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Proposed Development of an Underground Coal Mine and Associated Infrastructure, near Hendrina, Mpumalanga Province

Air Quality Impact Assessment Report

Project Number:

XST3791

Prepared for:

Umcebo Mining (Pty) Ltd

August 2016

Digby Wells and Associates (South Africa) (Pty) Ltd
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Report Type:	**Air Quality Impact Assessment Report**
Project Name:	**Proposed Development of an Underground Coal Mine and Associated Infrastructure, near Hendrina, Mpumalanga Province**
Project Code:	**XST3791**

Name	**Responsibility**	**Signature**	**Date**
Matthew Ojelede	Report Writer		August 2016
Danie Otto	Reviewer		August 2016

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DECLARATION OF INDEPENDENCE

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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 Umcebo Mining (Pty) Ltd, other than fair remuneration for work performed, specifically in connection with the proposed development of an underground coal mine and associated infrastructure, located near Hendrina, Mpumalanga Province.

Full Name:	Matthew Ojelede
Title/ Position:	Air Quality Specialist
Qualification(s):	PhD Environmental Management
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Registration(s):	National Association for Clean Air

EXECUTIVE SUMMARY

Digby Wells and Associates (South Africa) (Pty) Ltd (hereafter Digby Wells) was appointed as the independent Environmental Assessment Practitioner (EAP) to undertake the Environmental Impact Assessment (EIA) process for Umcebo Mining (Pty) Ltd (Umcebo), a subsidiary of Glencore Operations South Africa (Pty) Ltd. Umcebo is proposing the development and operation of a new underground coal mine and associated infrastructure at a site situated approximately 10 to 22 kilometres (km) south east of Hendrina in the Mpumalanga Province of South Africa (the project).

The project area proposed to be mined (underground) has a combined footprint of 6 714 ha and is located within the Steve Tshwete Local Municipality (STLM) and Msukaligwa Local Municipality (MLM).

The Air Quality Impact Assessment (AQIA) forms part of a suite of specialist studies for the EIA. The AQIA was conducted to assess future perturbation from the operation of the proposed project on ambient air quality. Taking cognisance of the proposed infrastructure, emissions from all point, area, volume and line sources were appraised in the inventory. Emission rates were generated, which served as input data for dispersion modelling.

The dispersion model simulations predicted the ground level concentrations for the following pollutants: dust, PM_{10}, $PM_{2.5}$, CO, SO_2 and NO_2 respectively. Model predictions showed that emissions from hauling of ore, venting of underground pollutants and those from crushers were the major contributors. The main findings of this AQIA study are summarised as follows:

- Daily PM_{10} – predicted levels are high in the project area and surroundings without mitigation measures in place. Predicted ground level concentrations will exceed the applicable National Ambient Air Quality Standard (NAAQS) of 75 µg/m^3 at the project boundary. At the sensitive receptors, ground level concentration predicted for XST 01 (6 km southeast of Hendrina Community) of 82 µg/m^3 exceeds the NAAQS prior to mitigation. After mitigation, concentrations at XST 01 will be lowered to 19 µg/m^3. After mitigation, predicted ground level concentration was lowered considerably at the project boundary and at selected sensitive receptors.
- Annual PM_{10} – predicted annual concentrations at 100th percentile will be in exceedance of the applicable NAAQS (40 µg/m^3) at the project boundary and beyond, especially at Mooivley West prior to mitigation. Concentrations at the sensitive receptors will be lower than the NAAQS.
- Daily $PM_{2.5}$ – predicted concentrations will exceed the applicable NAAQS (40 µg/m^3) at the project boundary and beyond prior to mitigation. Once appropriate mitigation measures are applied, the zone of impact will be minimised and the ground level concentrations will decrease to within NAAQS at the project boundary. Exceedances will be confined within the project boundary.

- Annual $PM_{2.5}$ – Predicted annual concentrations at Mooivley East will exceed the applicable NAAQS (20 µg/m^3), but is confined within the project boundary. However, due to the road link between Mooivley West and Hendrina South – exceedance is predicted over a small area between the project boundaries. Ground level concentrations at the selected sensitive receptors will be below the NAAQS.
- Dust deposition rates predicted for the proposed project area are quite high without mitigation measures. The residential and non-residential standards of 600 mg/m^2/day and 1200 mg/m^2/day will be exceeded at the project boundary and beyond. Once mitigation measures are applied, the zone of exceedance at Mooivley East will be minimised and confined to within the project boundary. However, due to the road link between Mooivley West and Hendrina South – exceedance is predicted over a much smaller area between the project boundaries after mitigation measures are applied.

For the gaseous pollutants, mainly emissions from the diesel generators (~15 MW) and from underground venting, the findings are summarised as follows:

- The predicted 1-hour NOx (all NO_X assumed to be NO_2) concentrations attributed to the proposed project projectwill result in ground level concentrations higher than the applicable NAAQS of 200µg/m^3 within the project areas – Mooivley East, Mooivley West and Hendrina South. The concentration at the project boundary and beyond will be below the NAAQS once operational.
- Predicted annual concentrations of NO_X will not exceed the NAAQS (40 µg/m^3) at the project boundary or at sensitive receptors.
- The 1-hour SO_2 concentrations predicted for the proposed Project will result in exceedance of the NAAQS of 350 µg/m^3 prior to mitigation. However, this exceedance will be confined within the mine boundary. Ground level concentration at the mine boundary and sensitive receptors will be below the NAAQS. With exceedance confined to within the mine boundary, mitigation runs were not conducted.
- The 24-hours SO_2 concentrations predicted will be lower than the NAAQS of 125 µg/m^3 at the project boundary and selected sensitive receptors. Since the predicted concentrations were very low, mitigation runs were not conducted in AERMOD.
- Model predictions show that the annual SO_2 emissions from the proposed Project will be very low and confined to the project boundary. Hence, mitigation runs were not conducted.
- The predicted 1-hour CO concentrations will be very low, with ground level concentration within the NAAQS of 30 mg/m^3. The 8-hour average also returned lower ground level concentration from the proposed operation of the mine. The concentrations predicted are lower than the NAAQS of 10 mg/m^3. Hence CO is not going to be much of a problem for the proposed Project.

The main outcome of this AQIA report is that particulate pollution (fallout dust, PM_{10} and $PM_{2.5}$) and gaseous emission from the generators and venting of pollutants from underground will have impacts on the ambient air quality without mitigation. Hence, suitable mitigation measures and monitoring programmes should be factored into the day to day operation of the mine to curtail impacts. It is recommended that the mine management commit to emission reduction strategies and ensure compliance with regulatory requirements of the National Environmental Management Air Quality Act, 2004 (Act No. 39 of 2004).

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APPA	Atmospheric Pollution Prevention Act, 1965 (45 of 1965) (APPA)
AQIA	Air Quality Impact Assessment
ASTM	American Society for Testing and Materials
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
IFC	International Finance Corporation
GN	Government Notice
LOM	Life of Mine
MM5	Mesoscale model - Fifth generation
NEMA	National Environmental Management Act
NDCR	National Dust Control Regulation
NEM:AQA	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
ROM	Run of Mine
TSP	Total Suspended Particulates
USEPA	United States Environment Protection Agency
WHO	World Health Organisation

1 Introduction

Umcebo Mining (Pty) Ltd (Umcebo), a subsidiary of Glencore Operations South Africa (Pty) Ltd (Glencore) is proposing the development and operation of a new underground coal mine and associated infrastructure at a site situated approximately 10-22 kilometres (km) south east of Hendrina in the Mpumalanga Province of South Africa (the Project).

Umcebo currently holds two Prospecting Rights (PRs), namely, MP 1265 PR and MP 1266 PR, located within the Ermelo Coal Field. The total extent of MP 1265 PR (referred to as Mooivley East and Mooivley West) is 3 923 hectares (Ha) and comprise the following farms and portions:

- Mooivley 219 IS – Potions 2, 4, 5 and Remaining Extent (RE) of the farm;
- Tweefontein 203 IS – Portions 2, 15, 16, 17 and Portion of Portion 14;
- Uitkyk 220 IS – Portions 2 and 3; and
- Orange Vallei 201 IS – Portions 1 and RE of the farm.

The total extent of MP 1266 PR (referred to as Hendrina South) is 2 787 Ha and comprises the following farm and portions:

- Elim 247 IS - RE of the farm;
- Geluksdraai 240 IS – 1 and 2;
- Orpenskraal 238 IS – RE of the farm; and
- Bosmanskrans 217 IS – Potions 1, 3, 4, 6, 8, 9 and RE of the farm.

The project area proposed to be mined (underground) has a combined footprint of 6 714 ha and is located within the Steve Tshwete Local Municipality and Msukaligwa Local Municipality.

1.1 Project Overview

The project area comprises three underground reserve blocks namely Mooivley East, Mooivley West and Hendrina South. The two Mooivley reserves comprise two incline shafts areas which will be developed to gain access to the two underground areas whilst the Hendrina South reserve comprises one incline shaft area. Mooivley West and Hendrina South will be mined at the same time. Once completed, Mooivley East mining activities will commence. The proposed mining method for the extraction of coal will be bord and pillar. The estimated Life of Mine (LoM) will be 30 years[1] for all mining areas with a production rate

[1] The MRA will be made for an initial period of 30 years, the maximum allowed in terms of the provisions of Section 23 of the MPRDA. At the end of this period an application for renewal of the mining right will be made for any remaining reserves.

of 2.4 million tonnes per annum at full capacity, with a total of approximately 78 million tonnes of Run of Mine (ROM). The mine will reach full production within the first four years.

The grade of coal is poor and therefore not suitable for export. The coal product will be transported to a nearby Eskom power station (i.e. Kusile, Kendal, Kriel, Grootvlei); via the existing road network.

Limited surface infrastructure will be established to support the mining activities. The primary structures proposed include: a package sewage treatment plant, water treatment plant, coal plant with the crushing and screening units, diesel generator set, fuel storage tanks, access and service roads, a conveyor belt and office and workshop buildings.

The project is proposed to commence with construction and development when all required licences and authorisations have been granted.

1.2 Terms of Reference

Digby Wells Environmental was required to assess potential impacts associated with the proposed project and associated activities/infrastructure on ambient air quality of the area. The Terms of Reference (ToR) encompasses a completion of an Air Quality Impact Assessment (AQIA) report based on available air quality data and modelled results from potential sources of emission within the project area. The AQIA report includes a baseline assessment and predicted air quality impacts from the proposed project on ambient environment.

As part of the ToR, the following was conducted:

- Emissions inventory of sources and likely pollutants based on the mining methods, processing and ancillary activities; and
- Dispersion modelling based on atmospheric conditions and emission inventory data generated.

In addition, the AQIA report was required to provide recommendations regarding appropriate monitoring programme, mitigation and management plans to ameliorate potential impacts.

2 Details of the Specialist

Matthew Ojelede completed his B.Sc. (Hons) degree at the University of Benin; a M.Sc. in Environmental Science (University of the Witwatersrand) 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 Aims and Objectives

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

- To establish all potential sources of emission and emission rates within the Project area;
- To identify all sensitive receptors in the vicinity of the proposed project;
- To assess available air quality monitoring data; and
- Assess predicted impacts against regulatory standards to ascertain compliance.

4 Methodology

4.1 Baseline Characterisation and Assessment

The methodology that was followed for the baseline characterisation and assessment relied solely on literature review of existing information; background dust fallout measurements conducted by Digby Wells Environmental in the project area, and modelled meteorological data obtained from Lakes Environmental Software (which was used to determine local prevailing weather conditions). In addition, the following tasks were completed as part of the baseline assessment:

- Identification of sensitive receptors;
- Review of required South African Legislations;
- Detailed assessment of available ambient air quality data; and
- Literature review of the environmental and health implications of pollutants anticipated from the operational phase of the project.

4.1.1 Dust Fallout Monitoring

Monitoring of dust deposition rates is often conducted to establish background levels in an area, to which future perturbations from a proposed project can be compared. At the time of compiling this report, dust monitoring programme has been ongoing for 3 months (from April to July 2016).

4.2 Emission Inventory

Establishment of an emissions inventory based on the proposed project and associated activities was conducted to provide input parameters for the dispersion modelling.

Emission factors published by the US-EPA in its AP-42 document “Compilation of Air Pollution Emission Factors” (USEPA 1995; 2006; 2008) and Australian National Pollutant Inventory (NPI) “Emission Estimation Technique (EET)” manuals have been used. The derived emission factors served as input data for our dispersion model, to predict the ground level concentrations and pollutant spread across the landscape.

There are various sources of emissions anticipated from the construction, operation and decommissioning phases. Envisaged emissions from the proposed development and operation of a new underground coal mine and associated infrastructure at Mooivley East, Mooivley West and Hendrina South include pollutants, such as:

- Inhalable fraction of particulate matter (airborne material that enters the nose and mouth during breathing, which can be deposited anywhere in the respiratory tract - aerodynamic diameters less than or equal to 10 µm). While the respirable fraction encompasses the airborne material that penetrates the lower gas exchange region of the lungs (aerodynamic diameters less than or equal to 2.5 µm);
- Dustfall; and
- Gaseous emissions: oxides of nitrogen (NO and NO_2, jointly known as NO_x), sulfur dioxide (SO_2) and carbon monoxide (CO) from point sources i.e. generator sets, and emissions from underground machinery vented to the atmosphere.

4.3 Air Quality Dispersion Modelling

Dispersion models compute ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations due to emissions from various sources. All emission scenarios would be simulated using the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) modelling system (a regulatory model approved by the Department of Environmental Affairs (DEA) for use in EIAs (DEA, 2012). The latter uses MM5 modelled meteorological data set for three years obtained from Lakes Environmental Software in Canada to simulate the climate prevalent in an area. This dataset consists of surface data, as well as upper air meteorological data that is required to run the dispersion model.

The dispersal of pollutants across the landscape was simulated for different averaging periods. In all instances, the worst-case scenario was demonstrated. It is important to note that the highest hourly-average and highest 24-hour-average presented in the maps are indicative of the highest concentrations expected for the average-period for that year at each position in the modelled domain, and must not be interpreted as being representative of general conditions. The intention of the predicted ground level concentrations is to present the worst-case scenario for those averaging periods.

The daily average concentrations were calculated as 99^{th} percentile. Annual averages were shown as the highest values (100^{th} percentile) according to the NEM: AQA Air Dispersion Regulation (2012). Isopleth plots of ground level concentrations for the different pollutants associated with the proposed underground coal mining operations were generated.

4.4 Legal Context

The prevailing legislation in the Republic of South Africa with regards to the Air Quality field is the NEM: AQA. The NEM: AQA repealed the Atmospheric Pollution Prevention Act, 1965 (45 of 1965) (APPA) and various other laws dealing with air pollution.

In the NEM: AQA, provincial environmental departments, 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 Environmental Management Act, 1998 (Act No. 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 Department of Environmental Affairs (DEA) has published the National Dust Control Regulations which specified the standards on November 1, 2013. In the National Dust Control Regulations, terms such as target, action and alert thresholds were omitted. Another notable observation was the reduction of the permissible frequency from three to two incidences within a year. The standard actually adopted a more stringent approach than previously, and would require dedicated mitigation measures now that it is in force.

The National Dust Fallout standard is given in the Table 4-1 below.

Table 4-1: National Dust Fallout Standards (using ASTM D1739:1970 or equivalent)

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

In December 2009, DEA published under Government Notice 1210 in Government Gazette 32816 the National Ambient Air Quality Standards (NAAQS) - Table 4-2 for particulate matter of aerodynamic diameter less than 10 micron metres (PM_{10}) and other pollutants such as Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3), Carbon Monoxide (CO) and Benzene (C_6H_6).

Also, the DEA has established National Ambient Air Quality Standards for PM_{10} (Table 4-2) and particulate matter of aerodynamic diameter less than 2.5 micron metres since June 2012 (GN486: 2012) as depicted in Table 4-3.

Table 4-2: National Ambient Air Quality Standards as of 24 December 2009

National Ambient Air Quality Standards for Sulphur Dioxide (SO_2)				
AVERAGING PERIOD	LIMIT VALUE (µg/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/m^3)	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/m³)**	**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 4-3: National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$)

National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$)			
AVERAGING PERIOD	**LIMIT VALUE (µg/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.			

5 Assumptions and Limitations

The following assumptions and limitations were identified:

- Modelled data was used as site-specific meteorological data was not available for the impact assessment study of the project area;
- Data input into the model was based on all documentation provided by the applicant;
- Stack parameters and emission rates were based on the capacity of three CAT 5000 KVA Diesel Generators (amounting to 15 MW specified for the proposed operation);
- The gaseous pollutants assessment was limited to pollutants associated with the CAT 5000 KVA Diesel Generators as specified by the manufacturers;
- Measurement of dust deposition was limited to three months; and
- Lack of ambient air quality data to assess baseline and cumulative impacts.

6 Baseline Environment

6.1 Regional Climate and Factors Influencing Air Dispersion

South Africa is located in the sub-tropics where high pressures and subsidence dominate. However, the southern part of the continent can also serve as a source of hot air that intrudes sub-tropics, and that sometimes lead to convective movement of air masses. On average, a low pressure will develop over the southern part of the continent, while the normal high pressures will remain over the surrounding oceans. These high pressures are known as Indian High Pressure Cell and Atlantic High Pressure Cell. The intrusion of continents will allow for the development of circulation patterns that will draw moisture (rain) from either tropics (hot air masses over equator) or from the mid-latitude and temperate latitudes.

Southern Africa is influenced by the two major high pressure cells, in addition to various circulation systems prevailing in the adjacent tropical and temperate latitudes. The mean circulation of the atmosphere over Southern Africa is anticyclonic throughout the year (except near the surface) due to the dominance of the three high pressure cells, namely South Atlantic High Pressure, off the west coast, the South Indian High Pressure off the east coast and the Continental High Pressure over the interior.

It is these climatic conditions and circulation movements that are responsible for the distribution and dispersion of air pollutants within the proposed project area and neighbouring provinces in South Africa.

6.1.1 Topography

The topography of the area is generally flat. There are no significant topographical features like ridgelines and mountain peaks that are prominent in some landscapes. Elevation ranges from 1 653 m and 1 715 m above mean sea level (mamsl).

6.1.2 Vegetation

Based on the assessment of the fauna and flora specialist at Digby Wells Environmental, the vegetation cover on site encompasses those of the Eastern Highveld Grasslands and the Soweto Highveld Grasslands in places (Digby Wells Environmental Fauna and Flora Report, 2016).

6.1.3 Climate and Meteorological Overview

South Africa experiences distinct weather patterns in summer and winter 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. 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 the Highveld. This inversion layer traps the pollutants in the lower atmosphere, which results in reduced dispersion and higher concentrations of pollutants near the surface. Preston-Whyte and Tyson (1988) describe the atmospheric conditions in the winter months as highly unfavourable for the dispersion of atmospheric pollutants.

Precipitation reduces erosion potential by increasing the moisture content of materials. In addition, precipitation represents an effective mechanism for removal of atmospheric pollutants and is therefore considered during air pollution studies. Rain-days are defined as days experiencing 0.1 mm or more rainfall.

Three year worth of site specific modelled meteorological data set from Lakes Environmental Software in Canada for the period January 2013 to December 2015 was obtained for a point in the proposed project area near Hendrina (26.228158 S, 29.777358 E). Data availability was 100%. Generally, a data set of greater than 90% is required in order for that month/year to be considered representative of the assessed area (SANS, 2011).

This dataset consists of surface data, as well as upper air meteorological data that is required to run the dispersion model. This dataset is used when site specific surface and upper air meteorological data is not available. The Pennsylvania State University / National Centre for Atmospheric Research (PSU/NCAR) meso-scale model (known as MM5) is a limited-area, non-hydrostatic, terrain-following sigma-coordinate model designed to simulate or predict meso-scale atmospheric circulation.

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 dust from a mechanically disturbed surface is similarly a function of the wind speed, in combination with the surface roughness. 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 the wind speed. The amount of particulate matter generated by wind is also dependent on the material's surface properties. This includes moisture content, the wind speed threshold mentioned previously and the amount of non-erodible particles and the particle size distribution of the material.

Wind roses comprise 16 spokes which represent 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 direction categories. The figure given at the bottom of the legend described the frequency with which calms occurred, i.e. periods during which the wind speed was below 0.5 m/s.

The spatial and annual variability in the wind field for the proposed project area is clearly evident in Figure 6-1. The predominant wind direction is from the northeast and east northeast accounting for 12% and 11% respectively. Secondary contributions are observed from northwest and west northwest respectively. Wind speed greater that ≥ 5.4 m/s occurred for about 11% of the time.

Over the three year period, calm conditions (wind speeds < 0.5 m/s) occurred for 3.78% of the time. Average wind speed was 3.3 m/s. Wind class frequency distribution per sector is given in Figure 6-4 and Table 6-1.

The diurnal patterns during the night, morning and evening hours were somehow similar, with the dominant winds coming from the northeast, except in the afternoon when westerly winds dominated (Figure 6-2). A dominant feature was the observance of strong winds greater than 5.4 m/s reaching ~14% in the morning and afternoon respectively.

The seasonal (Figure 6-3) patterns show spring to have been dominated by winds from the northwest (11%), west northwest (8%) and north northwest (9%) respectively. Wind speed ≥ 5.4 m/s was observed 18% of the time. Summer was dominated by winds from the northeast (19%), east northeast (16%) and east (10%), with winds ≥ 5.4 m/s occurring for 7% of the time. In autumn, winds from the east northeast (10%) and northeast (9%) were dominant, with winds ≥ 5.4 m/s occurring for 6% of the time. Winter was dominated by wind blowing from the northwest (10%), with secondary contributions from the west northwest (9%) and west (8%) respectively. Wind speed ≥ 5.4 m/s occurred for 12% of the time.

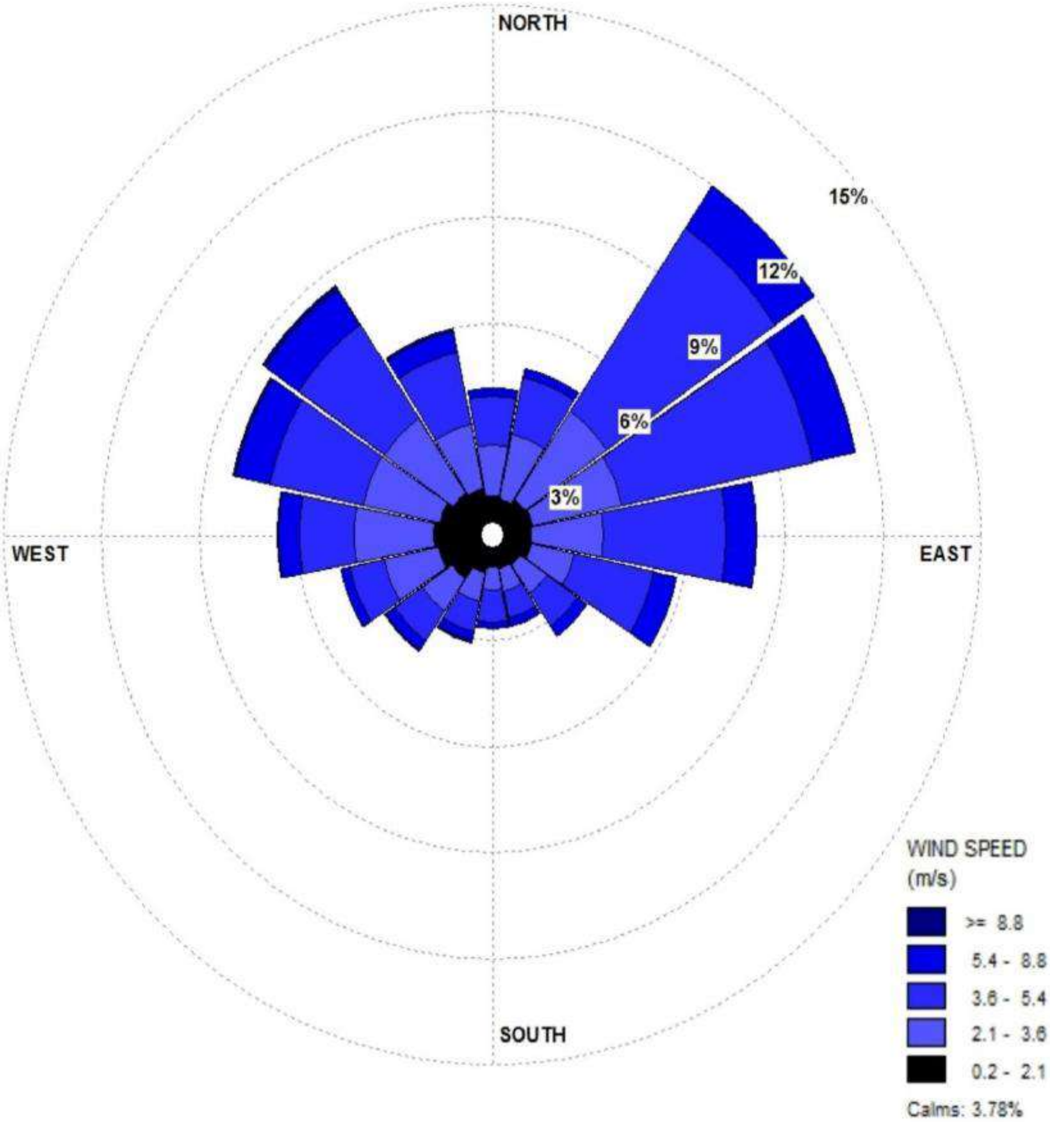

Figure 6-1: Surface wind rose

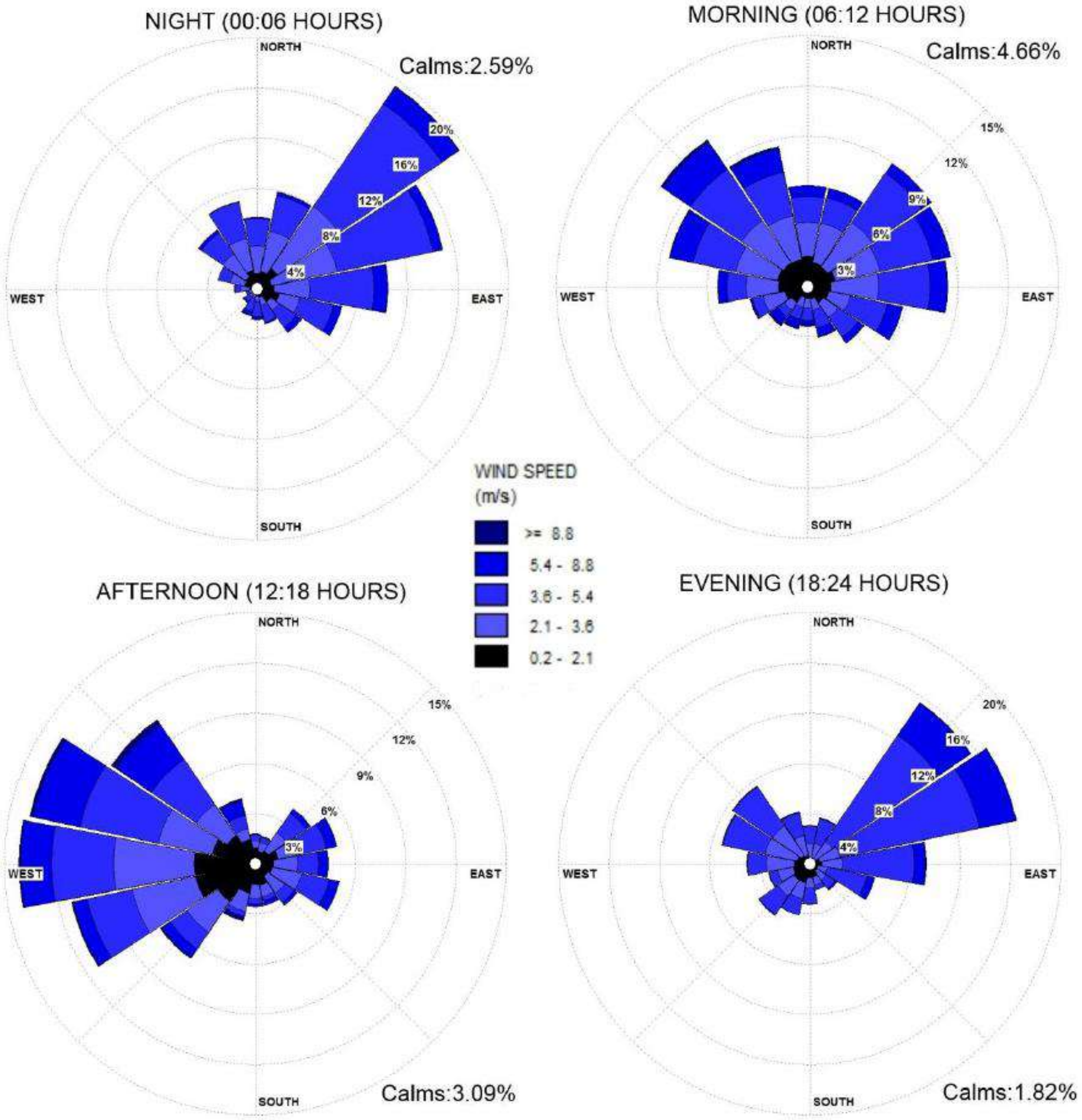

Figure 6-2: Diurnal variation of winds night-time: 00:00 – 06:00 (top right), morning 06:00 – 12:00 (top left), afternoon 12:00 – 18:00 (bottom left) and evening 18:00 – 24:00 (bottom right)

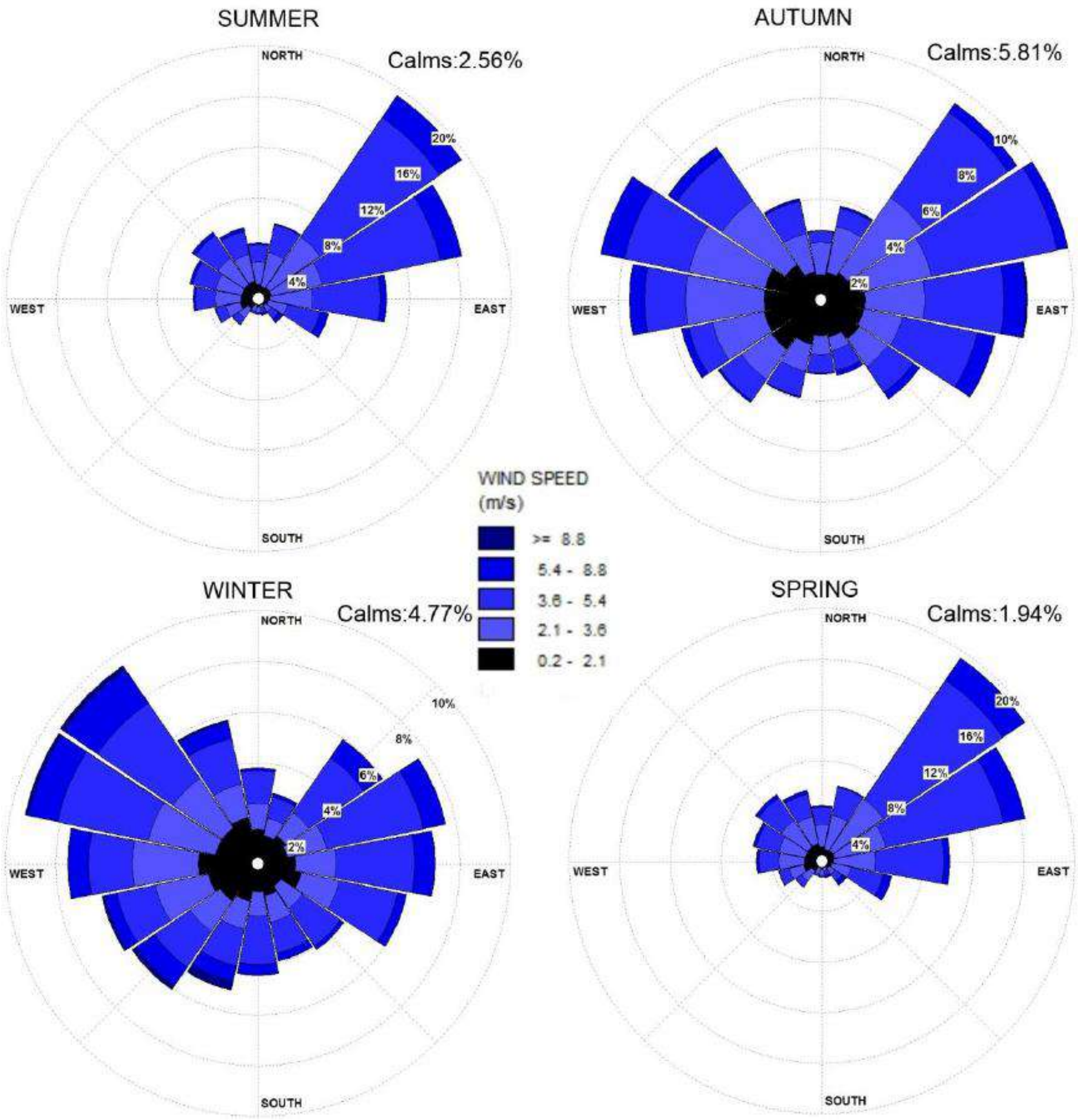

Figure 6-3: Seasonal variation of winds in summer (Dec – Feb); autumn (March – May); winter (Jun – Aug) and spring (Sep – Nov)

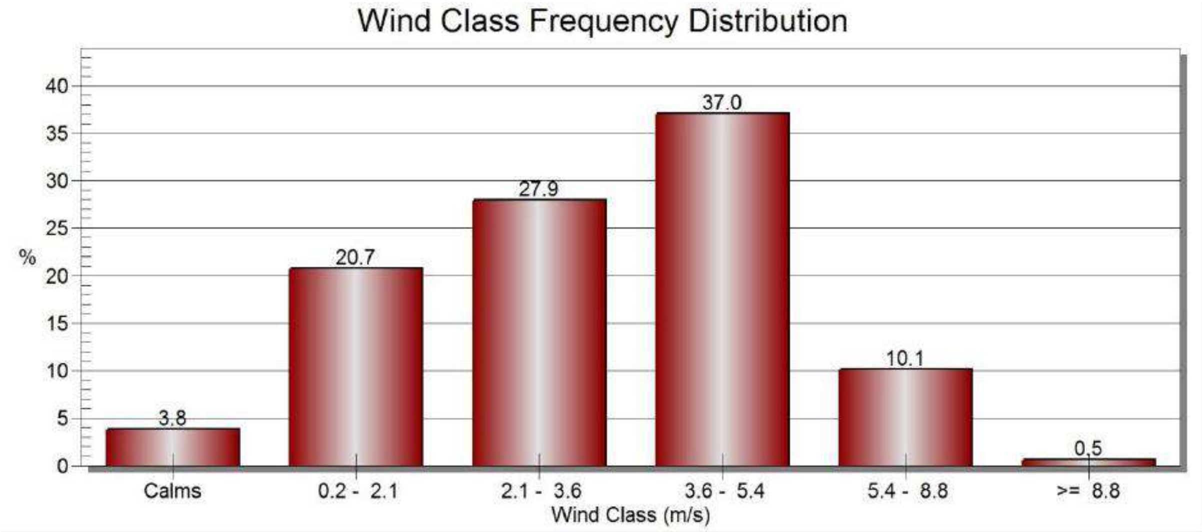

Figure 6-4: Wind Class Frequency Distribution

Table 6-1: Wind Class Frequency Distribution per Direction

No.	Directions / Wind Classes (m/s)	0.2 - 2.1	2.1 - 3.6	3.6 - 5.4	5.4 - 8.8	>= 8.8	Total (%)
1	N	1.11	1.46	1.36	0.23	0.00	4.16
2	NNE	1.06	1.85	1.66	0.25	0.00	4.82
3	NE	1.23	3.03	6.24	1.44	0.03	11.96
4	ENE	1.28	2.77	5.95	1.37	0.02	11.39
5	E	1.20	2.21	3.75	0.92	0.01	8.09
6	ESE	1.24	1.35	2.46	0.72	0.00	5.77
7	SE	1.04	0.99	1.13	0.35	0.00	3.51
8	SSE	0.98	0.66	0.78	0.24	0.01	2.68
9	S	0.92	0.67	0.88	0.19	0.02	2.67
10	SSW	1.12	0.84	0.85	0.24	0.08	3.14
11	SW	1.51	1.12	1.00	0.33	0.05	4.01
12	WSW	1.71	1.69	1.08	0.27	0.03	4.78
13	W	1.82	2.42	1.69	0.64	0.03	6.60
14	WNW	1.66	2.40	2.92	1.09	0.06	8.14
15	NW	1.45	2.57	3.17	1.21	0.13	8.54
16	NNW	1.36	1.86	2.05	0.62	0.07	5.96
	Sub-Total	**20.70**	**27.89**	**36.99**	**10.10**	**0.54**	**96.22**
	Calms						3.78
	Missing/Incomplete						0
	Total						**100**

6.1.4 Temperature

The monthly maximum and average temperature for the project area are given in Table 6-2. The maximum temperatures range from 17°C in July to 29°C in December and January, with monthly average ranging from ~8°C in July to 19°C in December, January and February (Figure 6-5). Annual average temperature for the proposed mining site is given as 15°C.

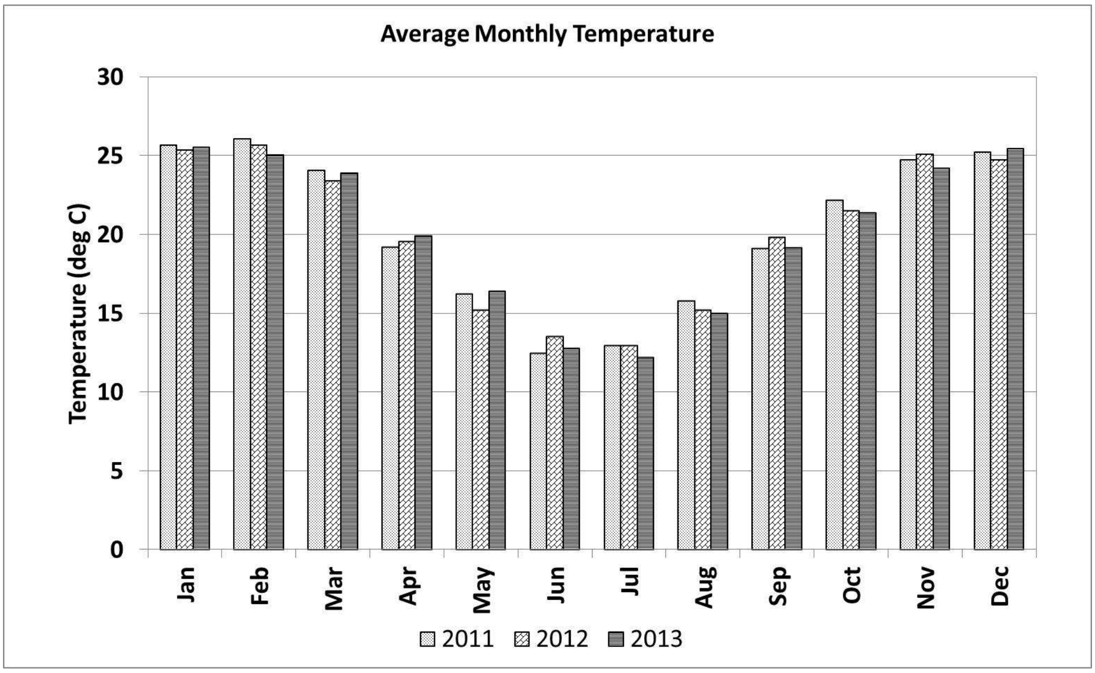

Figure 6-5: Average Monthly Temperature

Table 6-2: Monthly Temperature Records

Temp(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	29	28	26	25	20	18	17	23	26	27	27	29	25
Monthly Ave	19	19	17	14	11	9	8	11	14	16	18	19	15

6.1.5 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. For the proposed project area, wind speeds greater than 5.4 m/s occurred on average 36 days in a year from our analyses. Winds with such intensity leads to erosion of loose dust particulate matter and dispersion across the landscape (Table 6-3 and Figure 6-6). Figure 6-6 shows that wind speed higher than 5.4 m/s occurs every month with potential to erode loose material from the open surfaces.

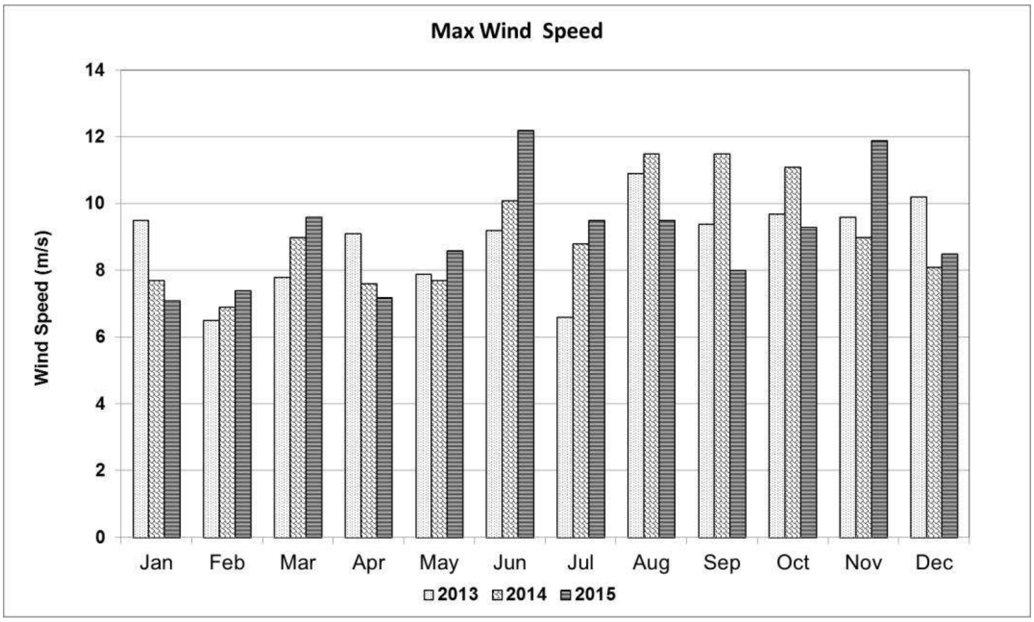

Figure 6-6: Monthly Maximum Wind Speed

Table 6-3: Monthly Wind Speed Records

Wind speed(m/s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	9.5	7.4	9.6	9.1	8.6	12.2	9.5	11.5	11.5	11.1	11.9	10.2	10.2
Monthly Ave	3.5	3.3	3.2	3.0	2.6	3.2	3.6	4.0	3.9	3.8	4.3	3.7	3.5

6.1.6 Relative Humidity

The data in Table 6-4 are representative of the relative humidity for the proposed Project area. The annual maximum and average relative humidity is given as 100% and 71%, respectively (Table 6-4). The monthly maximum reaches 100% throughout the year. The monthly average on the other hand is around 70% for the whole year, with the highest of 75% observed in the months of June (Figure 6-7).

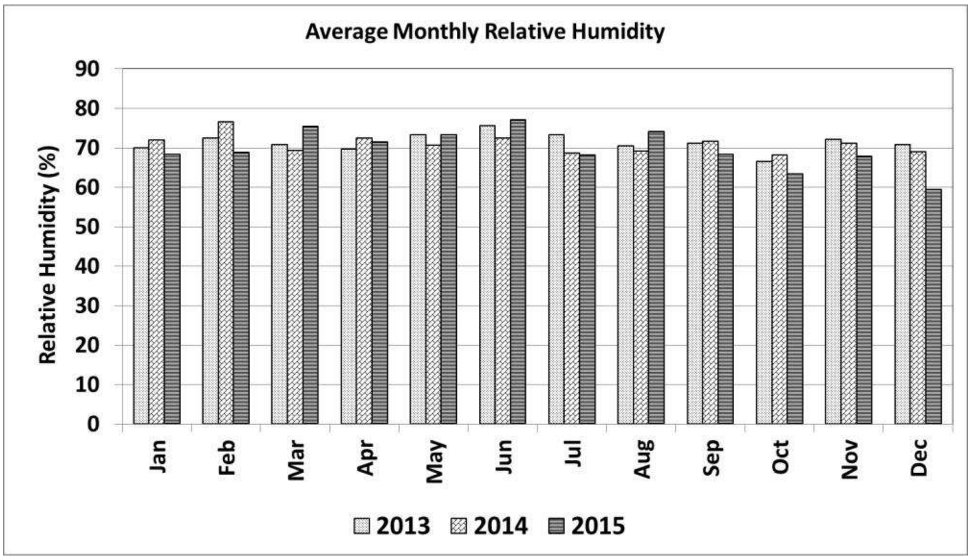

Figure 6-7: Average Monthly Relative Humidity

Table 6-4: 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.	70	73	72	71	72	75	70	71	70	66	70	66	71

6.1.7 Precipitation

The total monthly and average rainfalls are reported in Table 6-5 for the three-year period (2013 - 2015). The highest total monthly precipitation (196 mm) was observed in December. The lowest rate of 1 mm was observed in June. The annual total and average rainfall of 994 mm (max) and 60 mm are reported. The total monthly rainfall for the three years period is depicted in Figure 6-8.

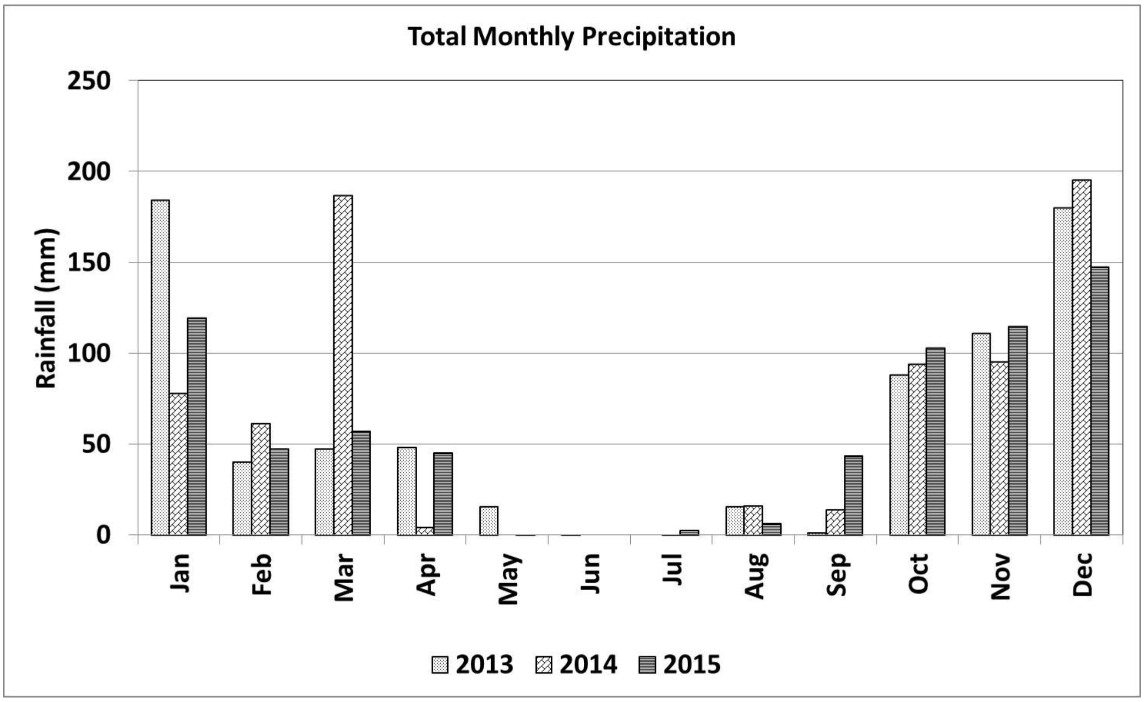

Figure 6-8: Total Monthly Precipitation

Table 6-5: Monthly Precipitation Record (mm)

Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Rainfall (Max)	184	61	187	48	16	1	3	16	44	103	135	196	994
Ave Monthly Rainfall	127	50	97	33	6	0	1	13	20	95	107	174	60

6.1.8 Evaporation

The Carolina Weather Station is the only station with evaporation data in the surrounding area. Monthly maximum S-pan evaporation data shows that the evaporation rates are high. It is believed that the evaporation figures for the proposed mining area will be similar to those measured in Carolina.

As shown inTable 6-6, the annual maximum and minimum evaporation rates for the Carolina area for the period 1958 - 1987 are 195 mm and 104 mm respectively. The highest monthly maximum evaporation (195 mm) was measured in December. The rate decreased significantly down to 96 mm in June. The monthly minimum ranges between 136 mm in November to 52 mm in June.

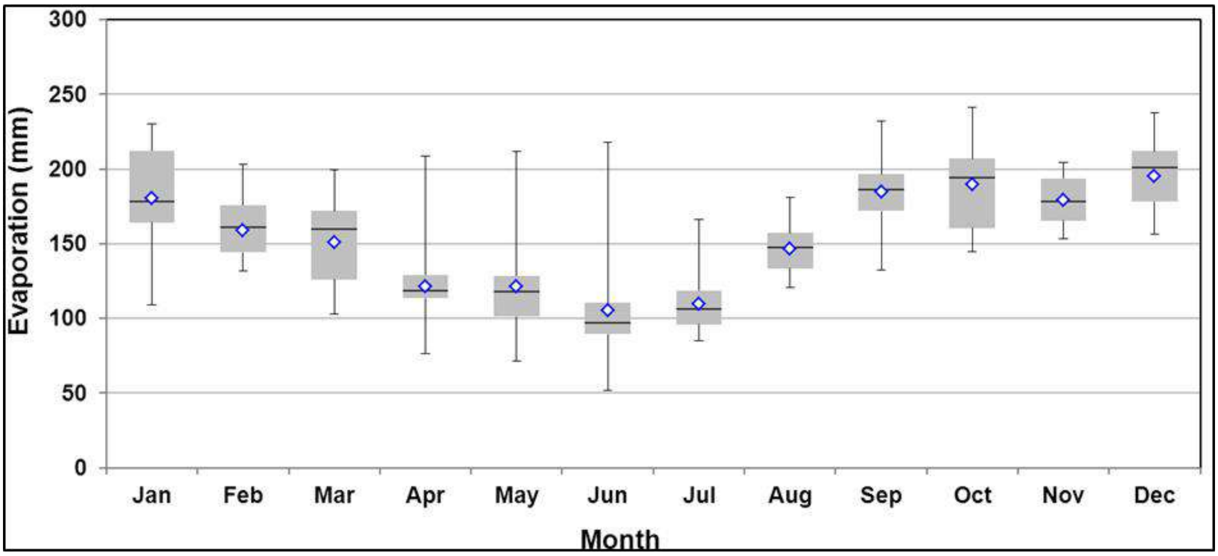

Figure 6-9: Average Monthly Evaporation for Carolina at the S-Pan Evaporation Station (1958 – 1987) (Source: South African Weather Service)

Table 6-6: Maximum and Minimum Evaporation Rates for Carolina station for 1958 - 1987 period (South African Weather Service)

Evaporation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	188	161	155	123	113	96	107	145	180	190	175	195	195
Monthly Min.	135	132	103	83	71	52	85	117	121	144	136	68	104

6.1.9 Boundary Layer Properties and Atmospheric Stability

The region of the atmosphere governing transport and dispersion of the majority of the pollutants is the planetary boundary layer. This layer is defined as the layer where the wind structure is influenced by the surface of the Earth.

The height of the planetary boundary layer varies with the atmospheric stability and this is important for the concentrations of pollutants in the air because the majority of the pollutant mass typically is confined within this layer. During night-time when conditions in most cases are stable, the planetary boundary layer is shallow, down to 20-50 metres (m) and the surface concentration of pollutants can therefore be quite high, especially close to emission sources that are active during the night. Under unstable conditions the planetary boundary layer can be as high as 2 km and pollutants are in this case distributed in the air column mainly by convective turbulence. In the vicinity of the top of the boundary layer, the horizontal winds are typically stronger and the pollutants that end up at these higher levels may be transported far away from the emission sources. In neutral conditions emitted pollutants are quickly mixed in the air by mechanical turbulence and the surface concentration is not particularly high. During neutral conditions the strong horizontal wind speeds can transport pollutants across large distances.

The atmospheric conditions may be divided into three broad classes in terms of stability: neutral, stable and unstable conditions. These major three categories are characterised by the following:

- *Neutral* conditions where the temperature is homogeneous throughout the boundary layer. This situation typically occurs in the transition from day to night and is characterised by strong winds and clouds and large amounts of mechanical turbulence.
- *Stable* conditions where the temperature is lowest close to the surface and increases towards the top of the boundary layer. This situation typically occurs during night-time or in winter situations and is characterised by little turbulence and a strong stratification of the planetary boundary layer which is quite shallow. This class can be further divided into stable and very stable classes.
- *Unstable* conditions where the temperature of the air closest to the surface is higher than the temperature of the air above it. This situation typically occurs during daytime at summer when the sun is shining and it is characterised by large amounts of convective turbulence usually resulting in the formation of cumulus clouds during the day. This class can be further divided into very unstable, moderately unstable and unstable classes.

The refined classes of atmospheric stability classes are further defined in the Table 6-7 and Table 6-8.

Table 6-7: Atmospheric Stability Classes

Designation	Stability Class	Atmospheric Condition
A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies, daytime conditions
C	Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

Table 6-8: Meteorological Conditions that define the Pasquill Stability Classes

Surface wind speed	Daytime incoming solar radiation			Night time cloud cover	
m/s	Strong	Moderate	Slight	> 50%	< 50%
< 2	A	A – B	B	E	F
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	C	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	D

*Note: Class D applies to heavily overcast skies, at any wind speed day or night.

6.2 Air Quality

The ambient air quality in the project area will be influenced by atmospheric pollutants from several local and regional sources, which include:

- Emissions from coal-fired power plants;
- Operational opencast and underground coal mines in the Mpumalanga Highveld; and
- Residential and agricultural activities in the vicinity.

In terms of Air Quality, the main pollutants of concern will be associated with particulate matter i.e. dust generated from mining activities and open sources during mining areas, and vehicular movement on dry and dusty roads.

6.2.1 Dust Fallout Baseline

Dust deposition data is crucial as measurements are used to assess monthly, seasonal, and inter-annual variability in the dust fallout rates – pre and during mining operations. The amount of dust collected at any given time is a function of the rate of deposition, which may vary widely depending on meteorological factors such as wind speed and direction and variations. The dust fallout sampling, analyses, comparison and interpretation is conducted according to the recommended 1929:2011 (ASTM1739-98 reapproved 2010).

The deposition results are illustrated by means of tables and graphs expressed in the units of mg/m^2/day averaged over a 30 day period. In terms of dust deposition standards, a four-band scale: residential, industrial, action and alert thresholds and permissible frequency of exceedances described in SANS1929:2011 was applied prior to the released of the NEM:AQA - National Dust Control Standard (NDCR, 2013), as presented in Table 6-9.

Table 6-9: Acceptable Dust Fall Rates as measured (NEMAQA - NDCR, 2013)

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

Dust falls that exceed the specified rates but that can be shown to be the result of some extreme weather or geological event shall be discounted for the purpose of enforcement and control. Such an event might typically result in excessive dust fall rates across an entire metropolitan region, and not be localized to a particular operation. Natural seasonal variations, for example the naturally windy months each year, will not be considered extreme events for this definition (SANS 1929:2011).

Any person who conducts any activity in such a way as to give rise to dust in quantities and concentrations that may exceed the dust fall standard (Table 6-9) set out in regulation 3 must, upon receipt of a notice from an air quality officer, implement a dust fall monitoring programme (NDCR, 2013).

The dust monitoring network was setup in April 2016 to assess deposition rate in the proposed project area. Results from the last 3 months of monitoring are incorporated in this impact assessment report. The dust monitoring sites, with site ID and coordinates are depicted in presented in Table 6-10 and in Figure 6-1 below.

Table 6-10: Hendrina Dust Monitoring Sites and Coordinates

Site ID	Latitude	Longitude
XST 01	-26.185488	29.775865
XST 02	-26.172053	29.774516
XST 03	-26.250195	29.828418
XST 04	-26.269934	29.711386
XST 05	-26.319068	29.858360

Results from the monitoring network are presented in Table 6-11 below. The graph showing the dust deposition rates compared to the relevant standards is presented (Figure 6-11). Deposition rates at the proposed mining area are within the standards, with no violation of the recommended observed during the sampling window.

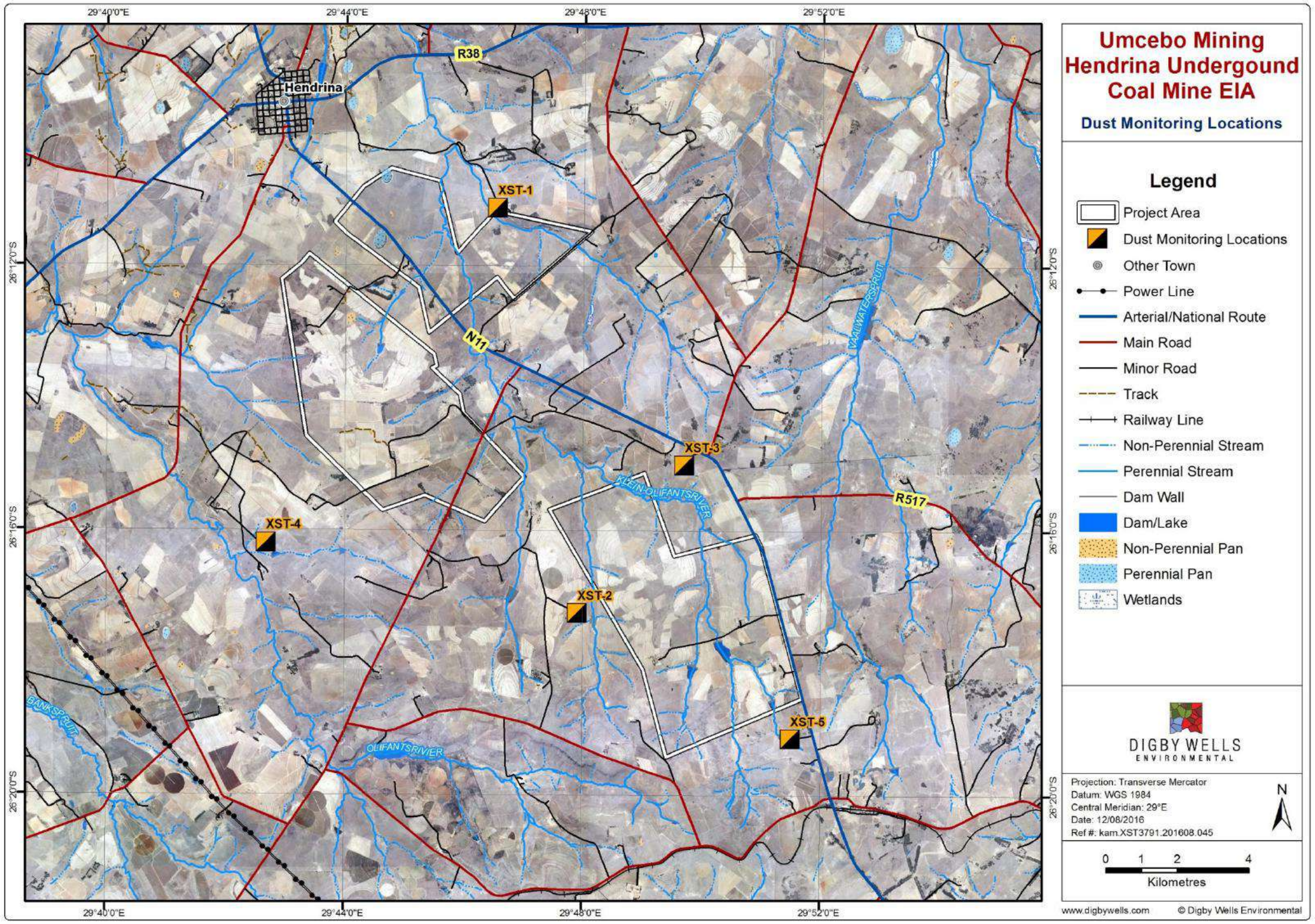

Figure 6-10: Hendrina Dust Monitoring Points

Table 6-11: Dust Deposition Rates for Hendrina (mg/m^2/day, 30 day average)

Dust levels measured in mg/m^2/day, 30 day average			
	May 2016	**June 2016**	**July 2016**
XST 01	82	32	79
XST 02	63	98	594
XST 03	30	35	128
XST 04	82	48	92
XST 05	62	87	91
*No data			

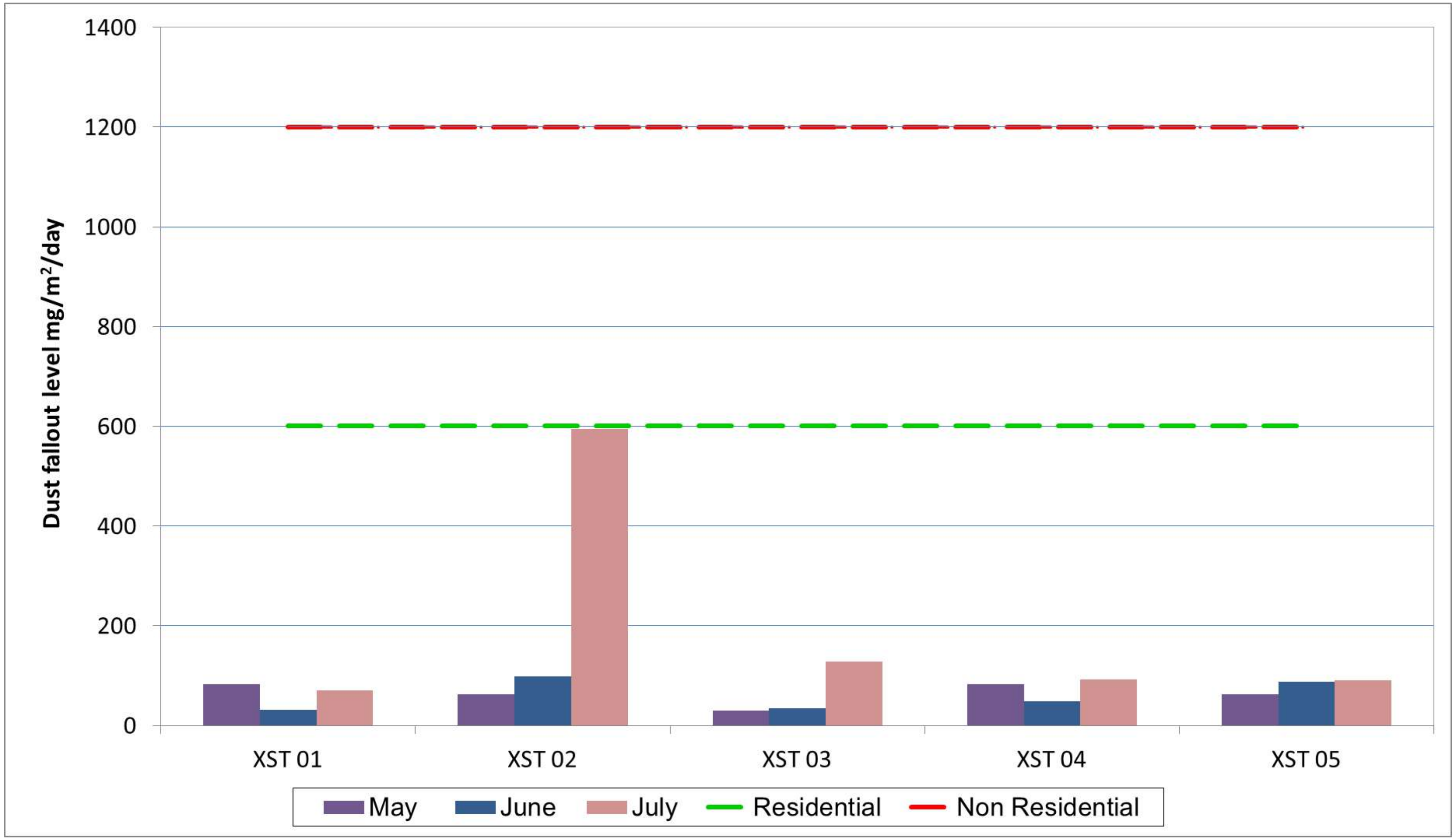

Figure 6-11: Hendrina Dust Deposition Rates

6.2.2 Particulates ($PM_{2.5}$, PM_{10}) and Gaseous Pollutants Baseline

There is no particulate matter monitoring in the project area or nearby vicinity for historical data required to assess background levels. This also applies to ambient monitoring of gaseous pollutants. Hence it was difficult to assess site specific background pollutant levels in the proposed project area.

6.3 Health Effects of the Potential Pollutants

6.3.1 Particulates and Gaseous Pollutants

The pollutants of concern associated with the proposed construction and operational phases of the Project will include particulate matter (whether in the form of dust fallout, PM_{10} or $PM_{2.5}$) and gases such NO_x (as NO_2), SO_2, and CO.

In terms of health effects, particulate air pollution is associated with complaints of the respiratory system (WHO, 2000). Particle size is important for health reasons because it controls where in the respiratory system a given particle deposits. 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).

With evidence of adverse health effects at low levels of exposure, WHO revised its Air Quality Guidelines (AQG) for PM in 2005, and adopted 10 µg/m^3 and 25 µg/m^3 as the annual and 24-hour limits, with the daily average not to be exceeded for more than 3 days/year. The corresponding guidelines for PM_{10} were set as 20 µg/m^3 (daily limit) and 50 µg/m^3 (annual limit) respectively. Short-term and long-term health effects associated with exposure to these pollutants are presented in Table 6-12. SO_2 can react with other compounds in the atmosphere to form small particles. These can penetrate deeply into sensitive parts of the lungs resulting in respiratory diseases. The latter also applies to NO_2 and CO in the environment.

6.3.1.1 Short-Term 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). Short-term exposure to SO_2 can result in an array of adverse respiratory effects. The same can be said of NOx in the atmosphere.

6.3.1.2 Long-Term Exposure

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

Studies have indicated an association between lung function and chronic respiratory disease and airborne particles. Older studies by Chestnut *et al* (1991) found that FVC (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.

Table 6-12: 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

6.3.2 Particulates ($PM_{2.5}$, PM_{10}) and Gaseous Pollutants Baseline

There is no particulate matter monitoring in the project area or nearby vicinity for historical data required to assess background levels. This also applies to ambient monitoring of gaseous pollutants. Hence it was difficult to assess site specific background pollutant levels in the proposed project area.

7 Assessment of Project Impacts

7.1 Emissions Inventory

The detailed infrastructural layout was received and utilised to develop an emissions inventory for the proposed Hendrina underground mine, which took cognizance of all emission sources envisaged. Equations from United States Environment Protection Agency (US EPA, 2006) and the Australian National Pollutant Inventory were utilised to calculate emission rates that served as inputs into the dispersion model.

The following were considered in the inventory: all point, area, volume and line sources; types of pollutants and emission rates – which encompasses:

- Material handling, tipping, loading and dumping of material;
- Crushing and screening of ore;
- Transportation of ore off site;
- Erosion from various stockpiles;
- Venting of pollutants from underground operation; and
- Generation of power from diesel generators.

7.1.1 Sources

7.1.1.1 Point Sources

The point sources considered are emissions from the diesel generator stacks (three generators -5000 KVA and a total of 15 MW generator farm). Stack specifications adopted for the generator point source was based on the design parameters from the CAT 5000 KVA specifications. Stack height of 7.5 m, Stack diameter of 0.2 m, exit flow velocity of 14.5 m/s, stack exit temperature of 462 k and operational hours of 8760 hours per year.

7.1.1.2 Volume Sources

Emissions from the crushers were modelled as volume sources. This encompasses the ore crushers - primary, secondary and tertiary respectively. The same applies to tipping at the conveyor tipping points. The crushers were assumed to be operational for 24h/day at release height of 10 m above the ground.

7.1.1.3 Line Source

The road width is 20 m used mainly by the trucks for transporting coal off site. The operational hours per year used in the model were 8760 hours. Impacts were limited to dust from dirt road and not gaseous emissions from trucks. The model incorporated the use of a 100 tonne truck in the hauling of ore and waste. Emissions due to hauling were modelled as line sources and the modelling parameters were based on guidance document from AERMOD User's Guide.

7.1.1.4 Area Source

Fugitive emissions from topsoil, overburden dump, product stockpile was considered in the model based on information supplied by the applicant.

7.2 Dispersion Modelling

Dispersion models compute ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from sources within the proposed operation. All emission scenarios will be simulated using the US 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).

Model results will predict contributions from the proposed Project to surrounding atmosphere and generate contour plots (maps) of ground level concentration zones per pollutant.

7.2.1 Modelling Domain

There are two input data processors that are regulatory components of the AERMOD modelling system:

- AERMET, a meteorological data pre-processor that incorporates air dispersion based on planetary boundary layer, turbulence structure and scaling concepts; and
- AERMAP, a terrain data pre-processor that incorporates complex terrain using USGS Digital Elevation Data.

The complex terrain module available in the AERMOD model was used. The influence of the terrain will vary with the source height and position and the local meteorology. Table 7-1 gives an overview of meteorological parameters and basic setup options for the AERMOD model runs utilised in the dispersion modelling.

The AERMAP terrain pre-processor requires the user to define a modelling domain. The modelling domain is defined as the area that contains all the receptors and sources being modelled with a buffer to accommodate any significant terrain elevations.

AERMOD's required model inputs are as follows:

- AERMET: calculates boundary layer parameters for input to AERMOD:
  - Model inputs: wind speed; wind direction; cover; ambient temperature; albedo; surface roughness; Bowen ratio.

- AERMAP: calculates terrain heights and receptor grids for input to AERMOD:
  - Model inputs: DEM data [x,y,z]; design of receptor grid (pol., cart., disc.); and
  - Model outputs for AERMOD: [x,y,z] and hill height scale for each receptor.
- AERMOD: calculates temporally-averaged air pollution concentrations at receptor locations for comparison to the relevant standard:
  - Model inputs: source parameters (from permit application); boundary layer meteorology (from AERMET); receptor data (from AERMAP).

Table 7-1: Summary of meteorological and AERMET parameters used for Hendrina

Number of grids (spacing)	250 m, 500 m
Number of grids points	6561
Years of analysis	Jan 2013 to Dec 2015
Centre of analysis	(26.228158 S, 29.777358 E)
Meteorological grid domain	20 km (east-west) x 20 km (south-north)
Meteorological grid cell resolution	250
Station Base Elevation	1671 m
MM5-Processed Grid Cell (Grid Cell Centre)	8905642 S, 489037 E
Anemometer Height	13 m
Sectors	The surrounding area land use type was considered to be cultivated land
Albedo	0.328 (generated with the AERMOD Model – when the land use types are specified)
Surface Roughness	0.2625
Bowen Ratio	4.75
Terrain Option	Elevated

7.2.2 Analysis and Interpretation

Impacts were assessed based on the predicted maximum ground level concentrations predicted at the project boundary which were compared to regulatory standards to determine compliance at the Project boundary and beyond.

It is noted that:

- The current standard for a pollutant was applied to all locations where members of the public may be exposed for the averaging periods (e.g. 1-hour, 8-hour, 24-hours, and annual).

Analysis of dispersion model highlighted the following:

- Predicted zones of maximum ground level impacts (PM and Gases); and
- Recommendations of impact management zones.

Once the areas of maximum impacts are identified, recommendations are provided regarding the mitigation measures to adopt. These recommendations should be incorporated into the day-to-day operation of the mine to prevent, control and abate emissions.

8 Dispersion Modelling Results

8.1 PM_{10}

8.1.1 PM_{10} Daily

The Isopleths showing 24-hour concentration zones of PM_{10} as a result of the operational phase of the proposed project are presented in Figure 8-1 and Figure 8-2. The predicted 24-hour (daily) concentrations show that the NAAQS (75 µg/m³) will be exceeded at the southern boundary at Mooivley East and at the northern and western boundary at Mooivlei East without mitigation measures in place (Table 8-1). The major contributions are emissions from roads, vents and crushers. Once mitigation measures are applied, the PM_{10} 24-hour impacts were confined to within few metres from the project boundary, south of Mooivley East and north of Mooivley West (Figure 8-2).

The predicted concentrations are the likely additions that the proposed Project will add on to ambient concentrations and not cumulative impact i.e. addition of projected emissions to existing background levels in the area. The concentrations predicted at the various sensitive receptors (represented as XST) pre and post mitigation measures are presented below (Table 8-1), with site XST 01 (6 km southeast of Hendrina Community) exceeding the NAAQS pre mitigation.

8.1.2 PM_{10} Annual

The Isopleths of predicted annual PM_{10} ground level concentration are presented in Figure 8-3 and Figure 8-4. The predicted annual concentrations at the sensitive receptors are within the NAAQS of 40 µg/m³ at selected receptors. With the application of mitigation measures, predicted concentrations are minimised and confined to within the project boundary. Concentrations predicted for the selected sensitive receptors pre and post mitigation are presented in Table 8-1.

8.2 $PM_{2.5}$

8.2.1 $PM_{2.5}$ Daily

The Isopleths showing the predicted 99th percentile 24-hr (daily) ground level concentration of $PM_{2.5}$ at the proposed Project area are presented in Figure 8-5 and Figure 8-6. The plot without mitigation shows exceedances at the proposed mine boundary (Mooivley East and Mooivley West) were in exceedance of the current NAAQS of 40 µg/m³. However, once mitigation measures are applied the zone of impact was minimised and confined to the project area (Figure 8-6). Concentrations predicted at the sensitive receptors are reported in Table 8-1.

8.2.2 $PM_{2.5}$ Annual

Isopleths showing the annual ground level concentration of $PM_{2.5}$ are presented in Figure 8-7 and Figure 8-8 respectively. The predicted concentrations at the project boundary were within the NAAQS of 20 µg/m³ with and without mitigation. With mitigation measures in place, the zone of impact was reduced and confined to the project area (Figure 8-8). The predicted concentrations for the sensitive receptors pre and post mitigation are reported in Table 8-1.

8.3 Dust Deposition

The predicted dust deposition rates anticipated from the proposed operation show that dust levels without mitigation will be severe. The predicted deposition rate at the Project boundary and beyond are higher than the National Dust Control Regulation of 1 200 mg/m²/day (NDCR, 2013) recommended for non-residential areas, especially at the western boundary at Mooivley West, southeast at Mooivley East and northwest at Hendrina South reached some 750 m past the project boundary. Exposure will be higher along the haul road and adjacent areas and around the crushers (Figure 8-9). Once mitigation measures, such as using dust suppressants on haul roads, vegetation of stockpiles, and housing of crushers / water sprays are applied – the deposition rates dropped significantly and the zone of impact was minimised (Table 8-1 and Figure 8-10). To assess the cumulative impacts, for each of the sensitive receptor sites, the highest dust deposition rates for each site over the three month period (May, June and July) was taken as the background (in brackets). The model predictions were then added to these background values. The final deposition rates (model + measured) for all the sites were within the dust deposition standards, except XST 2, with a combined deposition rate of above 600 mg/m²/day after mitigation.

It should be noted that isopleths 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 showing likely concentrations that the proposed project would add on to existing ambient air quality and should not be considered a cumulative impact. The dust deposition rates predicted for sensitive receptors pre and post mitigation are presented in Table 8-1. The cumulative impacts are presented in brackets.

Table 8-1: Comparison of Predicted Concentrations of PM_{10}, $PM_{2.5}$ and Dust Deposition at selected Sensitive Receptors

Pollutant	Averaging Period	South African Air Quality Standard (µg/m³)	Levels at receptors (µg/m³)				
			XST 01	XST 02	XST 03	XST 04	XST 05
PM_{10} (No Mitigation)	24 hour	75(1)	**82**	15	10	**21**	2
	Annual	40(1)	3	0.8	0.5	2	0.2
PM_{10} (With Mitigation)	24 hour	75(1)	19	7	2	5	0.4
	Annual	40(1)	0.6	0.4	0.1	0.3	0.04
$PM_{2.5}$ (No Mitigation)	24 hour	40(1)	**11**	2	1	4	0.4
	Annual	20(1)	0.6	0.3	0.09	0.3	0.04
$PM_{2.5}$ (With Mitigation)	24 hour	40(1)	7	0.9	0.4	2	0.2
	Annual	20(1)	0.2	0.09	0.03	0.1	0.01
Dust fall (mg/m²/day)							
Dust deposition (No Mitigation)	monthly	600(2) Residential) 1200(2) Residential)	40 (82)	80 (594)	79 (128)	70 (92)	21 (91)
Dust deposition with mitigation	monthly	600(2) Residential) 1200(2) Residential)	10 (82)	20 (594)	18 (128)	9 (92)	8 (91)

1. South African Ambient Air Quality Standard, 2009:2012
2. South African National Dust Control Standard, 2013

8.3.1 Nitrogen Dioxides (NO_2)

Isopleth showing model predictions: 1-hourly and annual NO_2 concentrations (all NO_x assumed to be NO_2) are presented (Figure 8-11 and Figure 8-12). The predicted 1-hour average is exceeded within the project area, however, the concentrations at the project boundary are within the South African 1-hour NAAQS (200 µg/m³). After mitigation measures were applied, no exceedance was predicted in the project area. The zone of impact was minimised and a further reduction observed in the ground level concentration at the Project area and beyond.

The predicted annual level is within the current NAAQS (40 µg/m³). Isopleth showing the annual ground level concentrations are presented (Figure 8-13 and Figure 8-14). The main contributor to the levels of NOx predicted is associated with emissions from the vent. The concentrations at the selected sensitive receptors are presented in Table 8-2 below.

8.3.2 Sulfur Dioxides (SO_2)

The isopleths of 1-hour, 24-hour and annual concentrations predicted for the proposed Project operation, primarily from the vent are presented in Figure 8-15, Figure 8-16 and Figure 8-17. The predicted 1-hour ground level concentration exceeded the NAAQS (350 µg/m³) within the mine boundary. The ground level concentrations at the project boundary and beyond were within the NAAQS.

The predicted 24-hour ground level concentrations of SO_2 will be exceeding the NAAQS 125 µg/m³ within the project boundary. However, at the project boundary and beyond the concentrations will be below the 24-hour NAAQS.

The predicted annual concentrations will be below the annual NAAQS of 40 µg/m³, within the project area and beyond. Predicted concentrations at the selected sensitive receptors are presented in Table 8-2.

8.3.3 Carbon Monoxide (CO)

Model simulation of 1-hour concentrations is presented in Table 8-2. The predicted 1-hour average CO maximum ground level concentrations will be below the regulatory NAAQS of 30 mg/m³. Mitigation runs was not conducted for CO because predicted concentrations were very low. The predicted 8-hour average concentrations were within the NAAQS (10 mg/m³) at the project area and at sensitive receptors.

A summary of the ground level concentration based on model predictions for the proposed project is presented in Table 8-2. The predicted concentrations are compared against the current NAAQSs to assess compliance.

Table 8-2: Comparison of Predicted Concentrations of NO_2, SO_2 and CO at selected Sensitive Receptors

Pollutant	Averaging Period	South African Ambient Air Quality Standard ($\mu g/m^3$)	Levels at receptors ($\mu g/m^3$)				
			XST 01	XST 02	XST 03	XST 04	XST 05
NO_2 (No Mitigation)	1 hour	200[(1)]	45	41	56	18	56
	Annual	40[(1)]	0.2	0.5	0.4	0.4	0.3
NO_2 (With Mitigation)	1 hour	200[(1)]	5	6	4	4	11
	Annual	40[(1)]	0.04	0.1	0.09	0.08	0.07
SO_2 (No mitigation)	1 hour	350[(1)]	48	36	17	13	3
	24 hour	125[(1)]	7	2	3	1	0.4
	Annual	50[(1)]					
CO	mg/m^3						
	1 hour	30[(1)]	0.34	0.25	0.12	0.09	0.02
	8 hour	10[(1)]	0.11	0.05	0.02	0.05	0.01

1. South African Ambient Air Quality Standard, 2009:2012

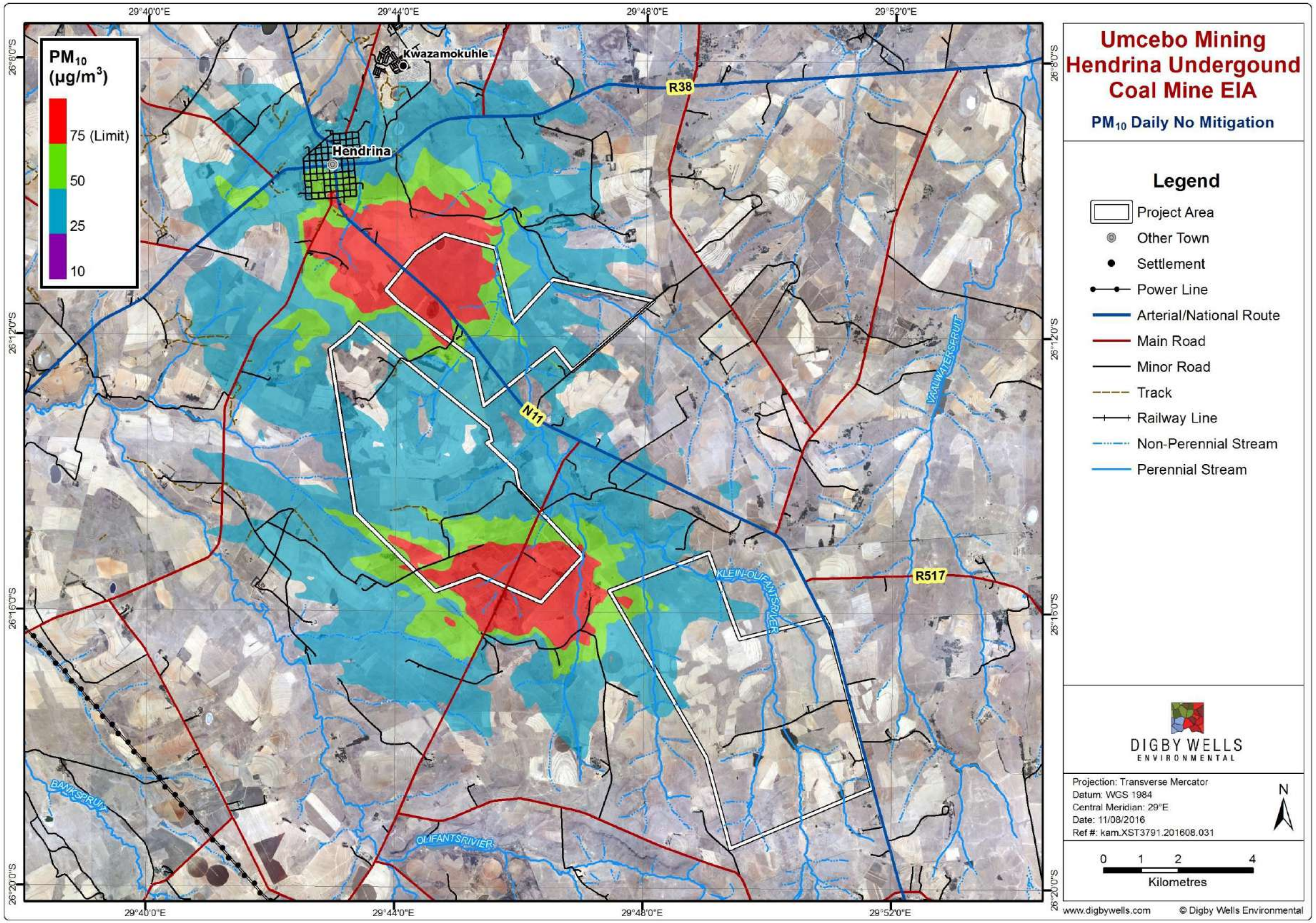

Figure 8-1: Predicted 24-hr average PM_{10} concentrations, 99th percentile (µg/m³) – No Mitigation

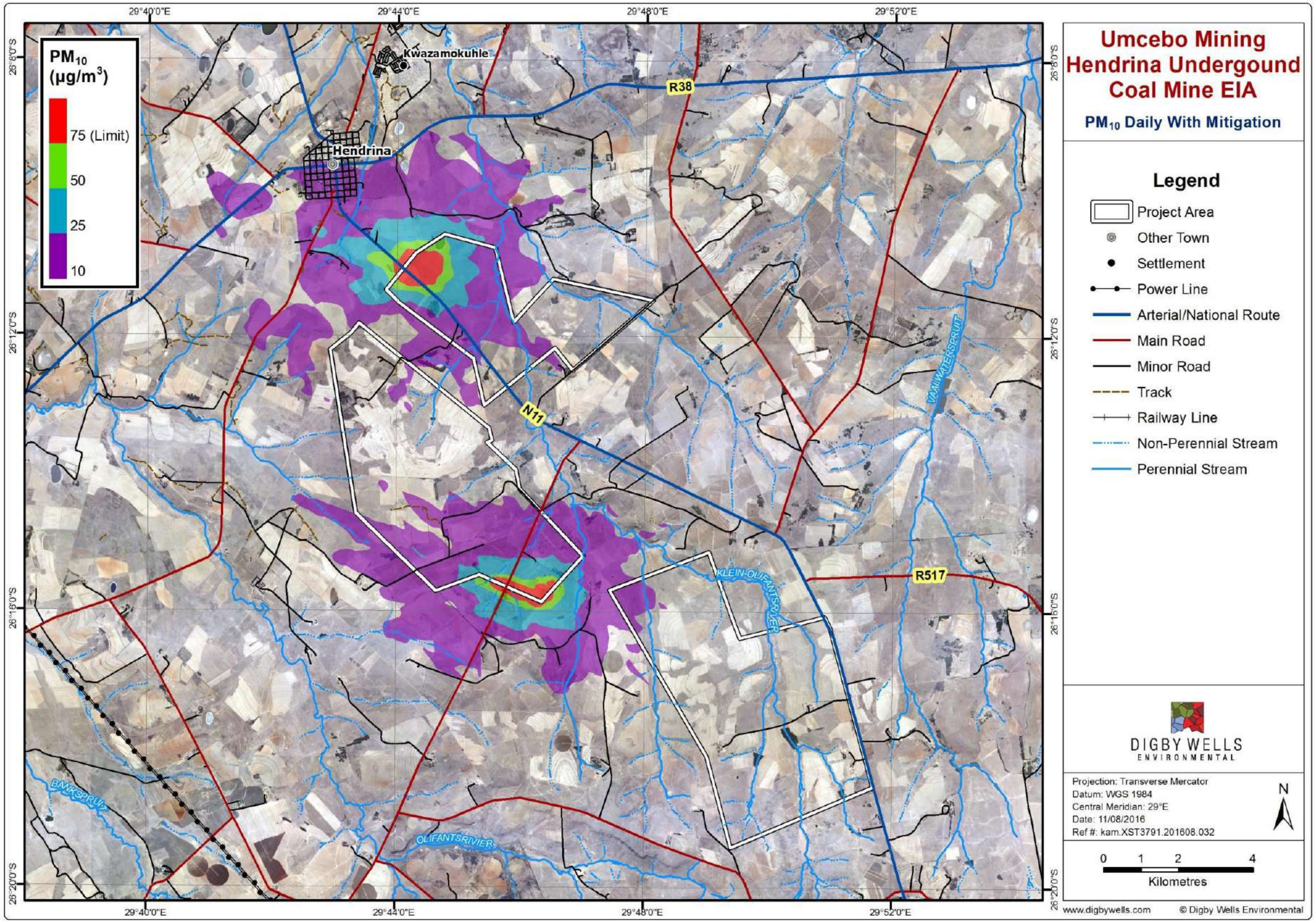

Figure 8-2: Predicted 24-hr average PM_{10} concentrations, 99th percentile ($\mu g/m^3$) – With Mitigation

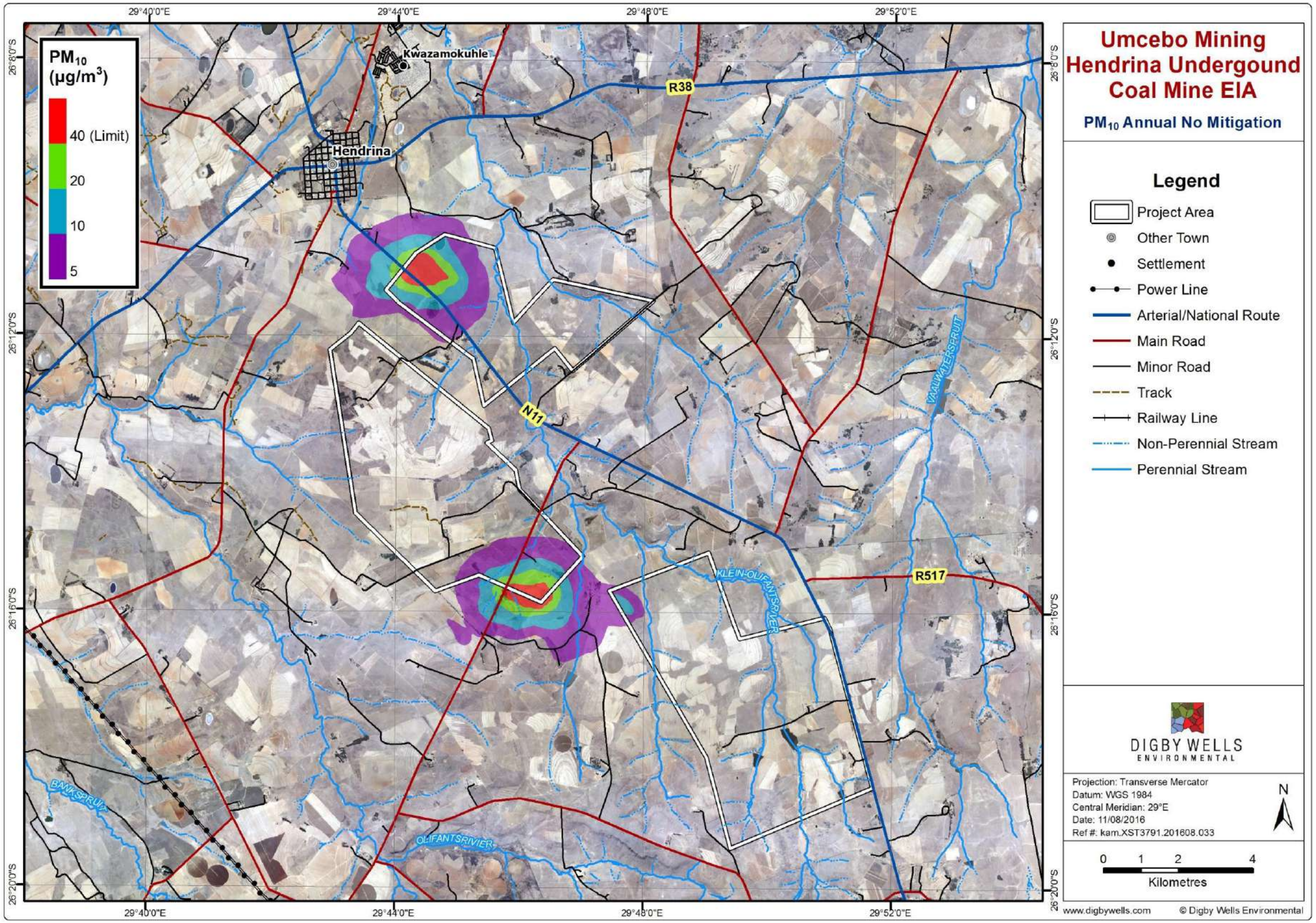

Figure 8-3: Predicted annual average PM_{10} concentrations without mitigation ($\mu g/m^3$) – No Mitigation

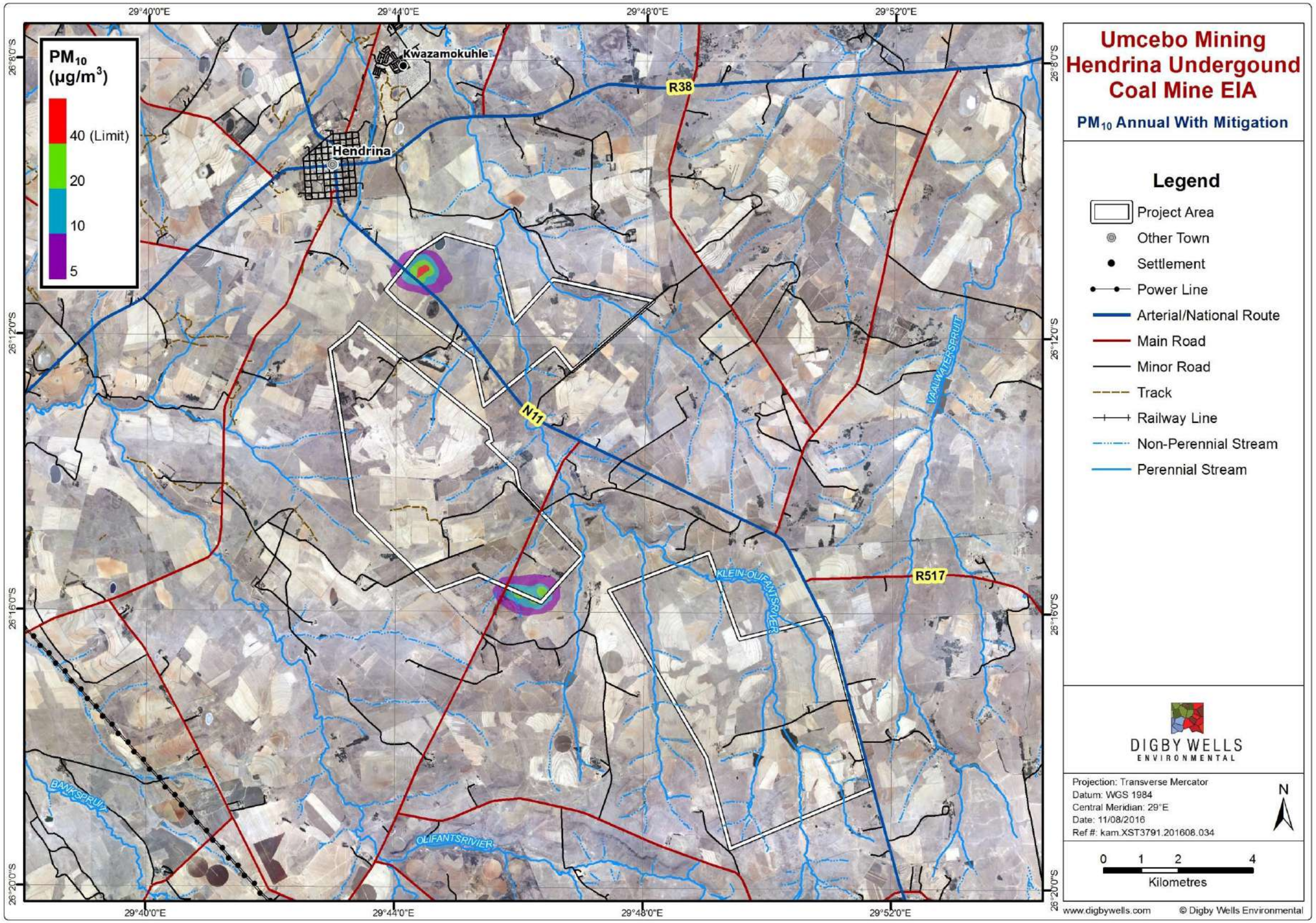

Figure 8-4: Predicted annual average PM_{10} concentrations without mitigation ($\mu g/m^3$) – with Mitigation

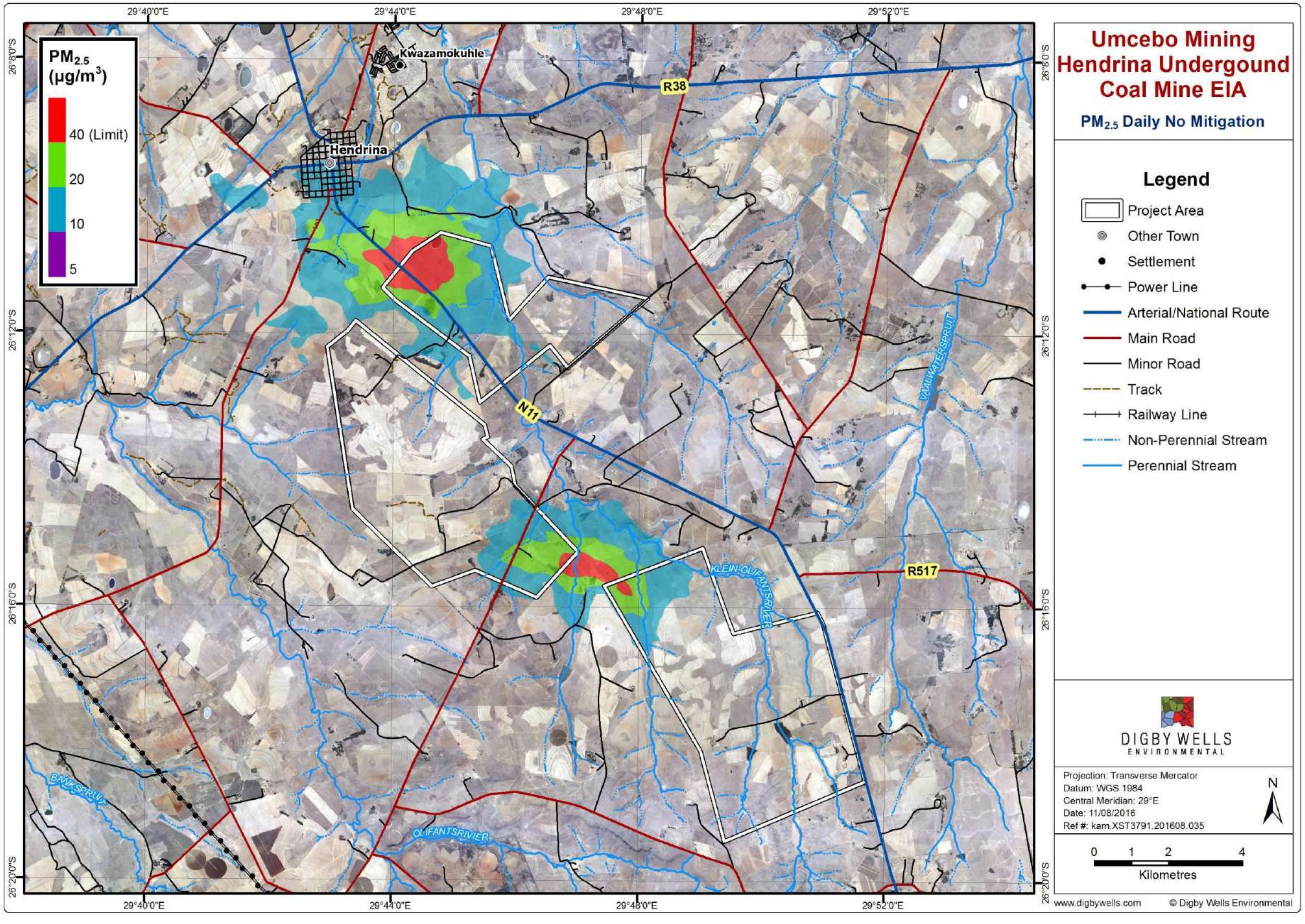

Figure 8-5: Predicted 24-hr average $PM_{2.5}$ concentrations, 99th percentile, without mitigation ($\mu g/m^3$) – No Mitigation

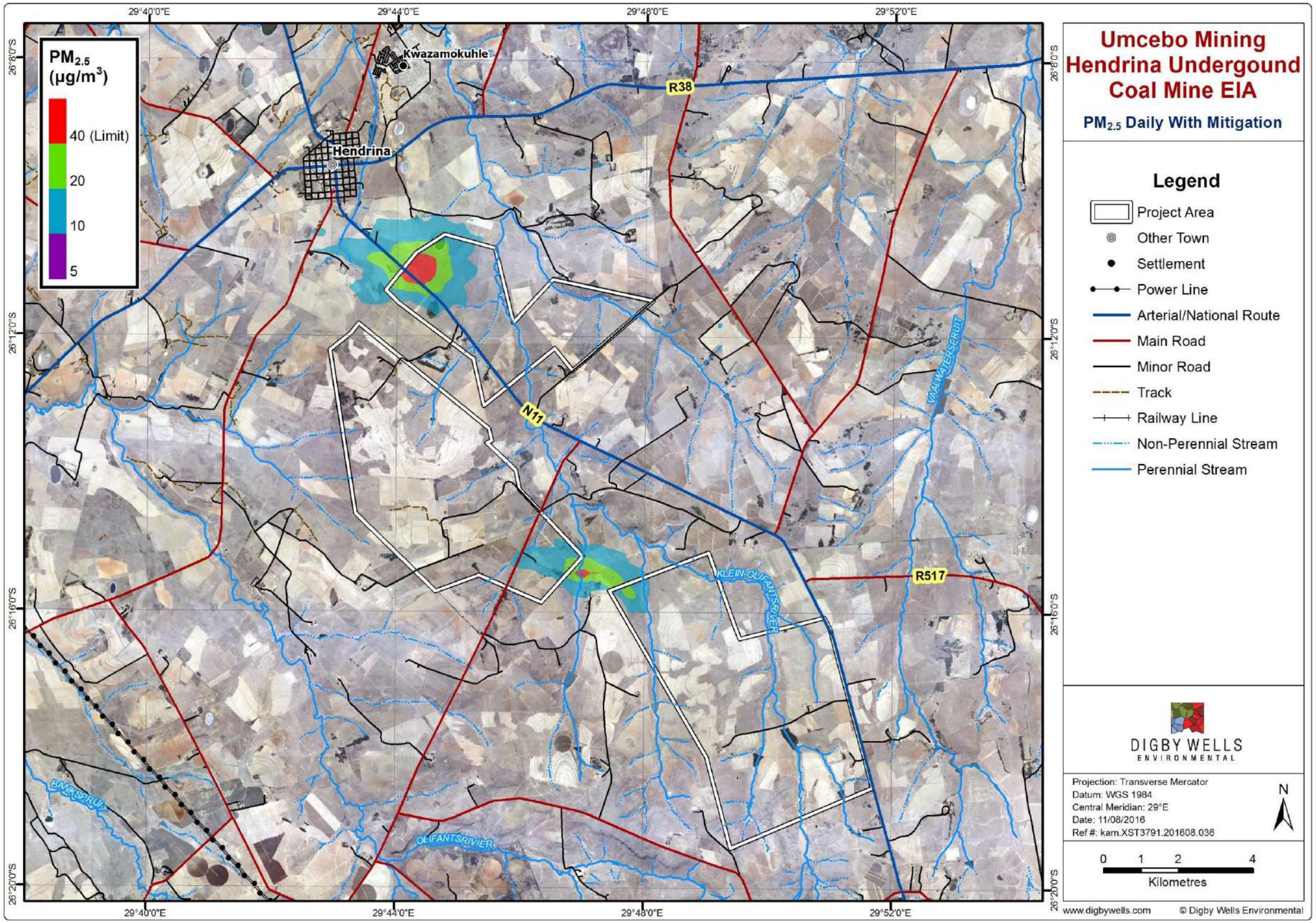

Figure 8-6: Predicted 24-hr average $PM_{2.5}$ concentrations, 99th percentile, without mitigation (µg/m^3) – with Mitigation

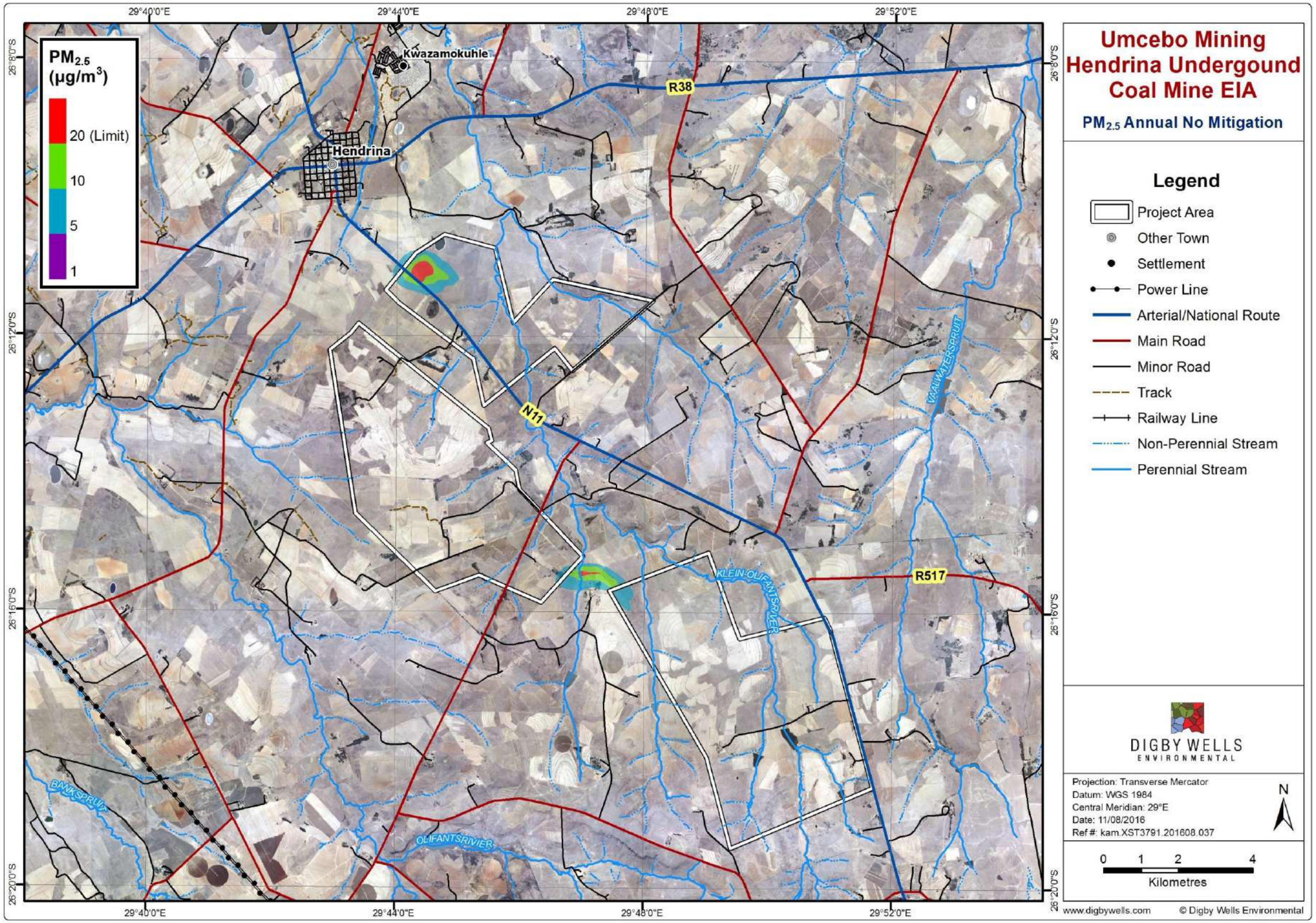

Figure 8-7: Predicted annual average $PM_{2.5}$ concentrations ($\mu g/m^3$), No mitigation

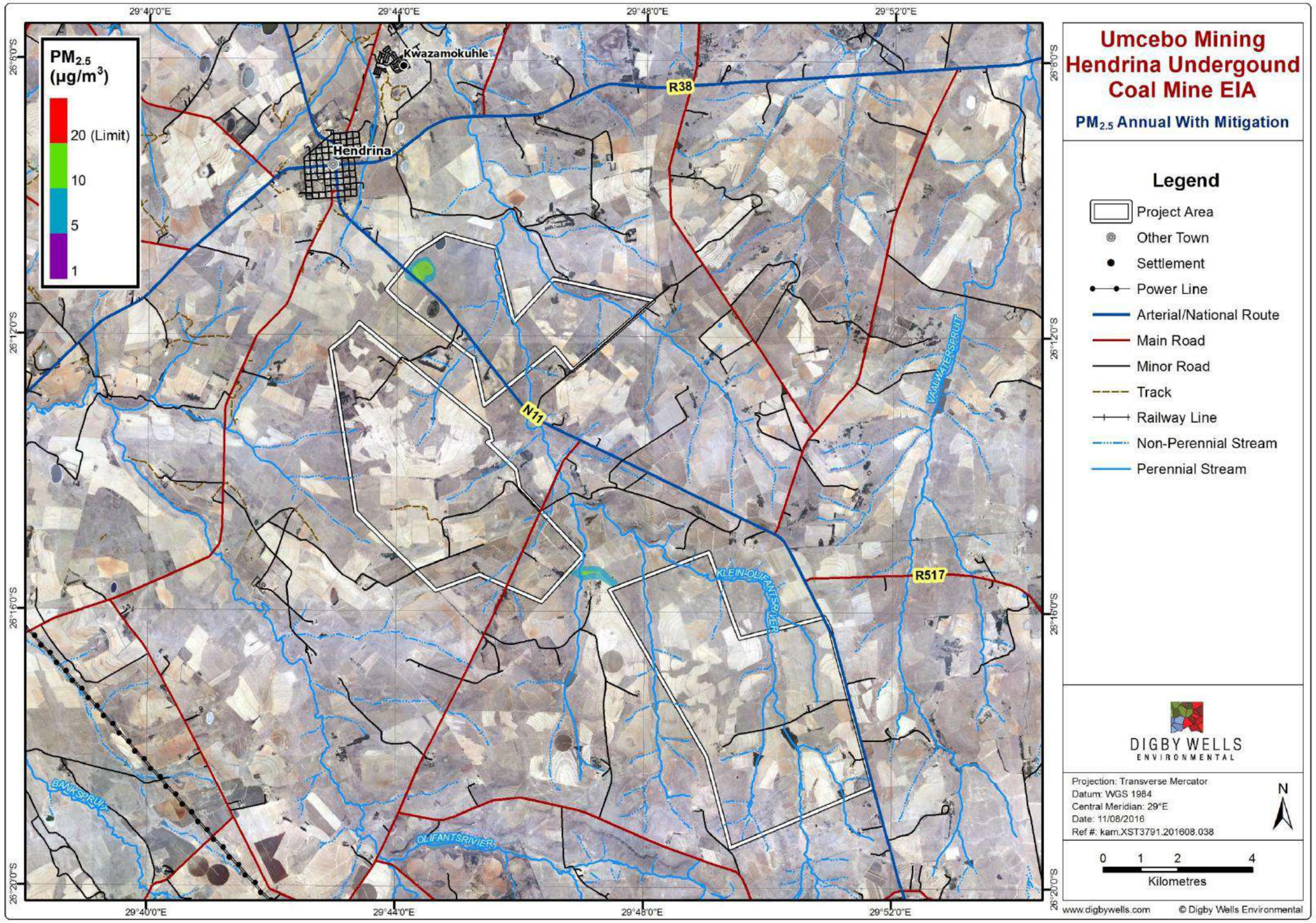

Figure 8-8: Predicted annual average $PM_{2.5}$ concentrations (µg/m^3), With mitigation

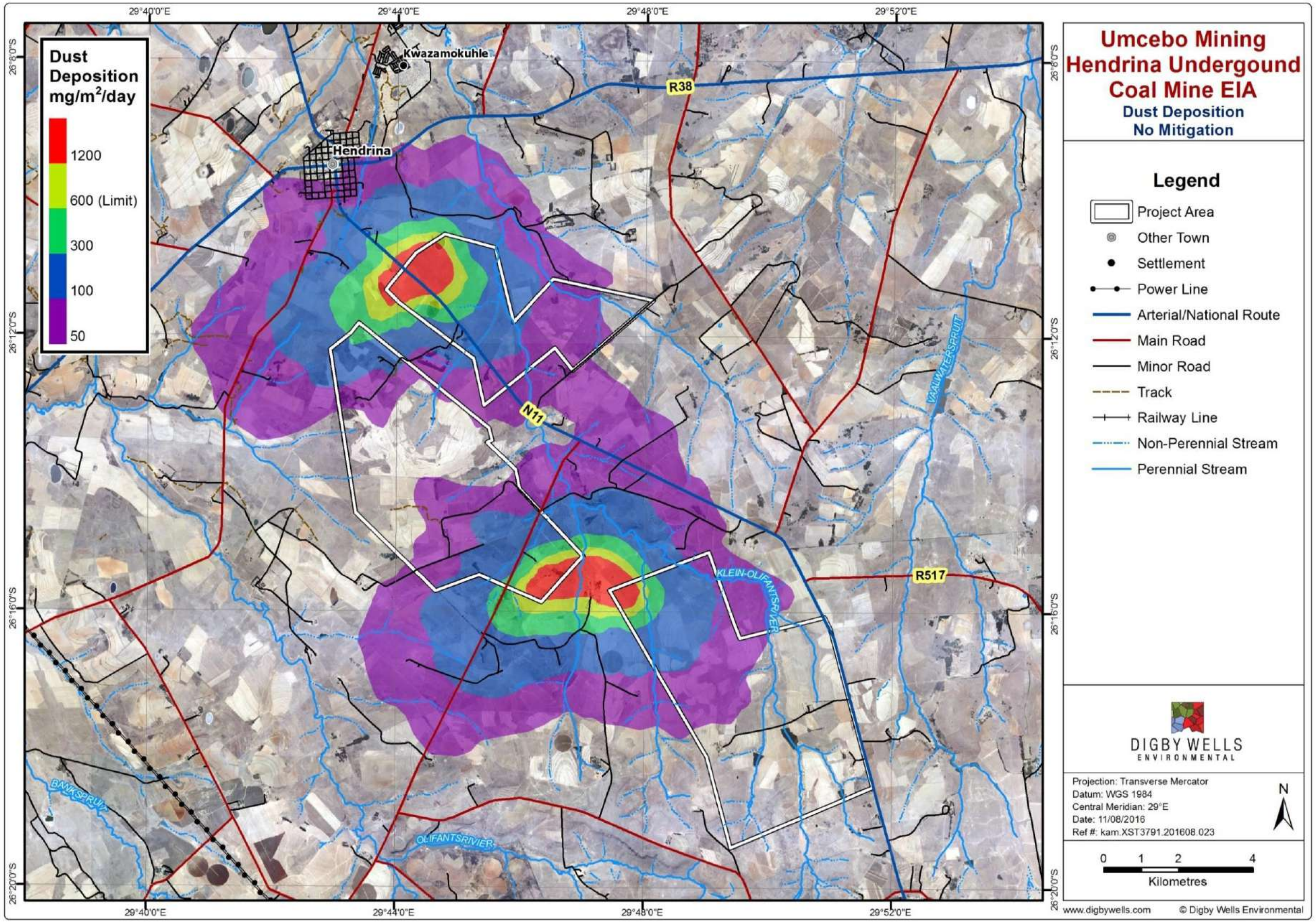

Figure 8-9: Predicted maximum (100th percentile) dust deposition (mg/m²/day) No mitigation

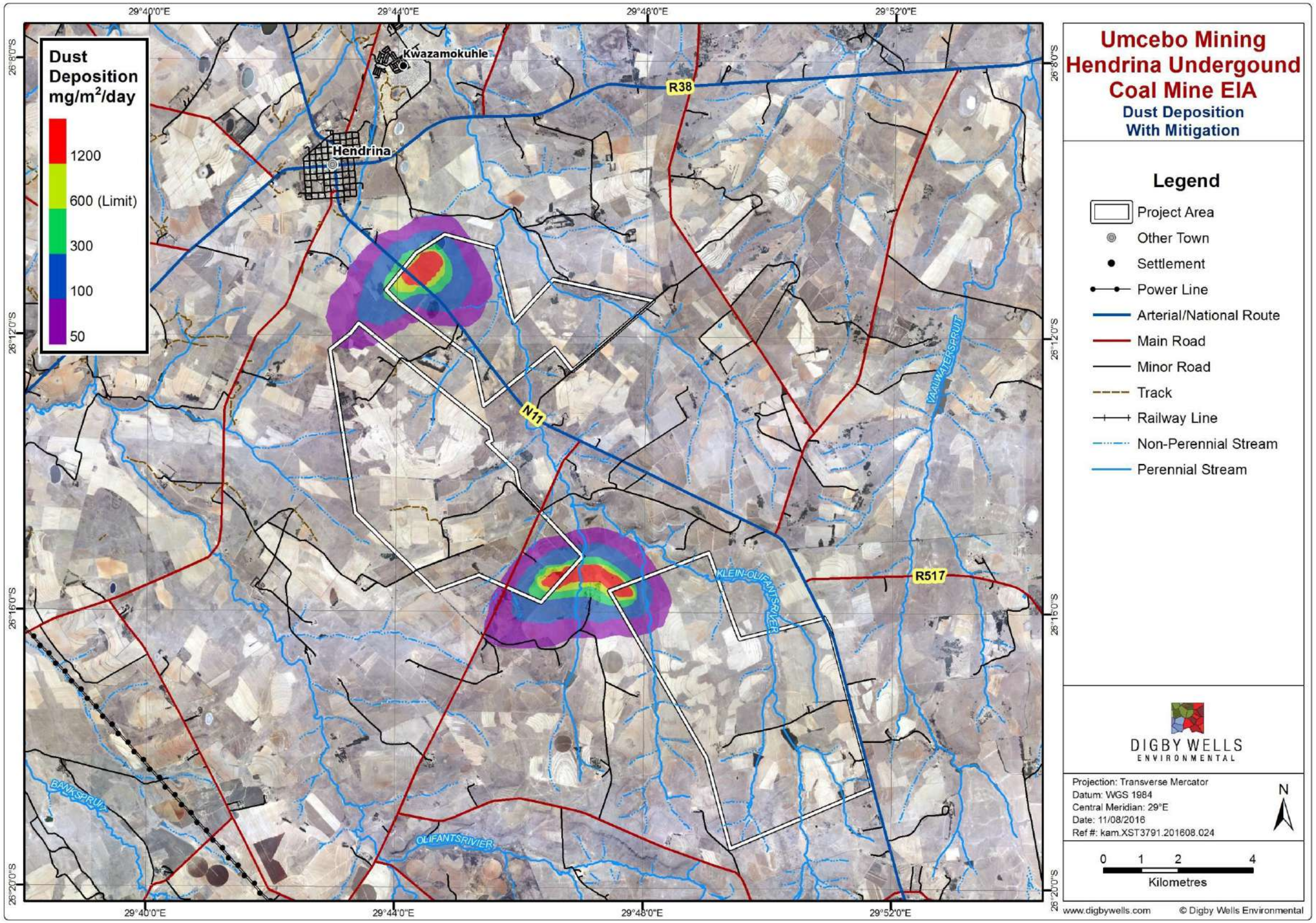

Figure 8-10: Predicted maximum (100th percentile) dust deposition (mg/m²/day) with mitigation

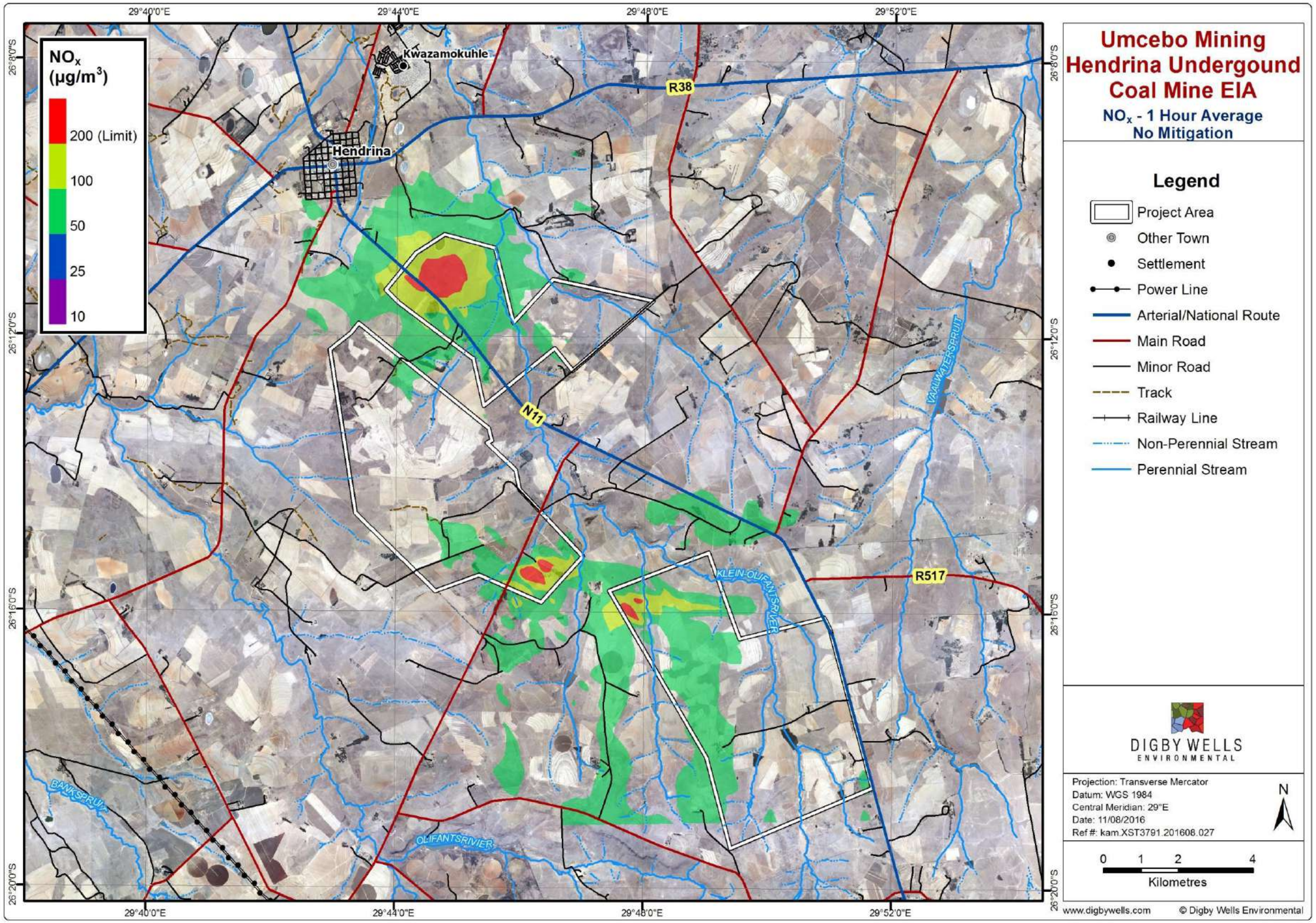

Figure 8-11: Predicted NO_2 Maximum 1-Hour Average Concentrations (µg/m^3) No Mitigation

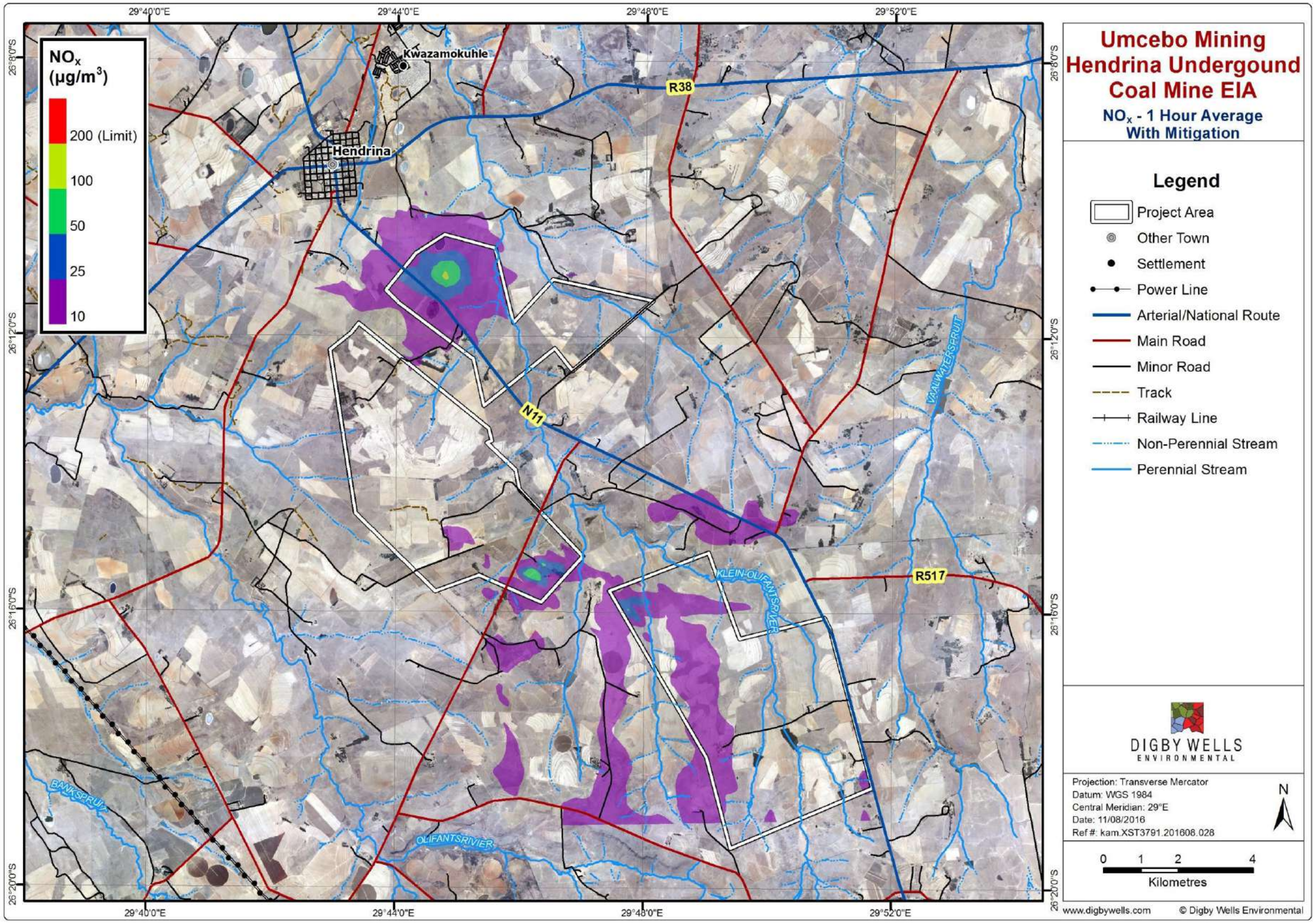

Figure 8-12: Predicted NO_2 Maximum 1-Hour Average Concentrations (µg/m³) With Mitigation

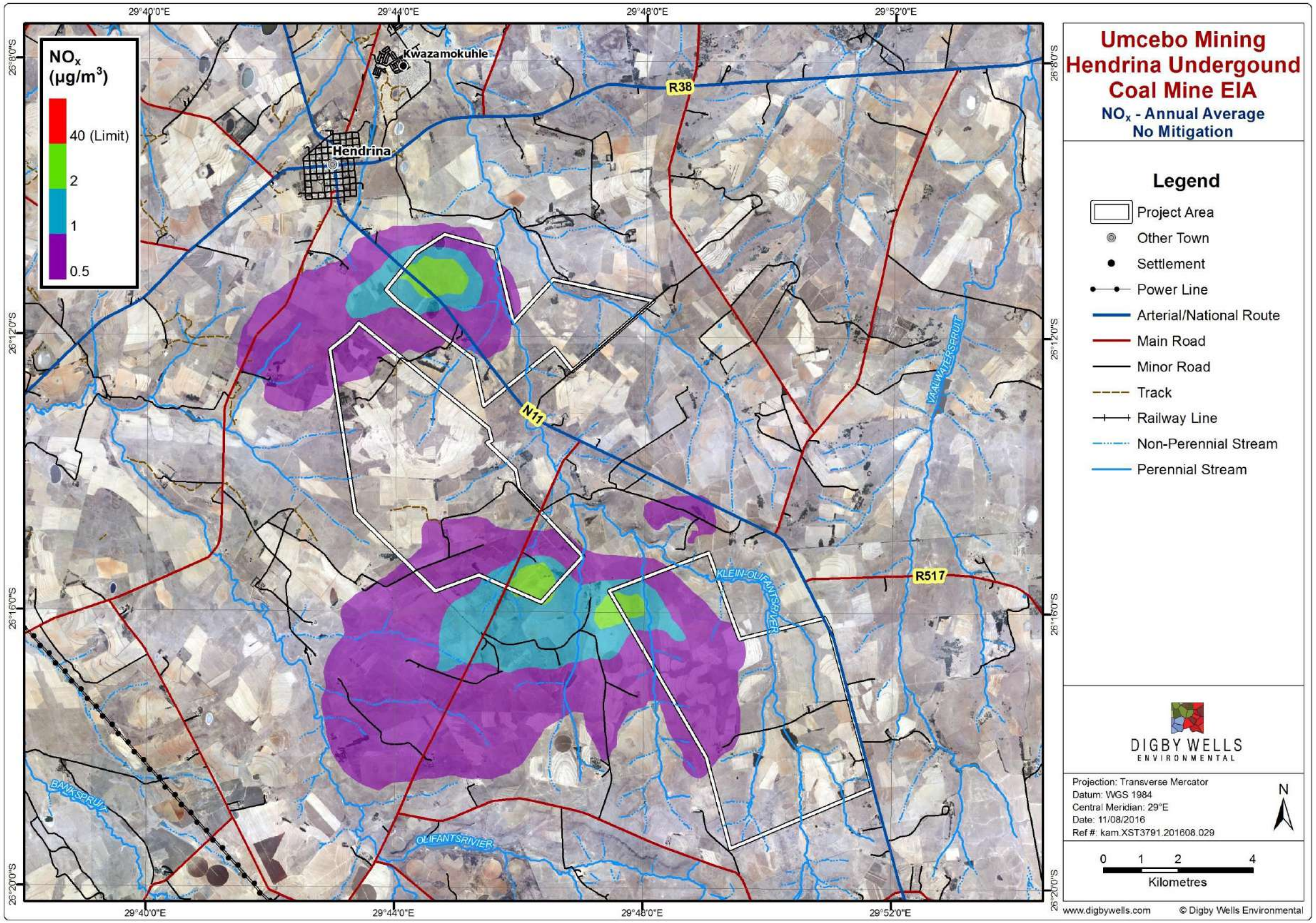

Figure 8-13: Predicted NO_2 Annual Concentration ($\mu g/m^3$) No Mitigation

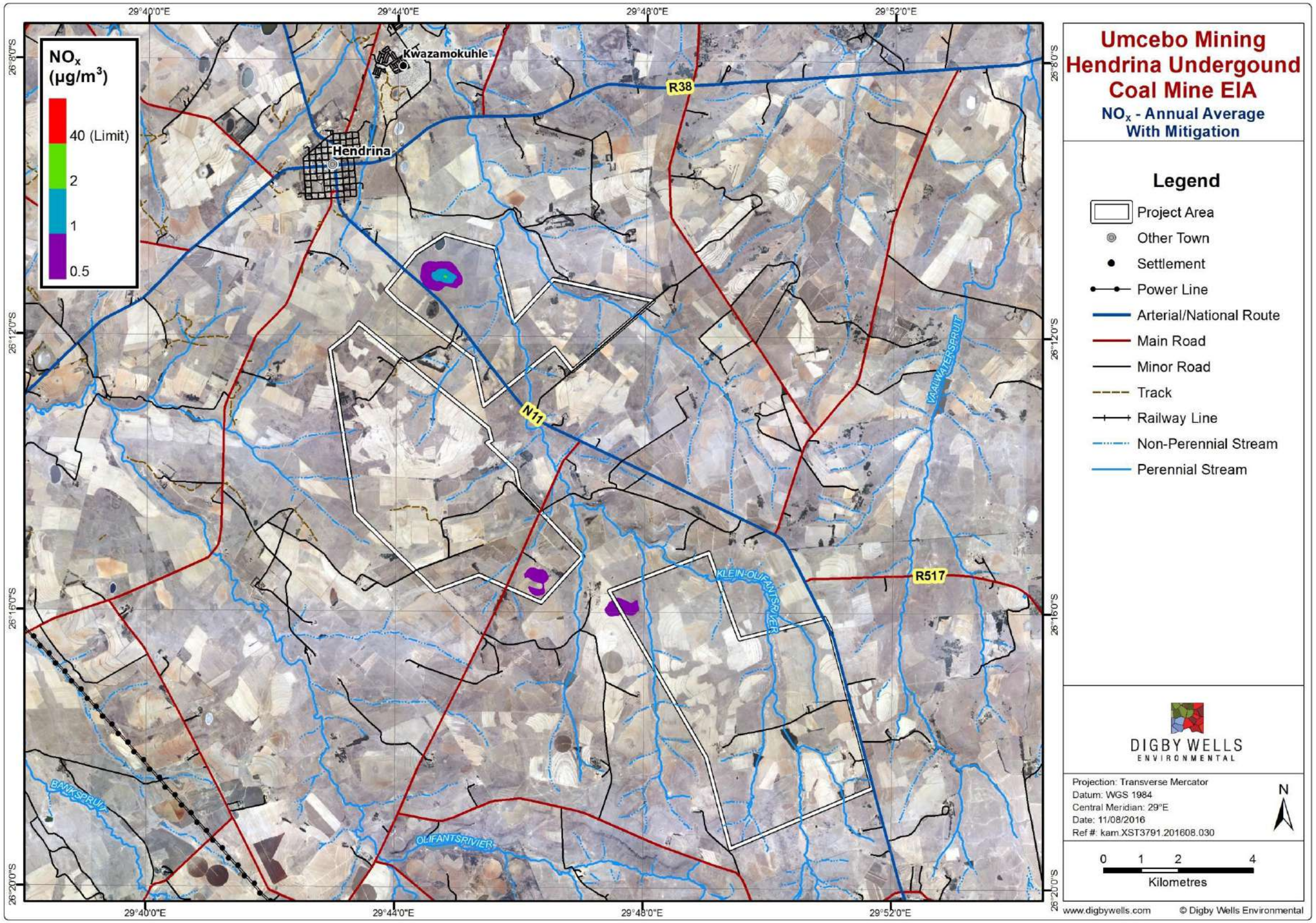

Figure 8-14: Predicted NO_2 Annual Concentration (µg/m^3) with Mitigation

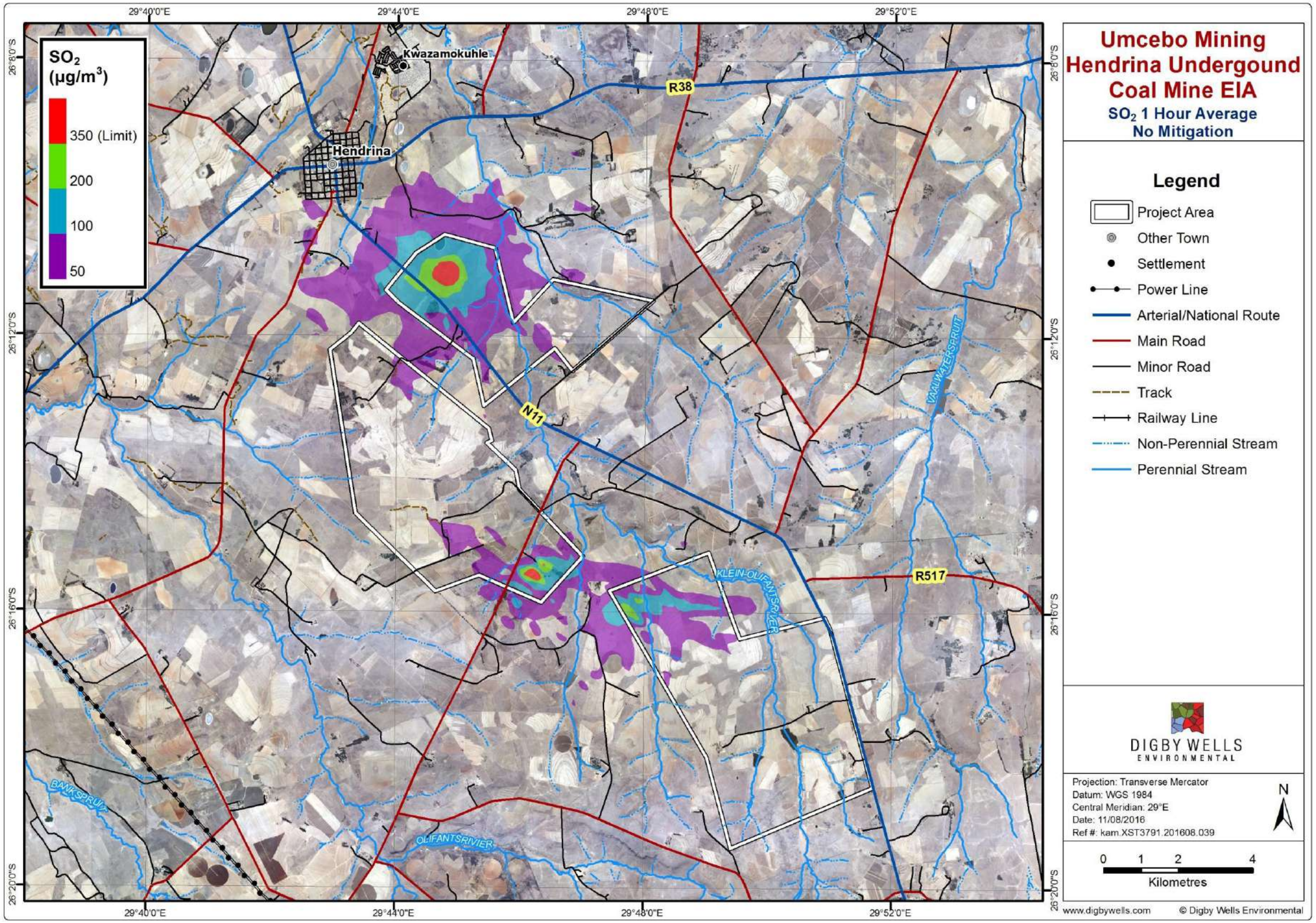

Figure 8-15: Predicted SO_2 Maximum 1-hour Average Concentrations (µg/m³) No Mitigation

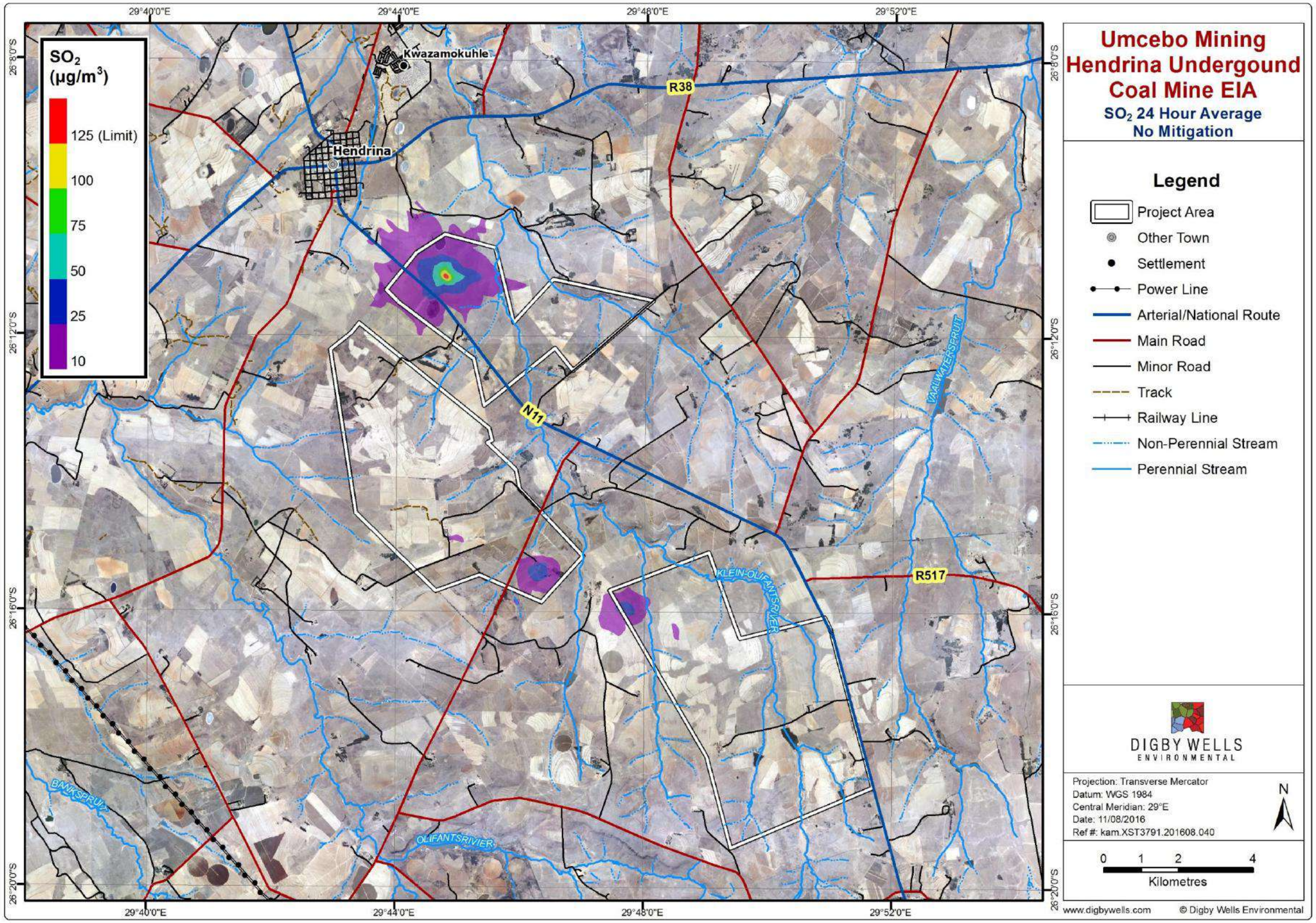

Figure 8-16: Predicted SO_2 Maximum 24-Hour Average Concentration (µg/m^3) No mitigation

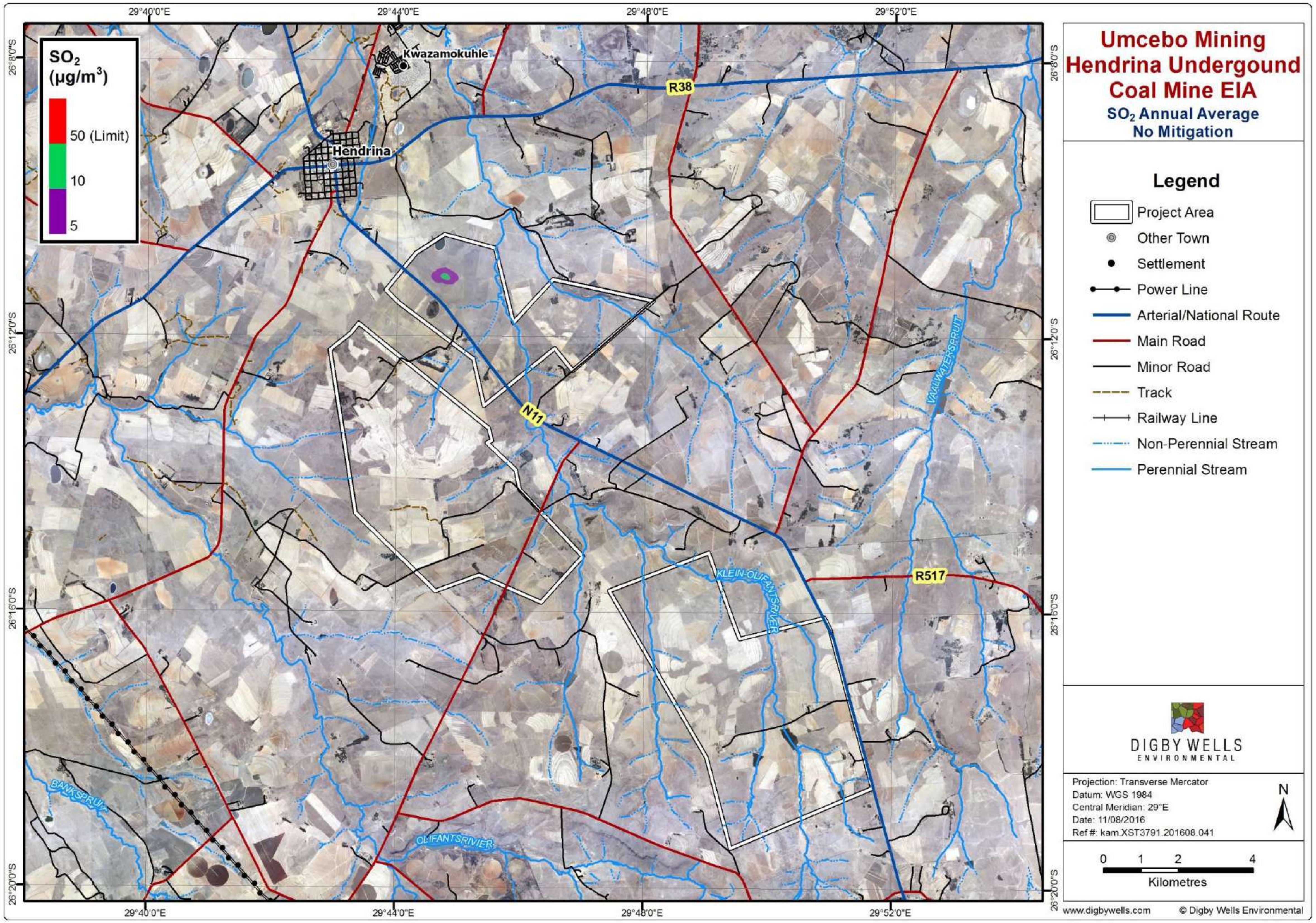

Figure 8-17: Predicted SO_2 Annual Average Concentration (µg/m³) No mitigation

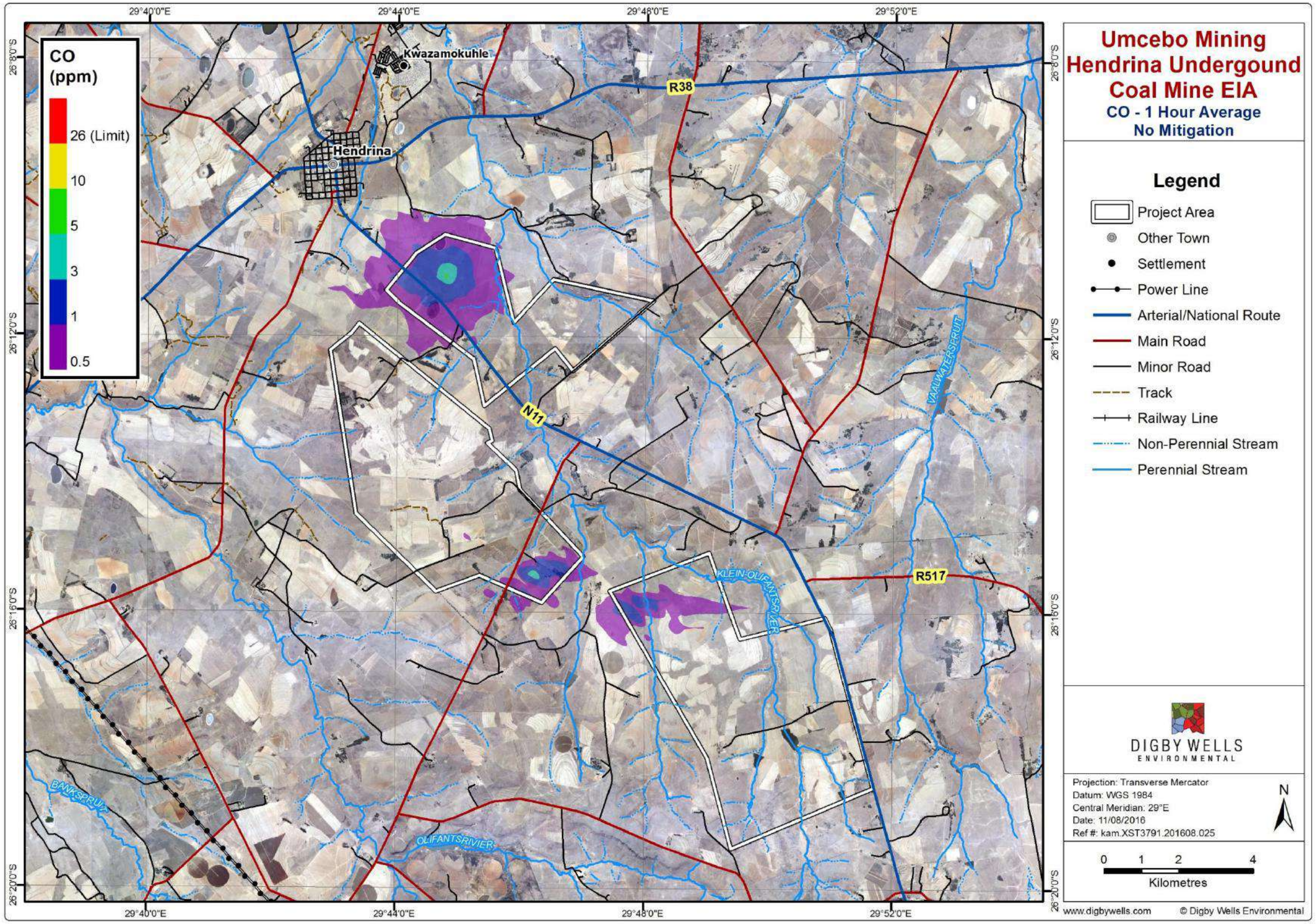

Figure 8-18: Predicted CO 1-hour Concentration (mg/ m^3)

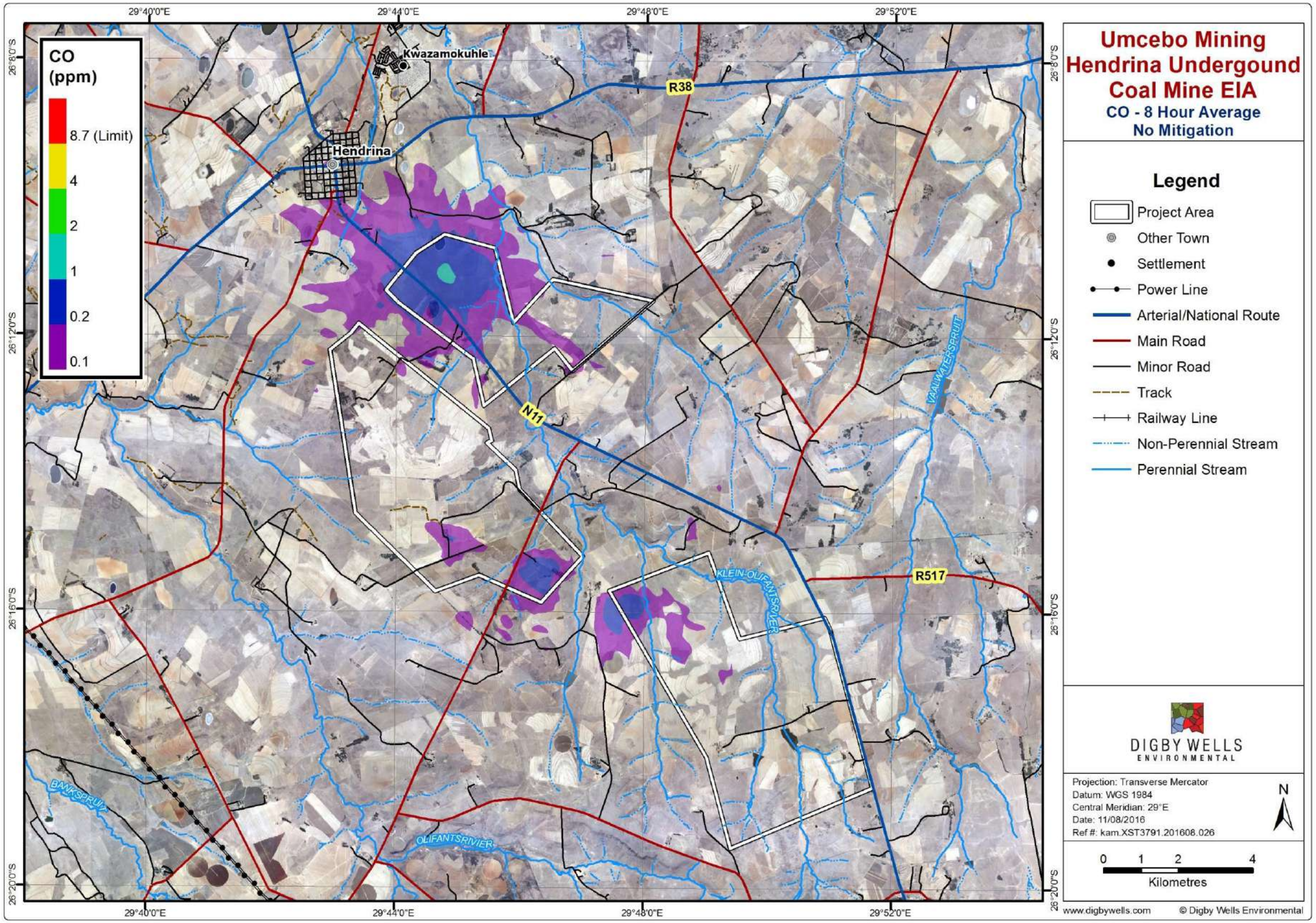

Figure 8-19: Predicted CO 8-hour Concentration (mg/ m^3)

8.4 Discussion

The impacts arising from the proposed project have been appraised using model prediction of emissions and the spread across the landscape.

For this AQIA study, the operational phase is typified as the worst case scenario since multiple activities will be conducted at the same time resulting in several sources of emissions i.e. operation of the overburden dump, product, topsoil stockpile, hauling of ore off site, venting of underground emissions and generation of power from diesel generators amongst other sources of air pollution. Once potential impacts are understood, mitigation measures are implemented to curtailed emissions within the project area. Hence, anticipated impacts on-site and beyond are expected to be minimal and within NAAQSs. The main findings of this AQIA study can be summarised as follows:

- Daily PM_{10} – predicted levels are high in the project area and surroundings without mitigation measures in place. Predicted ground level concentrations will exceed the applicable NAAQS (75 µg/m^3) at the project boundary. At the sensitive receptors, ground level concentration predicted for XST 01 of 82 µg/m^3 exceeds the NAAQS prior to mitigation. After mitigation, concentrations at XST 01 will be lowered to 19 µg/m^3. After mitigation, predicted ground level concentration was lowered considerably at the project boundary and at selected sensitive receptors.
- Annual PM_{10} – predicted annual concentrations at 100^{th} percentile will be in exceedance of the applicable NAAQS (40 µg/m^3) at the project boundary and beyond, especially at Mooivley West prior to mitigation. Concentrations at the sensitive receptors will be lower than the NAAQS.
- Daily $PM_{2.5}$ – predicted concentrations will exceed the applicable NAAQS (40 µg/m^3) at the project boundary and beyond prior to mitigation. Once appropriate mitigation measures are applied, the zone of impact will be minimised and the ground level concentrations will decrease to within NAAQS at the project boundary. Exceedances will be confined within the project boundary.
- Annual $PM_{2.5}$ – Predicted annual concentrations at Mooivley East will exceed the applicable NAAQS (20 µg/m^3), but latter is confined within the project boundary. However, due to the road link between Mooivley West and Hendrina South – exceedance is predicted over a small area between the project boundaries. Ground level concentrations at the selected sensitive receptors will be below the NAAQS.
- Dust deposition rates predicted for the proposed project area are quite high without mitigation measures. The residential and non-residential standards of 600 mg/m^2/day and 1200 mg/m^2/day will be exceeded at the project boundary and beyond. Once mitigation measures are applied, the zone of exceedance at Mooivley East will be minimised and confined to within the project boundary. However, due to the road link between Mooivley West and Hendrina South – exceedance is predicted over a much smaller area between the project boundaries after mitigation measures are applied.

For the gaseous pollutants, mainly emissions from the diesel generators (~15 MW) and from underground venting, the findings are summarised as follows:

- The predicted 1-hour NOx (all NO_X assumed to be NO_2) concentrations attributed to the proposed project will result in ground level concentrations higher than the applicable NAAQS of 200µg/m^3 within the project areas – Mooivley East, Mooivley West and Hendrina South. The concentration at the project boundary and beyond will be below the NAAQS once operational.
- Predicted annual concentrations of NO_X will not exceed the NAAQS (40 µg/m^3) at the project boundary or at sensitive receptors.
- The 1-hour SO_2 concentrations predicted for the proposed Project will result in exceedance of the NAAQS of 350 µg/m^3 prior to mitigation. However, this exceedance will be confined within the mine boundary. Ground level concentration at the mine boundary and sensitive receptors will be below the NAAQS. With exceedance confined to within the mine boundary, mitigation runs were not conducted.
- The 24-hours SO_2 concentrations predicted will be lower than the NAAQS of 125 µg/m^3 at the project boundary and selected sensitive receptors. Since the predicted concentrations were very low, mitigation runs were not conducted in AERMOD.
- Model predictions show that the annual SO_2 emissions from the proposed Project will be very low and confined to the project boundary. Hence, mitigation runs were not conducted.
- The predicted 1-hour CO concentrations will be very low, with ground level concentration within the NAAQS of 30 mg/m^3. The 8-hour average also returned lower ground level concentration from the proposed operation of the mine. The concentrations predicted are lower than the NAAQS of 10 mg/m^3. Hence CO is not going to be much of a problem for the operational phase of the proposed Project.

9 Impact Assessment

9.1 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 9-3. 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 AQIA. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 9-2, which is extracted from Table 9-1. The description of the significance ratings is discussed in Table 9-3.

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 9-1: 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.

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Table 9-2: Probability/Consequence Matrix

	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
Probability 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 9-3: 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	A positive impact. 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. 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	A minor negative impact 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 moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long-term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact 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) (-)

9.2 Project Activities

A list of project activities to be assessed for the project has been discussed in Table 9-4.

Table 9-4: Description of Activities to be assessed

Project Phase	Project Activity	Project Structures
Construction	Site Clearance	Topsoil Stockpiles
	Blasting and Excavation	One Shaft Area per mining right area
	Construction of Surface Infrastructure	Crushing and Screening Plant Mine Offices Change House Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads (with weighbridge) Overland Conveyor Sewage Treatment Plant Three Pollution Control Dam Water Treatment Plant Diesel Storage Tanks Ventilation Shaft per mining right area
	Water Abstraction and Use	Water Tanks and Pipes
	Waste Generation and Disposal	Waste Skips
	Power Generation	Diesel Generator
Operations	Underground Blasting and Mining	Heavy Machinery and Equipment
	Stockpiling	Waste Rock Berms Product Stockpile
	Hauling/Conveying of Coal	Overland Conveyor Belt Haul and Access Roads
	Plant and Equipment Operations	Crushing and Screening Plant Workshop and Diesel Storage Tanks
	Water Use and Storage	Pollution Control Dam and Jo Jo Tanks

Project Phase	Project Activity	Project Structures
	Waste Generation and Storage	Sewage Treatment Plant Waste Skips
	Power Generation	Diesel Generator
Mine Decommissioning and Closure	Removal of infrastructure and surface rehabilitation	Crushing and Screening Plant Mine Offices Change House Workshop Overburden and Product Stockpiles Site Fencing Access and Service Roads (with weighbridge) Overland Conveyor Sewage Treatment Plant Three Pollution Control Dam Water Treatment Plant Diesel Storage Tanks Ventilation Shaft per mining right area
	Waste Generation and Disposal	Waste Skips

9.3 Impact Assessment

9.3.1 Construction Phase

9.3.1.1 Project Activities Assessed

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

- Site clearing;
- Blasting and excavation;
- Construction of surface infrastructure;
- Waste generation and disposal; and
- Use of diesel generators.

Table 9-5: Interactions and Impacts of site clearing

Interaction	Impact
Dust generation	Reduction in air quality

9.3.1.2 Impact Description

Removal of vegetation using a range of construction equipment will lead to the generation of fugitive dust comprising TSP, PM_{10} and $PM_{2.5}$. Site clearing is short-term, less than a year and clearing will occur in phases, hence impacts on the atmospheric environment will be minimal and will cease once this activity ends.

9.3.1.3 Management Objectives

- To ensure that on-site and off-site emissions are within the NAAQS; and
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing.

9.3.1.4 Mitigation Options and Recommended Actions

- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors in line with the NAAQS at the start of construction and for the duration of this phase; and
- Regular review of air quality data to ensure compliance.

9.3.1.5 Construction Phase Impact Ratings

Table 9-6: Site Clearing

Dimension	Rating	Motivation	Significance
Activity and Interaction (Site clearing results in the generation of dust)			
Impact Description: Dust generation leads to poor air quality			
Prior to mitigation/ management			
Duration	Short term (2)	Dust generation will be short-term, limited to site clearing activities	Negligible (negative) – 54
Extent	Local (3)	Since site clearing will be conducted using a phased approach, impacts will be local.	
Intensity x type of impact	Major - negative (-4)	Dust emission during this activity can have major impacts on ambient air quality.	
Probability	Almost certain (6)	It is certain that dust will be generated from this activity	

Dimension	Rating	Motivation	Significance
Activity and Interaction (Site clearing results in the generation of dust)			
Mitigation/ Management actions			
▪ Application of wetting agents or dust suppressant on the dirt road and exposed areas to minimise emissions; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing or digging must occur; and ▪ Drop heights when loading and offloading material should be minimised (i.e. reduce distance between the excavator bucket and truck bed).			
Post- mitigation			
Duration	Short term (2)	Dust will be short-term, limited to site clearing activities	Negligible (negative) – 18
Extent	Limited (2)	Dust generated will be limited to the Project site and immediate surroundings due to the mitigation measures applied.	
Intensity x type of impact	Minor - negative (-2)	Emissions will result in minimal impact on the ambient air quality after mitigation.	
Probability	unlikely (3)	It is unlikely that dust emissions will have an effect on air quality after mitigation	

Table 9-7: Interactions and Impacts of Construction of Surface Infrastructure

Interaction	Impact
Wind erosion from exposed surfaces	Reduction in air quality

9.3.1.6 Impact Description

There will be movement of contractors and permanent workforce, vehicle activity on constructed access roads, and the levelling and compacting of surfaces during this activity. During the establishment of the access roads, haul roads, mine offices, crushing and screening plant, power plant and topsoil will be moved using Scrapers, Bull Dozers and stockpiled. This activity which will involve the use of heavy equipment leads to the generation of fugitive dust – TSP, PM_{10} and $PM_{2.5}$.

9.3.1.7 Management Objectives

- To ensure that on-site and off-site emissions are within the NAAQS; and
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing.

9.3.1.8 Mitigation Options and Recommended Actions

- Implement emissions management programme once construction commence;
- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors at the start of construction and for the duration of this phase; and
- Regular review air quality data to ensure compliance with the applicable NAAQSs.

Table 9-8: Construction of Surface Infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interaction (Construction of Surface Infrastructure results in Dust Generation)			
Impact Description: Deterioration of ambient air quality			
Prior to mitigation/ management			
Duration	Medium term (3)	Dust will be generated for duration of the construction phase	Minor (negative) – 54
Extent	Local (3)	Airborne dust may extend across the development site area.	
Intensity x type of impact	Moderate (-3)	Emissions will have moderate impacts on the surrounding areas since construction will happen in phases.	
Probability	Almost certain (6)	It is certain that dust will be generated and will impact ambient air quality.	
Mitigation/ Management actions			
▪ Application of dust suppressant on the dirt road and exposed areas; ▪ The area of disturbance at all times must be kept to a minimum and no unnecessary clearing, digging must occur; and ▪ The drop heights when loading onto trucks and at tipping points should be minimised (i.e. reduce distance between the excavator bucket and truck bed).			
Post- mitigation			
Duration	Medium term (3)	Dust will be generated for duration of the construction phase	Negligible (negative) – 15
Extent	Very Limited (1)	After mitigation measures are implemented, it is expected that dust impacts will be limited to isolated parts of the site.	
Intensity x type of impact	Minimal (-1)	Dust emissions will be minimal after mitigations are applied.	
Probability	Unlikely (3)	Unlikely that impact on ambient air quality will occur after mitigation measures are	

Dimension	Rating	Motivation	Significance
Activity and Interaction (Construction of Surface Infrastructure results in Dust Generation)			
		applied.	

Table 9-9: Interactions and Impacts of Waste Generation and Storage

Interaction	Impact
Dust and Gaseous Emissions	Reduction in air quality

9.3.1.9 Impact Description

Waste generation will encompass overburden from blasting and excavation of the shafts and consumption of raw material needed for construction purposes, including hazardous products like waste oil, chemicals, metallic scraps, trash and litter, garbage, sewage, amongst others.

9.3.1.10 Management Objectives

- To ensure that on-site and off-site emissions from waste generation and storage are within the NAAQS;
- To develop a waste management plan, which will identify anticipated liquid and solid waste streams and waste minimisation procedures are in place; and
- To optimise material handling and recycling strategy.

9.3.1.11 Mitigation Options and Recommended Actions

- Handling and storage of waste in accordance with the local regulations and chemicals must be stored in clearly labelled containers;
- Employees should be trained on the hazards of handling and storing hazardous materials;
- It is essential to ensure regular training and exercise for the staff on the emergency handling of hazardous waste;
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing;
- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors at the start of construction and for the duration of this phase; and
- Regular review air quality data to ensure compliance.

Table 9-10: Waste Generation and Disposal

Dimension	Rating	Motivation	Significance
Activity and Interaction (Waste Generation and Disposal can result in Dust and Volatiles Emissions)			
Impact Description: Reduction in air quality due to dust and gaseous emissions			
Prior to mitigation/ management			
Duration	Medium term (3)	Emissions will be medium term during the construction phase	Minor (negative) – 54
Extent	Local(3)	Impact can be felt at a local level extending beyond the project boundary.	
Intensity x type of impact	Moderate (-3)	Emissions will have moderate impacts on the surrounding areas since construction will happen in phases.	
Probability	Almost certain (6)	It is certain that emissions volatiles and dust will impact ambient air quality.	
Mitigation/ Management actions			
▪ Application of dust suppressant on the dirt road and exposed areas; ▪ The drop heights when loading onto trucks and at tipping points should be minimised (i.e. reduce distance between the excavator bucket and truck bed); ▪ Handling and storage of hazardous waste in clearly labelled containers; ▪ Training on the handling and storage of hazardous materials; and ▪ Training on the emergency procedures and action plans.			
Post- mitigation			
Duration	Medium term (3)	Emissions will be medium term during the construction phase	Negligible (negative) – 24
Extent	Limited (2)	Impacts will be limited to the Project site.	
Intensity x type of impact	Moderate - negative (-3)	The concentrations of pollutants emitted will decrease after mitigation measures are applied	
Probability	Unlikely (3)	It is unlikely that emissions will have an impact on ambient air quality after mitigation measures are applied	

Table 9-11: Interactions and Impacts of operating Diesel Generators

Interaction	Impact
Emissions of gaseous pollutants	Reduction in air quality

9.3.1.12 Impact Description

The production of power from diesel generators will result in the release of gaseous pollutants to the ambient environment, such as: NOx, SO_2, CO, and particulate matter. The dispersion modelling shows that emissions from the use of generator sets will reduce the quality of air in the area.

9.3.1.13 Management Objectives

- To ensure that on-site and off-site emissions are within the NAAQS; and
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing.

9.3.1.14 Mitigation Options and Recommended Actions

- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors at the start of construction and for the duration of this phase; and
- Regular review air quality data to ensure compliance.

Table 9-12: Generation of Power using Diesel Generators

Dimension	Rating	Motivation	Significance
Activity and Interaction (Generation of power leads to gaseous emissions: NOx, SO_2, CO and particulate matter)			
Impact Description: Reduction in air quality due to gaseous emissions			
Prior to mitigation/ management			
Duration	Medium term (3)	Emissions of gases during construction	Moderate (negative) – 77
Extent	Local(3)	Impact can be felt at a local level extending beyond the project boundary.	
Intensity x type of impact	Very serious - negative (-5)	Significant release of NOx, SO_2 and particulate matter resulting in changes to ambient atmosphere	
Probability	Definite (7)	It is definite that gases will be released resulting in poor air pollution	
Mitigation/ Management actions			
▪ Ensure generators are working at optimal conditions; ▪ Fitting of gas scrubbers; ▪ Use of low sulfur diesel; and ▪ Fitting electrostatic precipitators or bag house.			
Post- mitigation			
Duration	Medium term (3)	Emissions of gases during construction	Negligible

Dimension	Rating	Motivation	Significance
Activity and Interaction (Generation of power leads to gaseous emissions: NOx, SO_2, CO and particulate matter)			
Extent	Limited (2)	Impacts will be limited to the Project site.	(negative) – 24
Intensity x type of impact	Moderate - negative (-3)	The concentrations of pollutants emitted will decrease after mitigation measures are applied	
Probability	Unlikely (3)	It is unlikely that emissions will have an effect on ambient air quality after mitigation measures are applied	

9.3.2 Operational Phase

9.3.2.1 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:

- Underground Blasting and Mining;
- Stockpiling: Waste Rock Stockpile, Product, Topsoil Stockpiles;
- Hauling/conveying of coal;
- Waste generation and storage; and
- Generation of power using diesel generators.

Table 9-13: Interactions and Impacts of Underground Blasting and Mining

Interaction	Impact
Dust generation	Reduction in air quality

9.3.2.2 Impact Description

Underground blasting and mining will result in venting of fugitive emissions i.e. gaseous pollutants from underground operation. The pollutants generated encompass PM_{10}, $PM_{2.5}$, NO_2 and SO_2. These pollutants are capable of inducing health problems due to the depth of penetration in the human respiratory system.

9.3.2.3 Management Objectives

- To ensure that on-site and off-site emissions are within NAAQS; and
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing.

9.3.2.4 Mitigation Options and Recommended Actions

- Implement an emissions management programme once operation commences;
- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors at the start of the operation; and
- Regular review air quality data to ensure compliance.

Table 9-14: Impacts associated with Underground Blasting and Mining

Dimension	Rating	Motivation	Significance
Activity and Interaction (Underground Blasting and Mining will result in poor air quality)			
Impact Description: Deterioration of ambient air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Venting of underground emissions will occur for the project life	Minor (negative) – 72
Extent	Local (3)	Emissions may extend across the development site area	
Intensity x type of impact	Medium - negative (-4)	Emissions may have discernible impact on ambient air quality of the area	
Probability	Almost certain (6)	It is certain that the ambient air quality will be impacted.	
Mitigation/ Management actions			
▪ Use of baghouse; and ▪ Use of wet scrubbers.			
Post- mitigation			
Duration	Project life (5)	Venting of underground emissions will occur for the project life	Negligible (negative) – 27
Extent	Limited (2)	After mitigation measures are implemented, It is expected that emissions will be limited to the project site.	
Intensity x type of impact	Minor - negative (-2)	Impacts will be confined to the project boundary after mitigation measures are applied	
Probability	Unlikely (3)	It is unlikely that emissions will have an effect on ambient air quality after mitigation measures are applied	

Table 9-15: Interactions and Impacts of Stockpiling: Overburden, Product, and Topsoil

Interaction	Impact
Dust generation	Reduction in air quality

9.3.2.5 Impact Description

The stockpiling of overburden, product, and topsoil will result in emissions from loading, tipping, and associated wind erosion, resulting in fugitive emissions: dust fall, PM_{10} and $PM_{2.5}$.

9.3.2.6 Management Objectives

- To ensure that on-site and off-site emissions are within NAAQSs; and
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing.

9.3.2.7 Mitigation Options and Recommended Actions

- Implement an emissions management programme once operation commence;
- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors at the start of the operation; and
- Regular review air quality data to ensure compliance.

Table 9-16: Stockpiling: Overburden, Product and Topsoil

Dimension	Rating	Motivation	Significance
Activity and Interaction (Stockpiling will result in dust emissions and reduced air quality)			
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Dust erosion will occur throughout the project life	Moderate (negative) – 78
Extent	Local (3)	Dust emissions will affect the site and nearby settlements in the area.	
Intensity x type of impact	Very serious long-term negative (-5)	Long term impacts on the environment, as emissions have the potential to air quality beyond the Project boundary.	
Probability	Highly probable (6)	It is certain that impact will occur from stockpiling and operation of this activity.	
Mitigation/ Management actions			
▪ Application of wetting agents or dust suppressant;			

Dimension	Rating	Motivation	Significance
Activity and Interaction (Stockpiling will result in dust emissions and reduced air quality)			
▪ Minimise drop heights when loading and offloading material; ▪ Set maximum speed limits and have these limits enforced on stockpiles; and ▪ Vegetation of side walls of overburden and topsoil.			
Post- mitigation			
Duration	Project life (5)	Dust erosion will occur throughout the project life	Negligible (negative) – 30
Extent	Limited (2)	Limited to the Project site once mitigation measures are applied.	
Intensity x type of impact	Moderate - negative (-3)	Emissions will impact project site and surroundings	
Probability	unlikely (3)	It is unlikely that fugitive emissions from stockpiles will worsen air quality after mitigation measures are applied.	

Table 9-17: Hauling/Conveying of coal

Dimension	Rating	Motivation	Significance
Activity and Interaction (Hauling leads to emission and poor air quality)			
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Impact will cease after the operational life span of the Project	Moderate (negative) – 105
Extent	Regional (5)	Dust impact will affect the entire region	
Intensity x type of impact	Very serious – negative (-5)	Very serious long-term environmental impacts as the NAAQS are exceeded	
Probability	Definite (7)	It is definite that emissions will occur leading to poor are quality	
Mitigation/ Management actions			
▪ Application of wetting agents or dust suppressant (various grades depending on proximity to receptors) on the dirt road and exposed areas; and ▪ Set maximum speed limits and have these limits enforced.			
Post- mitigation			
Duration	Project life (5)	Impact will continue for the operational life span of the Project	Negligible (negative) – 30

Dimension	Rating	Motivation	Significance
Activity and Interaction (Hauling leads to emission and poor air quality)			
Extent	Limited (2)	Dust emissions will only occur within and around the Project site after mitigation measures are applied.	
Intensity x type of impact	Local- negative (-3)	Emissions extending as far as the Project site after mitigation measures are applied	
Probability	Unlikely (3)	It is unlikely that dust emissions will have considerable impact on air quality	

Table 9-18: Interactions and Impacts of Plant and Equipment Operations

Interaction	Impact
Dust generation	Reduction in air quality

9.3.2.8 Impact Description

The ore crusher and screening process releases fugitive dust. The dust generated encompasses dust fall-out, PM_{10} and $PM_{2.5.}$ The PM_{10} and $PM_{2.5}$ fractions are capable of health implications due to the depth of penetration in the human respiratory system.

9.3.2.9 Management Objectives

- To ensure that on-site and off-site emissions from the crushers are within the NAAQS; and
- To explore adequate mitigation measures for to curtail emissions and protect the environment, human health and wellbeing.

9.3.2.10 Mitigation Options and Recommended Actions

- Implement an emissions management programme once operation commence;
- Ensure crushers are enclosed with water sprays;
- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors at the start of the operation; and
- Regular review air quality data to ensure compliance.

Table 9-19: Impacts associated with Plant and Equipment Operations

Dimension	Rating	Motivation	Significance
Activity and Interaction (Crushing of ore results in fugitive dust emissions)			
Impact Description: Airborne dust leads to reduced air quality			
Prior to mitigation/ management			
Duration	Project life (5)	Crushing and screening will occur for the Project life	Moderate (negative) – 84
Extent	Municipal (4)	Airborne dust may extend across the development site area.	
Intensity x type of impact	Long-term environmental impairment - negative (-5)	Emissions from the crushers have the potential to exceed regulatory guideline	
Probability	Almost certain (6)	Emissions will be generated from the crushers leading to poor air quality	
Mitigation/ Management actions			
▪ Application of wetting agents (water spray) and potentially binding agent ; and ▪ Enclosure for crushers.			
Post- mitigation			
Duration	Project life (5)	Crushing and screening will occur for the Project life	Negligible (negative) – 27
Extent	Limited (2)	Dust emissions will be limited to the site and its immediate surroundings after mitigation measures are applied.	
Intensity x type of impact	Minor - negative (-2)	Emissions will be reduced considerably after mitigation with minor impact om ambient air quality.	
Probability	unlikely (3)	It is unlikely that dust emissions will have an effect after mitigation measures are applied.	

Table 9-20: Waste Generation and Storage

Dimension	Rating	Motivation	Significance
Activity and Interaction (Waste Generation and Storage will result in release of Dust and Volatiles)			
Impact Description: Reduction in air quality due to release of dust and gaseous			
Prior to mitigation/ management			
Duration	Project life (5)	Emissions will be for the project life	Minor (negative) – 66
Extent	Local(3)	Impact can be felt at a local level extending beyond the project boundary.	
Intensity x type of impact	Moderate (-3)	Emissions will have moderate impacts on the surrounding areas since construction will happen in phases.	
Probability	Almost certain (6)	It is certain that emissions volatiles and dust will impact ambient air quality.	
Mitigation/ Management actions			
▪ Vegetation of stockpiles; ▪ Handling and storage of hazardous waste in clearly labelled containers; ▪ Training on the handling and storage of hazardous materials; and ▪ Training on the emergency procedures and action plans.			
Post- mitigation			
Duration	Project life (5)	Emissions will be for the project life	Negligible (negative) – 30
Extent	Limited (2)	Impacts will be limited to the Project site.	
Intensity x type of impact	Moderate - negative (-3)	The concentrations of pollutants emitted will decrease after mitigation measures are applied	
Probability	Unlikely (3)	It is unlikely that emissions will have an impact on ambient air quality after mitigation measures are applied	

Table 9-21: Interactions and Impacts of using Diesel Generators

Interaction	Impact
Emissions of gaseous pollutants	Reduction in air quality

9.3.2.11 Impact Description

The production of power from diesel generators will result in the release of gaseous pollutants to the ambient environment, such as: NOx, SO_2, CO, and particulate matter. The area impacted can be extensive reaching localities nearby since gaseous pollutants are easily dispersed in the atmosphere. Results from the dispersion model show that emissions from the use of the generator sets will reduce the quality of air.

9.3.2.12 Management Objectives

- To ensure that on-site and off-site emissions are within NAAQS; and
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing.

9.3.2.13 Mitigation Options and Recommended Actions

- Implement an emissions management programme once construction commence;
- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors; and
- Regular review air quality monitoring data to ensure compliance.

Table 9-22: Generation of power using Diesel Generators

Dimension	Rating	Motivation	Significance
Activity and Interaction (Generation of power leads to gaseous emissions: NOx, SO_2, CO and particulate matter)			
Impact Description: Reduction in air quality due to gaseous emissions			
Prior to mitigation/ management			
Duration	Project life (5)	Emissions of gases during operational phase will occur for the project life	Moderate (negative) – 91
Extent	Local (3)	Impact can be felt locally, extending outside the mine boundary as gaseous pollutants are easily dispersed.	
Intensity x type of impact	Very serious - negative (-5)	Significant changes of the ambient air quality baseline	
Probability	Definite (7)	It is certain that emissions will occur	
Mitigation/ Management actions			
• Ensure generators are working at optimum conditions; • Fitting of gas scrubbers; • Use of low sulfur diesel; and • Fitting electrostatic precipitators or bag house.			

Dimension	Rating	Motivation	Significance
Activity and Interaction (Generation of power leads to gaseous emissions: NOx, SO_2, CO and particulate matter)			
Post- mitigation			
Duration	Project life (5)	Emissions of gases will occur for the operational life or project life	Negligible (negative) – 30
Extent	Limited (2)	Impacts will be limited to the Project site.	
Intensity x type of impact	Moderate - negative (-3)	The area impacted will be minimised after mitigation measures are applied.	
Probability	unlikely (3)	It is unlikely that emissions will have considerable impact on air quality after mitigation measures are applied	

9.3.3 Decommissioning Phase

9.3.3.1 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:

- Dismantling and removal of infrastructure; and
- Surface rehabilitation

Table 9-23: Interactions and Impacts of Removal of Infrastructure

Interaction	Impact
Dust generation	Reduction in air quality

9.3.3.2 Impact Description

The dismantling of mine infrastructure and removal of rubble and materials leads to the generation of dust. This 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 $PM_{2.5}$.

9.3.3.3 Management Objectives

- To ensure that emissions on-site and of-site from the dismantling and removal of rubbles from the project area are not in exceedance of the NAAQS; and
- To explore adequate mitigation measures for the protection of the environment, human health and wellbeing.

9.3.3.4 Mitigation Options and Recommended Actions

- Implement an emissions management programme during this phase; and
- Monitoring air quality on site, at upwind and downwind locations, and at sensitive receptors.

Table 9-24: Significance Rating for Removal of Infrastructure

Dimension	Rating	Motivation	Significance
Activity and Interaction (Removal of Infrastructure results in dust emission)			
Impact Description: Reduce air quality due to dust emission			
Prior to mitigation/ management			
Duration	Medium term (3)	Impact on air quality is limited to the duration of the decommissioning phase	Negligible (negative) – 24
Extent	Limited (2)	Emission will be limited to the site and its immediate surroundings	
Intensity x type of impact	Minor (1)	Emissions will have minimal impacts on ambient air quality since a phased approach will adopted	
Probability	Probable (4)	It is probable that emissions will impact on ambient air quality	
Mitigation/ Management actions			
▪ The dismantling area disturbed must be kept to a minimum; ▪ Drop heights when offloading materials for rehabilitation must be minimised; ▪ Limit demolition activities to non-windy days; and ▪ Dust suppression on exposed surfaces.			
Post- mitigation			
Duration	Short term (2)	Dust impact will be limited to the duration of this activity	Negligible (negative) – 12
Extent	Very limited (1)	Dust emitted from this activity will be limited to project site after mitigation.	
Intensity x type of impact	Minimal (1)	Emissions will have minimal impact on ambient air quality	
Probability	Unlikely (3)	It is unlikely that the ambient air quality will be impacted since emissions will be localised.	

Table 9-25: Significance Rating for Rehabilitation

Dimension	Rating	Motivation	Significance
Activity and Interaction (Rehabilitation will result in dust emission)			
Impact Description: Reduction in air quality			
Prior to mitigation/ management			
Duration	Medium term (3)	Impact on air quality will be medium term for the duration of the rehabilitation which might last for more than 2 years.	Minor (negative) – 45
Extent	Local (3)	Limited to the site and its immediate surroundings	
Intensity x type of impact	Moderate short term (3)	Emission can have an impact on ambient air quality	
Probability	Likely (5)	Emission from the rehabilitation activities will definitely impact the quality of air.	
Mitigation/ Management actions			
▪ Drop heights should be minimised when offloading materials for rehabilitation; ▪ Limit rehabilitation activities to non-windy days; ▪ Rehabilitation in accordance with rehabilitation plan; and ▪ Dust suppression on exposed surfaces.			
Post- mitigation			
Duration	Medium term (3)	Impact on air quality will be medium term for the duration of the rehabilitation	Negligible (negative) – 18
Extent	Limited (2)	Emissions will be limited to the development site and surrounding areas.	
Intensity x type of impact	Minimal (1)	Emission will not have discernible impacts on air quality.	
Probability	Unlikely (3)	It is unlikely that emission will impact air quality after mitigation measures are applied.	

10 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.

10.1 Project Activities with Potentially Significant Impacts

This section lists the aspects that are the major contributors to the deterioration of ambient air quality during the operational phase (Table 10-1), as confirmed by model predictions. Hence, these project activities should be carried with mitigation measures in place if the proposed Project operation is to comply with the NAAQS.

Table 10-1: Potentially Significant Impacts

Aspects	Potential Significant Impacts
Hauling/conveying of coal	Dust generation
	Reduction in air quality
Crushing	Dust generation
	Reduction in air quality
Power generators	Release of gases
	Reduction in air quality

10.2 Summary of Mitigation and Management

Table 10-2 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 EMP. Table 10-3 dwells on the applicable NAAQS.

Table 10-2: Project Activities Requiring Management

Activities	Phase	Size and Scale of Disturbance	Mitigation Measures	Compliance with Standards	Time Period for Implementation
Site Clearing	Construction	▪ It was assumed that clearing would occur in phases i.e. 25% of the area cleared at a time ▪ Impact is limited to the site and immediate surrounding.	▪ Site clearing must be done in phases ▪ 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	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013) ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012	▪ Mitigation measures should be implemented at the commencement of this activity.
Drilling and Blasting	Construction	▪ Impact will be localized	▪ Activity must be carried out judiciously to ameliorate dust emissions ▪ Wet drilling	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013) ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012	▪ Mitigation measures should be implemented at the start of this activity
Construction of Surface Infrastructure	Construction	▪ Few meters from project activity. Impacts will be limited to the site and immediate surroundings.	▪ Activity must be carried out judiciously to ameliorate dust emissions ▪ Use of suppressants on exposed areas to reduce dust generation	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013) ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012	▪ Mitigation measures should be implemented at the commencement of this activity
Power Generation using Diesel Generators	Construction	▪ The region generally can be affected by emissions from this source	▪ Use of low sulfur diesel; ▪ Selective catalytic reduction technology ▪ Gas scrubbers	▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012	▪ Mitigation measures should be implemented at the start of this activity

Activities	Phase	Size and Scale of Disturbance	Mitigation Measures	Compliance with Standards	Time Period for Implementation
Underground Blasting and Mining	Operational	▪ Impact will be localized, extending across the site to nearby settlements.	▪ Use of baghouse at the vent outlet ▪ Gas scrubbers at the vent outlet	▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012 ▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013)	▪ Mitigation measures should run concurrently with this activity and for the project life
Stockpiling	Operational	▪ Impact will be localized, extending across the site to nearby settlements.	▪ The drop heights when loading and tipping points should be minimised ▪ The use of dust suppressants and binders on exposed areas ▪ Routine maintenance and vegetation of side walls of storage facilities i.e. topsoil and waste stockpile throughout the lifespan of the project ▪ Monitoring of dust deposition rates in the vicinity of the proposed mine is recommended. However, if the dust deposition rates are in violation of the permissible frequency of exceedance on several occasions, monitoring of PM10 may be required.	▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012 ▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013)	▪ Mitigation measures should run concurrently with this activity and for the project life

Activities	Phase	Size and Scale of Disturbance	Mitigation Measures	Compliance with Standards	Time Period for Implementation
Hauling/Conveying of Ore	Operational	▪ Impact will be localized, extending across the site to nearby settlements.	▪ The drop heights when loading and tipping points should be minimised ▪ The use of dust suppressants and binders on exposed areas ▪ Routine maintenance and vegetation of side walls of storage facilities i.e. topsoil and waste stockpile throughout the lifespan of the project ▪ Monitoring of dust deposition rates in the vicinity of the proposed mine is recommended. However, if the dust deposition rates are in violation of the permissible frequency of exceedance on several occasions, monitoring of PM10 may be required	▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012 ▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013)	▪ Mitigation measures should run concurrently with this activity and for the project life
Plant and Equipment Operation	Operational	▪ Impact will be localized, extending across the site to nearby settlements	▪ Use of water sprays ▪ Enclosure of crushers ▪ Monitoring of dust deposition rates in the vicinity of the proposed mine is recommended. However, if the dust deposition rates are in violation of the permissible frequency of exceedance on several occasions, monitoring of PM10 may be required	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013) ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012	▪ Mitigation measures must commence at the start of the operation and for the project life
Waste Generation and Storage	Operational	▪ Impact will be localized, extending across the site to nearby settlements	▪ Vegetation of stockpiles ▪ Handling and storage of hazardous waste in clearly labelled containers ▪ Training on the emergency procedures and action plans	▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012 ▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013)	▪ Mitigation measures should run concurrently with this activity and for the project life

Activities	Phase	Size and Scale of Disturbance	Mitigation Measures	Compliance with Standards	Time Period for Implementation
Production of power from Diesel Generators	Operational	▪ The impact can be localized extending across the site	▪ Use of low sulfur diesel ▪ Selective catalytic reduction technology ▪ Use of electrostatic precipitators; ▪ Gas scrubbers	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013) ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012	▪ Mitigation measures should be implemented at the start of this activity
Demolition & removal of all infrastructure 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 ▪ Limit demolition activities to non-windy days ▪ Profiling and vegetation of open areas	▪ South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013) ▪ National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009; 2012	▪ Mitigation measures should run concurrently with this activity

Table 10-3: Prescribed Environmental Management Standards, Practice, Guideline, Policy or Law

Specialist field	Applicable standard, practice, guideline, policy or law
Air Quality	South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) - National Ambient Air Quality Standard: 2009; 2012
	South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013)

11 Monitoring Programme

The proposed Project will be responsible for the implementation of all monitoring programmes (Table 11-1). The recommended monitoring actions for the proposed Hendrina mining operation are detailed below. The mine management will also be responsible for keeping a record of all environmental monitoring undertaken for the project.

The existing dust monitoring networks in the area should be maintained during the life of the project. As and when necessary, the mine management can undertake a regular review and update of the dust monitoring networks.

Project management should continue with the ambient monitoring of dust deposition. However, should the dust deposition rates violate the permissible frequency of exceedance on several occasions during the year, a continuous PM_{10} monitor may be required – to establish ambient levels of these pollutants in the vicinity of the proposed operational. Such data will be useful, if in future the project comes under scrutiny from regulatory authorities. Monitoring sites should be placed judiciously downwind and preferably at a residential receptor site(s). There must be a programme in place to ensure the PM_{10} sampler monitors is calibrated annually to ensure the integrity of the measured data.

Regular passive sampling of ground level concentrations of gaseous pollutants i.e. SO_2, and NO_X should be conducted. The proposed ambient monitoring must be a continuous process for the life of the project to assess ambient concentrations and public exposure at the mine boundary and at sensitive receptor(s).

Table 11-1: Monitoring Plans

Method	Monitoring Location	Frequency	Target	Reporting
Dust monitoring using the ASTM Method	Existing locations where baseline dust deposition data were collected (2016)	Monthly	South African National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Dust Control Regulations (2013)	A designated air quality officer to collect data/analyse and reporting to regulatory authorities on compliance
Passive sampling	Existing dust monitoring locations where baseline data were collected	Passive sampling of gases: SO_2 and NO_2	National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Standard for Ambient Air Quality 2009	A designated air quality officer to collect data/analyse and reporting to regulatory authorities on compliance

12 Conclusion and Recommendation

An AQIA was undertaken to assess the proposed project impacts. 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 dust deposition rates, PM_{10} and $PM_{2.5}$, and hourly NO_x attributed to the proposed Project will impact ambient air quality without mitigation measures. It is worth mentioning that these exceedances are not confined to the project area, rather, surrounding environments can be affected.

The hauling of ore off site, venting and emissions from the crushers represent the highest contributors. Mitigation measures as suggested in this report will help reduce the emissions from these sources i.e. the removal of gaseous emissions through wet or dry scrubbing, sulfur dioxide can be scrubbed out, oxides of nitrogen can be removed by the process known as selective catalytic reduction and use of low sulfur diesel for power generation.

Results of the dispersion modelling exercise, coupled with the impact assessment ratings conducted show that impacts will be negligible to moderate. The main findings of this AQIA study are summarised as follows:

- Daily PM_{10} – predicted levels are high in the project area and surroundings without mitigation measures in place. Predicted ground level concentrations will exceed the applicable NAAQS (75 µg/m^3) at the project boundary. At the sensitive receptors, ground level concentration predicted for XST 1 of 82 µg/m^3 exceeds the NAAQS prior to mitigation. After mitigation, concentrations at XST 01 will be lowered to 19 µg/m^3. After mitigation, predicted ground level concentration was lowered considerably at the project boundary and at selected sensitive receptors.
- Annual PM_{10} – predicted annual concentrations at 100th percentile will be in exceedance of the applicable NAAQS (40 µg/m^3) at the project boundary and beyond, especially at Mooivley West prior to mitigation. Concentrations at the sensitive receptors will be lower than the NAAQS.
- Daily $PM_{2.5}$ – predicted concentrations will exceed the applicable NAAQS (40 µg/m^3) at the project boundary and beyond prior to mitigation. Once appropriate mitigation measures are applied, the zone of impact will be minimised and the ground level concentrations will decrease. Exceedances will be confined within the project boundary.
- Annual $PM_{2.5}$ – predicted annual concentrations at Mooivley East will exceed the applicable NAAQS (20 µg/m^3), but this will be confined within the project boundary. However, due to the road link between Mooivley West and Hendrina South – exceedance is predicted over a small area between the project boundaries. Ground level concentrations at the selected sensitive receptors will be below the NAAQS.

- Dust deposition rates predicted for the proposed project area are quite high without mitigation measures. The residential and non-residential standards of 600 mg/m^2/day and 1200 mg/m^2/day will be exceeded at the project boundary and beyond. Once mitigation measures are applied, the zone of exceedance at Mooivley East will be minimised and confined to within the project boundary. However, due to the road link between Mooivley West and Hendrina South – exceedance is predicted over a much small area between the project boundaries after mitigation measures are applied.

For the gaseous pollutants, mainly emissions from the diesel generators (~15 MW) and from underground venting, the findings are summarised as follows:

- The predicted 1-hour NOx (all NO_X assumed to be NO_2) concentrations attributed to the proposed Project will result in ground level concentrations higher than the applicable NAAQS of 200µg/m^3 within the project areas – Mooivley East, Mooivley West and Hendrina South. The concentration at the project boundary and beyond will be below the NAAQS once operational.
- Predicted annual concentrations of NO_X will not exceed the NAAQS (40 µg/m^3) at the mine, the project boundary and sensitive receptors.
- The SO_2 concentrations for the 1-hour averaging period predicted for the proposed Project will result in exceedance of the NAAQS of 350 µg/m^3 prior to mitigation. However, this exceedance will be confined within the mine boundary. Ground level concentration at the mine boundary and sensitive receptors will be below the NAAQS. With exceedance confined within the mine boundary, mitigation runs were not conducted.
- The 24-hours predicted concentrations of SO_2 will be lower than the NAAQS of 125 µg/m^3 at the project boundary and selected sensitive receptors. Since the predicted concentrations were very low, mitigation runs were not conducted in AERMOD.
- Model predictions show that the annual SO_2 emissions from the proposed Project will be very low and confined to the project boundary. Hence, mitigation runs were not conducted.
- The predicted maximum 1-hour CO concentrations will be very low with not exceedance anticipated. Ground level concentration will be lower than the NAAQS of 30 mg/m^3. The 8-hour average also returned lower ground level concertation from the proposed operation of the mine. The concentrations predicted are lower than the NAAQS of 10 mg/m^3. Hence CO is not going to be much of a problem for the proposed Project.

In conclusion, the proposed Project will exacerbate the ambient air quality of the area as indicated from the dispersion model predictions. However, if the crusher is enclosed with dust extraction system and fitted with water spray, use of dust suppressant on haul roads and exposed areas, use of selective catalytic technology, gas scrubbers and electrostatic precipitators for the generator emissions, and a baghouse is used for collecting emissions from underground released through the ventilation shafts, predicted impacts will be reduced to within compliance. Hence, management should ensure that mitigation measures recommended in this report are factored into the design and day to day operation of the proposed mine.

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Appendix A: Curriculum Vitae

Dr Matthew Ojelede

Unit Manager: Atmospheric Sciences

Atmospheric Sciences

Digby Wells Environmental

1 Education

BSc (Hons) Geology (University of Benin, Edo State, Nigeria)

MSc Environmental Science (WITS) with course work:

- Environmental Chemistry
- Environmental Management
- Air Quality –Physics and Chemistry of the Urban Atmosphere
- Global Environmental Change: Adaptation and Mitigation
- Geographic Information System
- Mining and the Environment

PhD Environmental Management (UJ)

2 Language Skills

English and Edo language

3 Employment

June 2012 – September 2012	University of Johannesburg (Researcher)
October 2012 to present	Digby Wells Environmental

4 Experience

Seven years' experience in ambient air quality monitoring, analysis and interpretation of data and relevant legislations. Worked extensively on a variety of air quality projects for several mining companies i.e. Crown Gold Recoveries, Eastplat, Anglogold Ashanti amongst others. In the past worked with a prominent member of a group of researchers from the University of the Witwatersrand, University of Pretoria and the National Health Laboratory Service (NHLS) in looking at the "Adverse Health Impacts Associated with Dust Emissions from Gold Mine Tailings" for the Mine Health and Safety Council.

Countries worked in: South Africa, Mali, Mozambique, Malawi and Liberia

5 Project Experience

Relevant Experience

- Seven years' experience as research assistant in atmospheric sciences
- Five years' experience in air quality management consulting to the mining sector
- Author of academic articles
- Conducted a number of Air Quality Impact Assessment Studies in Liberia, Malawi, Mali, Mozambique and South Africa.

Project Experience

- Air Quality Baseline Assessment, Emissions Inventories, Dispersion Modelling and Air Quality Management Plans
- Air Quality Impact Assessment study for an IPP power station and associated infrastructure, Limpopo, South Africa
- Ventersburg Gold Mine Air Quality Impact Assessment study, Free State, South Africa
- Air Quality Baseline Assessment study for Falea Uranium Project, Mali
- Air Quality Scoping report for the Harwar Colliery Mpumalanga, South Africa
- Baseline Air Quality Assessment study for Mkango Resources Limited, Songwe Rare Earth project, Malawi
- Air Quality Impact Assessment study for the proposed Balama Graphite Mine, Mozambique
- Air Quality Impact Assessment study for New Liberty Gold Mine, Liberia
- Air Quality Impact Assessment study for Loulo Gold Mine, Mali.

6 Professional Affiliations

- National Association for Clean Air (NACA)
- South African Society for Atmospheric Sciences (SASAS)
- International Association of Impact Assessment South Africa (IAIAsa).

7 Professional Registration

- South African Council for Natural Scientific Professions (SACNASP): In progress

8 Publications

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