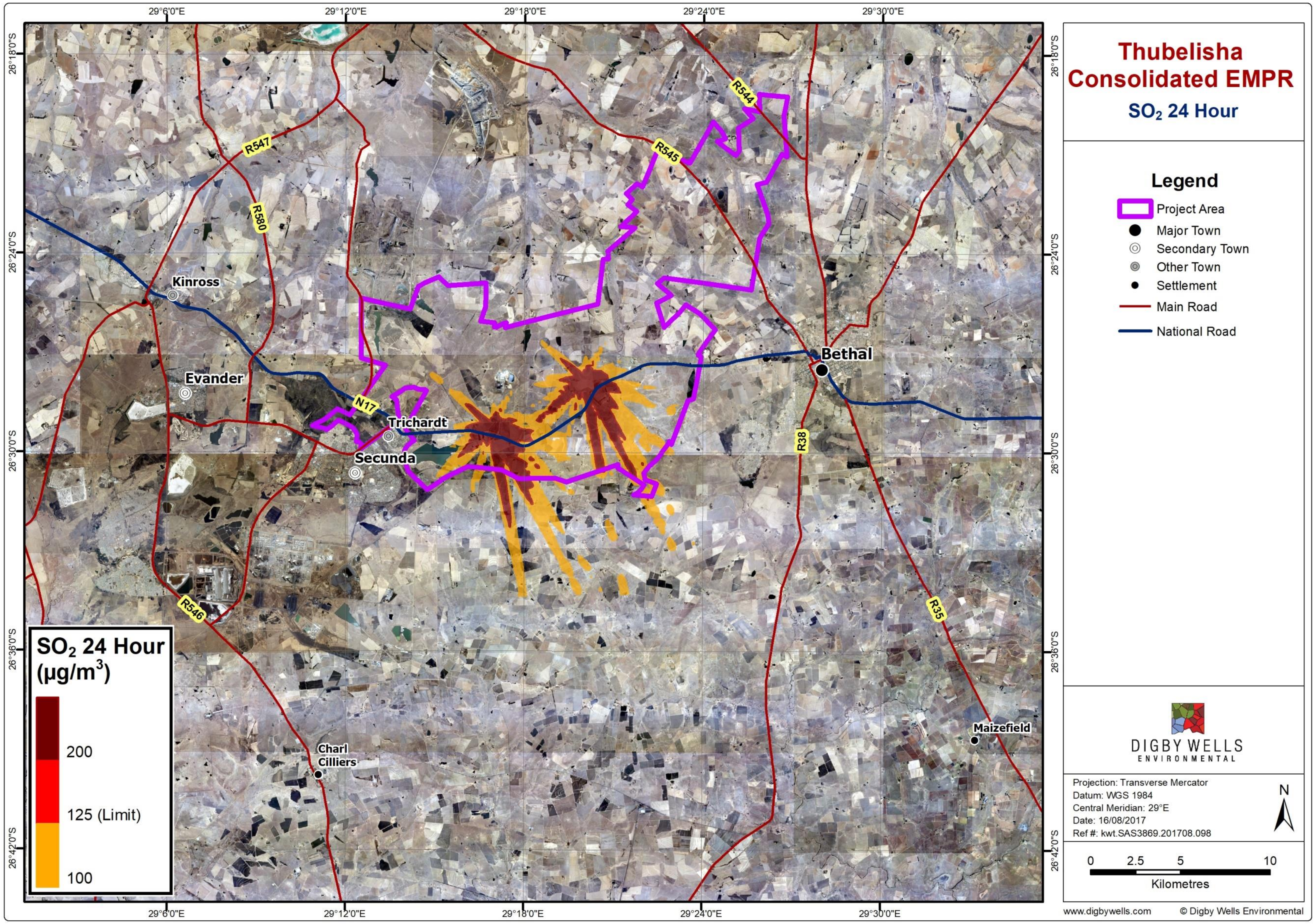

Figure 5-6: Predicted SO_2 24-Hours concentrations (µg/m^3), No mitigation

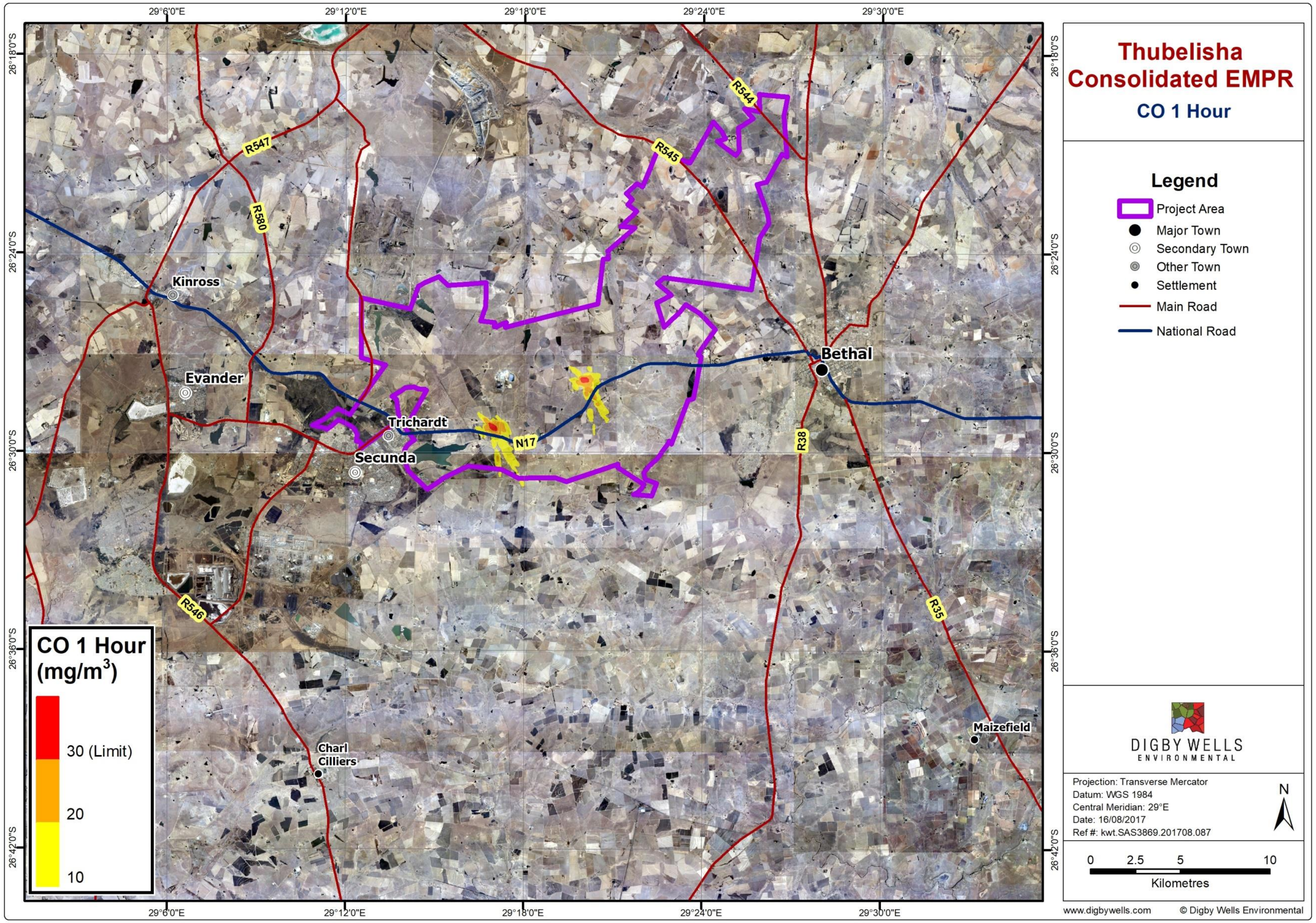

Figure 5-7: Predicted CO 1-Hour concentrations (µg/m³), No mitigation

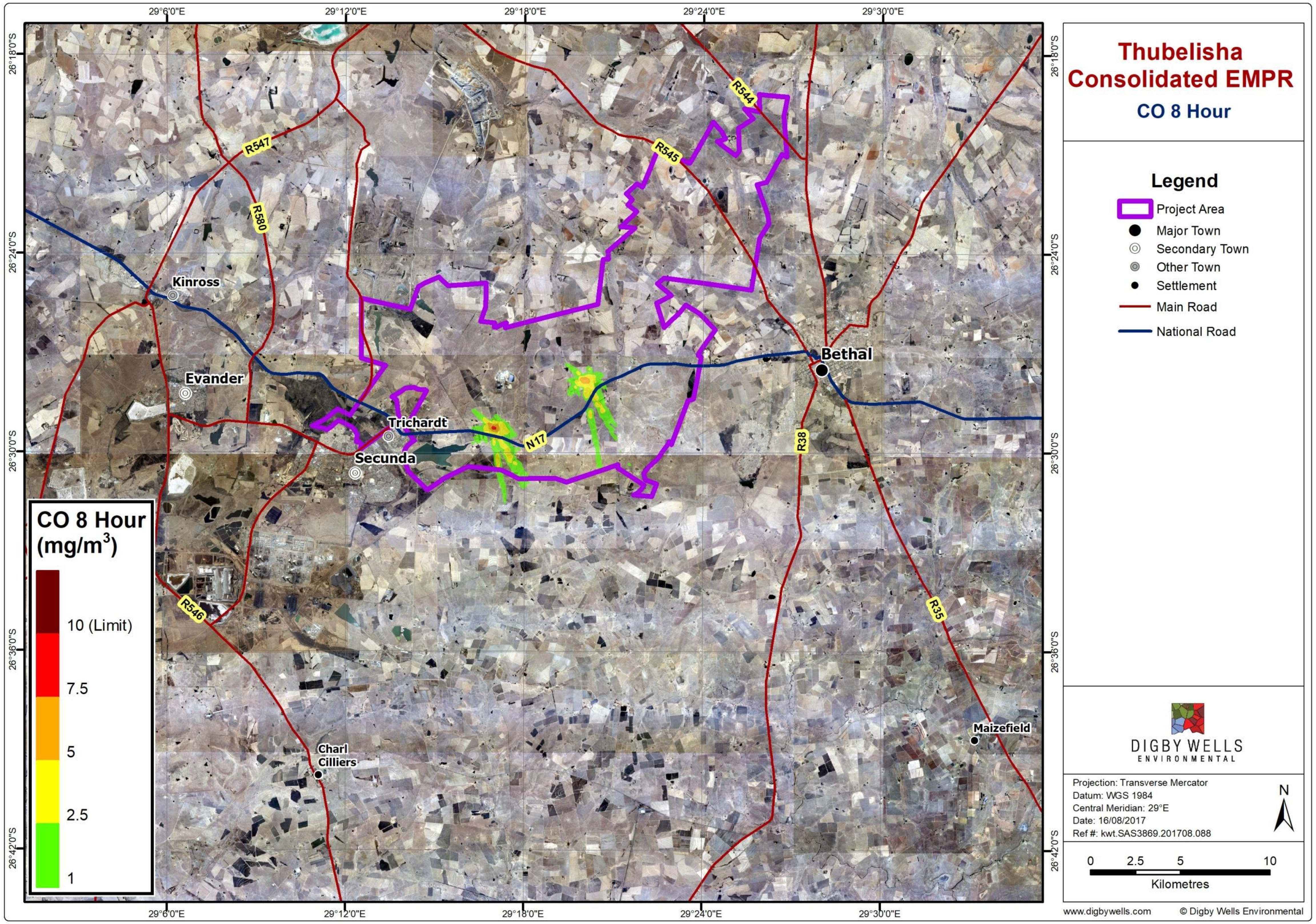

Figure 5-8: Predicted CO 8-Hours concentrations (µg/m^3), No mitigation

5.2 Discussion

The impacts arising from the operation phase of the project have been appraised using model prediction of GLC and the spread of pollutants across the landscape.

5.2.1 Findings

The predicted GLC show that emissions associated with the short averaging periods can present a problem during the operational phase of the project. In terms of spatial impacts, the zones of exceedances for the pollutants assessed are confined to the vicinity of the vent i.e. 30 m to 40 m away. The predicted GLC presented and discussed in this report are the worst-case scenario, with the emissions rates applied at 100% of the South African OEL. However, if conditions are curtailed within the project area during the operational phase, associated impacts on-site and offsite are expected to be negligible. The main findings of this AQIA study can be summarised as follows:

- Daily PM_{10} – Predicted GLC are in exceedance (≥ 75 µg/m^3) at the vent area and some 20 m to 40 m away. GLC at the Project boundary and sensitive receptors are generally below the standard and within compliance levels.
- Annual PM_{10} – Predicted GLC are very low at the Project boundary and at sensitive receptors (Table 5-1).
- Daily $PM_{2.5}$ – Exceedances (≥ 40 µg/m^3) are limited to the vicinity of the vent raise and the project area. Predicted GLC at the Project boundary and the nearby receptors are below the standard.
- Annual $PM_{2.5}$ – Predicted annual concentrations did not exceed the current South African limit (20 µg/m^3). The model could not generate isopleths because the predicted concentration was too low to plot. Hence, not presented in this report
- The dust deposition rates predicted were below the residential and non-residential limits of 600 mg/m^2/day and 1 200 mg/m^2/day.
- Hourly NO_2 - The predicted NO_2 concentrations predicted at the proposed Project area are exceeded in the vicinity of the vent shaft, with the zone of exceedance reaching some 30 m in the southeast direction. GLC at the Project boundary and at nearby receptors are below the standard.
- Annual NO_2 – Predicted annual GLC did not exceed the existing South African standard (40 µg/m^3), onsite and offsite.
- 1-hour SO_2 GLC was in exceedance within a radius of 20 m to 40 m, especially in the southeast direction. As with the other pollutants, GLC at the nearby receptors were below standard.
- 24-hours SO_2 GLC predicted is similar to the 1-hour plot in spatial impacts. GLC are within the South African standard of 125 µg/m^3 at the Project boundary and identified receptors.

- Hourly CO – Predicted maximum hourly concentrations are within the regulatory limit value. No exceedance of the South African standard of 30,000 µg/m^3 was predicted.

All the simulations were done for the worst case scenario, assuming that the emission rates are at 100% of the South African OEL and no mitigation measures were in place. It was assumed that the sources are operational for 24-hours a day, all seven days a week, 350 days per year.

6 Impact Assessment

6.1 Methodology used in Determining and Ranking the Nature, Significance, Consequence, Extent, Duration and Probability of Potential Environmental Impacts and Risks

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature

Where

Consequence = Intensity + Extent + Duration

And

Probability = Likelihood of an impact occurring

And

Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 6-3. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this EIA/EMP Report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 6-2, which is extracted from Table 6-1. The description of the significance ratings is discussed in Table 6-3.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 6-1: Impact Assessment Parameter Ratings

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts. Irreparable damage to highly valued items.	On-going and widespread benefits to local communities and natural features of the landscape.	Province/ Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area.	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources or low sensitive environments, not affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures. <10% probability.

Rating	Intensity/Replicability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature = -1)	Positive Impacts (Nature = +1)			
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management.	Highly unlikely / None: Expected never to happen. <1% probability.

Table 6-2: Probability/Consequence Matrix

Probability	Significance																																					
7	-147	-140	-133	-126	-119	-112	-105	-98	-91	-84	-77	-70	-63	-56	-49	-42	-35	-28	-21	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147
6	-126	-120	-114	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54	-48	-42	-36	-30	-24	-18	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126
5	-105	-100	-95	-90	-85	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30	-25	-20	-15	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
4	-84	-80	-76	-72	-68	-64	-60	-56	-52	-48	-44	-40	-36	-32	-28	-24	-20	-16	-12	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
3	-63	-60	-57	-54	-51	-48	-45	-42	-39	-36	-33	-30	-27	-24	-21	-18	-15	-12	-9	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
2	-42	-40	-38	-36	-34	-32	-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42
1	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	-21	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Consequence																																					

Table 6-3: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive)
36 to 72	An important positive impact. The impact is insufficient by itself to justify the implementation of the project. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive)
-3 to -35	An acceptable negative impact for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative)
-36 to -72	An important negative impact which requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative)
-73 to -108	A serious negative impact which may prevent the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe effects	Moderate (negative)
-109 to -147	A very serious negative impact which may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative)

6.1.1 Impact Assessment Rating

6.1.1.1 Construction Phase

6.1.1.1.1 Project activities assessed

As part of the Construction Phase, the following activities are identified that may impact on the ambient air quality of the area i.e. increasing particulate matter loading in the atmosphere:

Table 6-4: Interactions and Impacts of Construction Phase

Interaction	Impact
Site Clearing	▪ Dust emissions due to the generation of airborne dust ▪ Soiling of surfaces due to fall out dust
Construction of ventilation shaft	

6.1.1.1.2 Impact Description

Removal of vegetation using a range of construction equipment prior to the development of the ventilation shaft and vent raises will lead to the generation of fugitive dust comprising TSP, PM_{10} and $PM_{2.5}$. The sinking of the shaft will result in blasting and generation of fugitive dust. This activity is short-term and area impacted is considered minimal and impacts on the atmospheric environment will cease once the construction phase ends.

6.1.1.1.3 Management Objectives

The management objective is to ensure that emissions on-site and off-site impacts due to site clearing and sinking of the ventilation shafts are not in exceedance of the applicable regulatory standards for the protection of the environment, human health and wellbeing.

6.1.1.1.4 Management Actions and Targets

The mine management should have in place action plans and target to ensure that pollution levels are compliant with regulatory standards.

6.1.1.1.5 Construction Phase Impact Ratings

The impact rating took cognisance of the duration (how long the impact may be prevalent), the spatial scale (the physical area which could be affected by an impact), the severity (how severe the impact will be) and the probability of the impact occurring (which is related to the likelihood of such an impact happening). The ratings ascribed to each of the aforementioned are discussed in Table 6-5.

Table 6-5: Development of ventilation shaft

Activity and Interaction (Site Clearing and Development of Mine Infrastructure)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in ambient air quality due to dust generation and soiling of surfaces			
Prior to mitigation/ management			
Duration	Short term (1)	Dust will be generated for the duration of the construction phase	Negligible (negative) – 20
Extent	Limited (2)	Limited to the project area and immediate surroundings	
Intensity	Minor (2)	Minor effect on surrounding area	
Probability	Probable (4)	There is a possibility that generated dust will impact ambient air quality	
Nature	Negative		
Mitigation/ Management actions			
▪ Application of dust suppressant on exposed areas; ▪ Set maximum speed limits on site and to have these limits enforced; ▪ The area of disturbance at all times must be kept to the development footprint and no unnecessary clearing, digging or scraping must occur; ▪ The drop heights when loading onto trucks and at tipping points should be minimised.			
Post- mitigation			
Duration	Short term (1)	Dust generation will be less than 1 year and is reversible	Negligible (negative) – 12
Extent	Very Limited (1)	Impacts will be limited to isolated parts of the site	
Intensity	Minimal (1)	Minimal impacts on air quality after mitigation	
Probability	Probable (4)	Probable that impact on ambient air quality will occur	
Nature	Negative		

6.1.1.2 Operational Phase

6.1.1.2.1 Project Activities Assessed

As part of the Operational Phase of the Project, the following activities are identified that may impact on the ambient air quality of the area i.e. increasing the concentration of pollutants in the atmosphere:

- Tipping to the bunker; and
- Crushing at the bunker; and
- Operation of the ventilation shaft.

Table 6-6: Interactions and Impacts of Tipping and Crushing

Interaction	Impact
▪ Tipping ▪ Crushing	Reduction in air quality due to the emission of particulate matter

6.1.1.2.2 Impact Description

The mining process will involve the hoisting of materials from underground to surface via the incline shaft to the bunker and crushing. The impact on ambient air quality is limited.

6.1.1.2.3 Management Objectives

The management objective is to ensure that emissions on-site and off-site from mining processes are not in exceedance of the applicable standards for the protection of the environment, human health and wellbeing.

6.1.1.2.4 Management Actions and Targets

Based on the findings of this study, a screening monitoring is imperative. Implementation of emissions reduction programme to lower emissions.

Table 6-7: Mining Process: Tipping and Crushing

Activity and Interaction (Tipping and crushing)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Impact will be for the project life	Minor (negative) – 27
Extent	Limited (2)	Airborne dust limited to project site.	
Intensity x type of impact	Minor - negative (-2)	Minor. Very little change to the baseline.	

Activity and Interaction (Tipping and crushing)			
Dimension	**Rating**	**Motivation**	**Significance**
Probability	Unlikely (3)	Impacts are unlikely.	
Mitigation/ Management actions			
▪ Enclosure of tipping points and crusher; and ▪ Use of water spray.			
Post- mitigation			
Duration	Project life (5)	Impact will be for the project life	Negligible (negative) – 7
Extent	Very Limited (1)	Impacts will be very limited to the project site.	
Intensity x type of impact	Minimal - negative (-1)	Minimal Impacts	
Probability	Highly unlikely (1)	It is unlikely that dust emissions will have an effect on ambient air quality.	

Table 6-8: Interactions and Impacts of Vent Shaft

Interaction	Impact
Ventilation shaft	Reduction in air quality due to the emission of particulates and gaseous pollutants

6.1.1.2.5 Impact Description

The mining process will involve the ventilation of pollutants generated underground via the vent shaft upcast to the ambient environment. The impact on ambient air quality is limited.

6.1.1.2.6 Management Objectives

The management objective is to ensure that emissions on-site and off-site from the operation of the ventilation shaft are not in exceedance of the applicable standards for the protection of the environment, human health and wellbeing.

6.1.1.2.7 Management Actions and Targets

Based on the findings of this study, a screening monitoring is imperative. Implementation of emissions reduction programme to further lower emissions.

Table 6-9: Operation of the Ventilation Shaft

Activity and Interaction (Operation of the Ventilation Shaft)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Impact will be for the project life	Minor (negative) – 27
Extent	Limited (2)	Airborne dust limited to project site.	
Intensity x type of impact	Minor - negative (-2)	Minor. Very little change to the baseline.	
Probability	Unlikely (3)	Impacts are unlikely	
Mitigation/ Management actions			
▪ Use of electrostatic precipitators; ▪ Selective Catalytic Converters; and ▪ Scrubbers.			
Post- mitigation			
Duration	Project life (5)	Impact will be for the project life	Negligible (negative) – 7
Extent	Very Limited (1)	Impacts will be very limited to the project site.	
Intensity x type of impact	Minimal - negative (-1)	Minimal Impacts	
Probability	Highly unlikely (1)	It is highly unlikely that dust emissions will have adverse effect on ambient air quality.	

6.1.1.3 Decommissioning Phase

6.1.1.3.1 Project Activities Assessed

As part of the Decommissioning Phase, the following activities are identified that may impact on the ambient air quality of the area i.e. increasing particulate matter concentration in the atmosphere:

- Sealing of shaft and rehabilitation.

Table 6-10: Interactions and Impacts of Decommissioning and Removal of Infrastructure

Interaction	Impact
Sealing of shaft and rehabilitation	Dust emissions and reduction in air quality

6.1.1.3.2 Impact Description

The dismantling of mine infrastructure, removal of rubble and sealing of the ventilation shaft leads to the generation of dust. The subsequent rehabilitation of the project area including sealing of shafts will involve the use of heavy machinery and vehicles similar to the construction phase. This will result in the release of fugitive dust containing TSP, PM_{10} and $PM_{2.5}$.

6.1.1.3.3 Management Objectives

The management objective is to ensure that emissions on-site and of-site from the dismantling process, sealing of shaft and subsequent rehabilitation of the project area are not in exceedance of the applicable standards.

6.1.1.3.4 Management Actions and Targets

Adoption of a realistic emissions reduction programme to assess performance and compliance to applicable standards.

Table 6-11: Significance rating for sealing of Vent Shafts and Rehabilitation

Activity and Interaction (Sealing of Vent Shaft and rehabilitation results in dust emission)			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Medium term (3)	Impact on air quality will be medium term for this phase	Negligible (negative) – 27
Extent	Local (3)	Limited to the site and its immediate surroundings	
Intensity x type of impact	Moderate short term (3)	Moderate impact is expected	
Probability	Unlikely (3)	Likely that dust will impact on the nearby receptors.	
Mitigation/ Management actions			
▪ Drop heights should be minimised when offloading materials; ▪ Limit rehabilitation activities to non-windy days; and ▪ Rehabilitation in accordance with rehabilitation plan; ▪ Dust suppression on exposed surfaces.			
Post- mitigation			
Duration	Medium term (3)	Impact on air quality will be medium term for the duration this phase	Negligible (negative) – 12

Activity and Interaction (Sealing of Vent Shaft and rehabilitation results in dust emission)			
Dimension	**Rating**	**Motivation**	**Significance**
Extent	Limited (2)	Airborne dust will be limited to the development site area.	
Intensity x type of impact	Minimal (1)	Minimal dust impact	
Probability	Rare (2)	Rare that dust will impact nearby receptors.	

7 Environmental Management Programme

The objective of an Environmental Management Plan (EMP) is to present mitigation to (a) avoidable adverse impacts associated with the development of a project and (b) to enhance potential positives.

7.1 Summary of Mitigation and Management

Table 7-1 to Table 7-3 provide a summary of the proposed project activities, environmental aspects and impacts on the receiving environment. Information on the frequency of mitigation, relevant legal requirements, recommended management plans, timing of implementation, and roles / responsibilities of persons implementing the EMPr. Table 7-4 dwells on the applicable standards.

Table 7-1: Project Activities Requiring Management

Activities	Phase	Size and Scale of Disturbance	Mitigation Measures	Compliance with Standards	Time Period for Implementation
Site Clearing	Construction	▪ The area to be disturbed is very small Impact is limited to the site and immediate surroundings.	▪ Site clearing must be done in phases and use of suppressants and binders on exposed areas to reduce dust generation; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s); ▪ The drop heights when loading onto trucks and at tipping points should be minimised; ▪ Dust suppression must take place on exposed surfaces.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004 standards 2009; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013). ▪ Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters (PM 2.5) 2012 ▪	▪ Mitigation measures should be concurrent with operation.
Sinking of Vent Shafts	Construction	▪ Small area, impact will be limited to the site and immediate surroundings.	▪ Activity must be carried out judiciously to ameliorate dust emissions.	▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters (PM 2.5) ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013).	▪ Mitigation measures should be concurrent with operation.

Activities	Phase	Size and Scale of Disturbance	Mitigation Measures	Compliance with Standards	Time Period for Implementation
Crushing of Ore at the Bunker	Operational	▪ Impact will be localized, limited to the site and immediate surroundings.	▪ Use of water sprays; and ▪ Enclosure of crushers.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004 standards 2009; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013). ▪ Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters (PM 2.5) 2012.	▪ Mitigation measures should be concurrent with operation.
Stockpiling	Operational	▪ Impact will be localized, limited to the site and immediate surroundings.	▪ The use of dust suppressants and binders on exposed areas	▪ National Environmental Management: Air Quality Act, Act.39 of 2004 standards 2009; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013). ▪ Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters (PM 2.5) 2012.	▪ Mitigation measures should be concurrent with operation.

Activities	Phase	Size and Scale of Disturbance	Mitigation Measures	Compliance with Standards	Time Period for Implementation
Operation of the Ventilation Shaft	Operational	▪ Impact will be limited to the Project site and immediate surroundings.	▪ Use of electrostatic precipitator and Selective Catalytic Converters if emissions are exceeding the regulatory standards.	▪ Mine Health and Safety Act, 1996 (Act No. 29 of 1996) ▪ National Environmental Management: Air Quality Act, Act.39 of 2004 standards 2009; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013). ▪ Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters (PM 2.5) 2012.	▪ Mitigation measures should be concurrent with operation.
Sealing of Ventilation Shaft and Rehabilitation	Decommissioning	▪ Impact will be limited to the site and immediate surroundings.	▪ The dismantling area disturbed must be kept to a minimum; ▪ Drop heights when offloading must be minimised; and ▪ Limit demolition and rehabilitation activities to non-windy days.	▪ National Environmental Management: Air Quality Act, Act.39 of 2004 standards 2009; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013). ▪ Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters (PM 2.5) 2012.	▪ Mitigation measures should be concurrent with operation.

Table 7-2: Potential Impacts and Outcomes of the EMPr

Activities	Potential Impacts	Phase	Mitigation	Standard to be Achieved/Objective
Site clearing	▪ Reduction in the quality of air due to dust generation	▪ Construction	▪ The use of dust suppressants and binders on exposed areas to reduce dust generation; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s); ▪ The drop heights when loading onto trucks and at tipping points should be minimised.	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004): 2009; 2012 and the National Dust Control Regulations (2013). ▪ Mine Health and Safety Act, 1996 (Act No. 29 of 1996).
Sinking of Ventilation Shaft	▪ Reduction in air quality due to dust generation	▪ Construction	▪ The use of dust suppressants and binders on exposed areas to reduce dust generation; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or blasting, scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s); ▪ The drop heights when loading onto trucks and at tipping points should be minimised.	
Crushing	▪ Reduction in the quality of air due to dust generation	▪ Operational	▪ Use of water sprays; and ▪ Enclosure of crushers	
Stockpiling	▪ Reduction in the quality of air due to dust generation	▪ Operational	▪ The drop heights when loading and tipping points should be minimised; ▪ The use of dust suppressants and binders on exposed areas; ▪ Routine maintenance of storage facilities i.e. stockpile throughout the lifespan of the mine to avoid exposing surfaces to wind erosion	
Operation of the Ventilation Shaft	▪ Reduction in air quality due to release of gases and particulate pollutants.	▪ Operational	▪ Use abatement technologies to reduce emissions released to the environment	

Activities	Potential Impacts	Phase	Mitigation	Standard to be Achieved/Objective
Sealing of Ventilation Shaft and Rehabilitation	▪ Reduction in the quality of air due to dust generation	▪ Decommissioning	▪ The area disturbed must be kept to a minimum; ▪ Drop heights when offloading must be minimised; and ▪ Limit activities to non-windy days (≤ 5.4 m/s).	

Table 7-3: Proposed Mitigation and Management Measures

Activities	Potential Impacts	Aspects Affected	Mitigation Type	Time Period for Implementation	Compliance with Standards
Site clearing	▪ Reduction in air quality due to dust generation	▪ Air Quality	▪ The use of dust suppressants and binders on haul roads to reduce dust generation; ▪ Limit activity to non-windy days; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging or scraping must occur, especially on windy days (with wind speed ≥ 5.4 m/s); ▪ The drop heights when loading onto trucks and at tipping points should be minimised.	▪ Must be carried out concurrently with this activity	▪ National Environmental National Environmental Management: Air Quality Act, Act.39 of 2004 standards 2009; ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Dust Control Regulations (2013). ▪ Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters (PM 2.5) 2012.Mine Health and Safety Act, 1996 (Act No. 29 of 1996) Occupational Exposure Limits
Sinking of Ventilation Shaft	▪ Reduction in air quality due to dust generation	▪ Air Quality	▪ The area of disturbance at all times must be kept to a minimum at all times	▪ Must be carried out concurrently with this activity	
Crushing	▪ Reduction in air quality due to dust generation	▪ Air Quality	▪ Use of water sprays; and ▪ Enclosure of crushers	▪ Must be carried out concurrently with mining operations	
Stockpiling	▪ Reduction in air quality due to dust generation	▪ Air Quality	▪ The drop heights when loading and tipping points should be minimised; ▪ The use of dust suppressants and binders on exposed areas; ▪ Routine maintenance of side walls of storage.	▪ Must be carried out concurrently with mining operations	

Activities	Potential Impacts	Aspects Affected	Mitigation Type	Time Period for Implementation	Compliance with Standards
Operation of the Ventilation Shaft	▪ Reduction in air quality due to dust generation	▪ Air Quality	▪ Ensure fans are in good working condition – so vent emissions are within compliance; ▪ Monitoring of air quality underground to ensure personnel are not exposed; and ▪ Use of technology to lower emissions	▪ Must be carried out concurrently with mining operations	
Sealing of Ventilation Shafts and Rehabilitation	▪ Reduction in air quality due to dust generation	▪ Air Quality	▪ The dismantling area disturbed must be kept to a minimum; ▪ Drop heights when offloading must be minimised; and ▪ Limit demolition activities to non-windy days.	▪ Must be carried out once mining operation ceases.	

Table 7-4: Prescribed Environmental Management Standards, Practice, Guideline, Policy or Law

Specialist field	Applicable standard, practice, guideline, policy or law
Air quality	National Environmental Management: Air Quality Act (Act.39 of 2004) National Ambient Air Quality Standard for Pollutants, 2009
	National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) – National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Microns Meters ($PM_{2.5}$), 2012
	National Dust Control Regulation 2013: “Dust fallout Standards”

8 Monitoring Programme

The findings of this study have shown that the operational phase will lead to minimal impact on the ambient atmosphere. As a result, continuous assessment of ambient level of pollutants will not be recommended. However, once-off biannual sampling of PM and gases in the vicinity of the Project is recommended. Sasol will be responsible for the implementing the monitoring campaign through an independent consultant. The recommended monitoring actions are detailed below. Sasol will be responsible for keeping records of all environmental monitoring undertaken for the Project.

8.1 PM_{10} Monitoring Programme

Sasol management should conduct once-off biannual PM_{10} monitoring – to establish ambient levels of this pollutant at a representative site during the operational phase. Such data will be useful, if in future the Project comes under scrutiny from regulatory authorities.

8.2 Gaseous Monitoring Programme

It is recommended that once operation commences, once-off biannual sampling of gaseous pollutants i.e. SO_2, NO_2, and CO should be conducted. This should continue for three or four years and discontinued if measured levels are low and insignificant.

9 Conclusion and Recommendation

An AQIA was undertaken to determine the impacts associated with the proposed construction and operation of the ventilation shaft and associated facilities. Pollutants quantified and evaluated in the assessment included dust fallout, fine particulate matter (PM_{10} and $PM_{2.5}$) as well as gaseous pollutants (SO_2, NO_2 and CO).

The model predications presented in this report have shown that there are instances were dust fallout rate, daily PM_{10} and $PM_{2.5}$, and hourly NO_2 and 1-hour and 24-hour SO_2 GLC exceeded the recommended South African standards. Despite these exceedances, the zones of exceedance are mainly within the Project boundary (at a radius of 20 m to 40 m)from the ventilation shaft. The GLC predicted at the surrounding receptors are below the South African standard.

Results of the dispersion modelling exercise, coupled with the impact assessment ratings conducted show that impacts will be negligible. The operation of the ventilation shaft will not pose a risk to the environment and exposed receptors.

In conclusion, the operation of the ventilation shaft will not result in adverse impacts. If the ventilation shaft and associated facilities are operated with mitigation measures in place i.e. enclosure of crusher, fitting of dust extraction system and water spray, use of selective catalytic technology and gas scrubbers at the vent upcast, predicted particulate and gaseous emissions will have negligible impacts on air ambient quality of the area.

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Appendix A: Declaration of Independence and Specialist CV

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I, Matthew Ojelede as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Sasol Mining (Pty) Ltd, other than fair remuneration for work performed, specifically in connection with the proposed operation of the ventilation shafts, near Trichardt in Mpumalanga Province.

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