AIR QUALITY IMPACT ASSESSMENT –

SPITSVALE CHROME MINE–

KENNEDYS VALE & SPITSKOP OPERATIONS

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Title	**Quality Impact Assessment for Spitsvale Chrome Mine, Kennedys Vale and Spitskop Operations**		
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DECLARATION

I declare that –

General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
All the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Clive Wray

Member

____
Signature of the specialist:

Rayten Engineering Solutions

25 February 2016

SUMMARY

Rayten Engineering Solutions was appointed by Environmental Management Assistance (EMA) to conduct an Air Quality Impact Assessment for the Spitsvale Chrome Mine, Kennedys Vale and Spitskop proposed operations, referred to as ***Spitsvale mine*** herein. The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the proposed Spitsvale mine on ambient air quality.

As part of the Air Quality Impact Assessment, a Baseline Air Quality Assessment was undertaken to determine the prevailing meteorological conditions at the site, establish baseline concentrations of key air pollutants of concern, identify existing sources of emissions and identify key sensitive receptors surrounding the project site. Use was made of modelled MM5 meteorological data for the period 2012 – 2014. Baseline concentrations for dust fallout were analysed with the use of dust fallout monitoring data provided by the client for the period July – September 2015. A comprehensive air quality monitoring dataset was not available. It is recommended that baseline monitoring of dust fallout, PM10 and PM2.5 is conducted at the site for a period of at least 12 months.

The Air Quality Impact Assessment consisted of an emissions inventory and subsequent dispersion modelling simulations to determine TSP (as dust fallout), PM10 and PM2.5 concentrations associated with the construction and operational phases of the proposed Spitsvale mine. Comparison of the modelled concentrations was made with the South African Ambient Air Quality Standards and the South African National Dust Control Regulations in order to determine compliance.

The main conclusions based on the information obtained during the Baseline Assessment can be summarised as follows:

- Based on the prevailing wind fields for the period January 2012 to December 2014, emissions from proposed operations at Spitsvale mine will likely be transported towards the south-west and north-east. During the day time emissions are likely to be transported in a north-easterly and northerly direction. In the night time emissions are likely to be transported in a south-westerly direction. Moderate to fast wind speeds observed during all time periods may result in effective dispersion and dilution of emissions from Spitsvale mine.
- A comprehensive air quality monitoring dataset for PM10 and PM2.5 concentrations was not available and could not be presented for the study area. Dust fallout concentrations at the proposed mine for the period July to September 2015 were relatively low and did not exceed the residential dust fallout standard of 600 mg/m^2/day and ranged from approximately 57 – 569 mg/m^2/day. However, a more comprehensive dust fallout monitoring dataset is required to assess the baseline dust fallout rates for the study area.
- Existing sources of emissions surrounding the proposed Spitsvale Mine are mainly associated with exiting mining operations, vehicle dust entrainment on unpaved roads, wind erosion from exposed areas and potentially domestic fuel burning in surrounding residential areas.

- There are residential areas located within close proximity (<10 km) and along the proposed mine's boundary line. These include Steelpoort, Ga-Mampuru, Ga-Manapane and Ga-Matate. There are also a couple of small dwellings and communities located within the mine's boundary line near the centre of the haul route.

The main conclusions of the Impact Assessment for the mine can be summarised as follows for the construction and operational phases:

- Based on the dispersion modelling plots for the construction phase the following conclusions can be made:
  - Predicted incremental dust fallout rates beyond the mine boundary are in compliance with the allowable dust fallout limit of 1200 mg/m^2/day for non-residential and 600 mg/m^2/day for residential areas.

- Based on the dispersion modelling plots for the operational phase the following conclusions can be made:
  - Predicted incremental dust fallout rates beyond the mine boundary are in compliance with the allowable dust fallout limit of 1200 mg/m^2/day for non-residential and 600 mg/m^2/day for residential areas.
  - Predicted incremental PM10 concentrations beyond the mine boundary are in compliance with the daily average standard of 75 µg/m^3 and the annual average standard of 40 µg/m^3.
  - Predicted incremental PM2.5 concentrations outside the mine's boundary are in compliance the daily average standard of 40 µg/m^3 and the annual average standard of 20 µg/m^3.
- Although the predicted concentrations due to proposed operations are expected to be low beyond the mine boundary, it should be noted that exceedances of the dust fallout, PM10 and PM2.5 standards were observed inside the mine boundary along the main haul route and near the mining areas. There are some small communities and dwellings that reside within the mine's boundary and near to the haul route. There are also communities that are located near to the mine boundary. Steelpoort for instance is located in close proximity to the Tubutse mining area (north-east of Spitkop farm). Therefore, it is recommended that a detailed dust management plan is developed and incorporated during the design stages of the mine. The plan should focus on sources of dust located in close proximity to the residential receptors located within and along the mine boundary.
- Furthermore, the possibility of looking at an alternative site for the Tubutse operations should be investigated. There are residential receptors that are located along the north-eastern boundary of the mine and in close proximity (< 500m) to the Tubutse mining area that may be effected by dust emissions during the day.

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LIST OF ABBREVIATIONS

AQA	Air Quality Act
CO	Carbon Monoxide
DEA	Department of Environmental Affairs
EMA	Environmental Management Assistance
NAEIS	National Atmospheric Emissions Inventory System
NPI	National Pollutant Inventory
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
Mtpa	Million tonnes per annum
O_3	Ozone
PM_{10}	Particulate Matter, aerodynamic diameter equal to or size less than 10µm
$PM_{2.5}$	Particulate Matter, aerodynamic diameter size equal to or less than 2.5µm
ROM	Run of Mine
SO_2	Sulphur Dioxide
TSP	Total Suspended Particles
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WHO	World Health Organisation

1 INTRODUCTION

BCR Minerals propose to mine Chrome and associated minerals (platinum group metals) using open cast and truck and shovel mining methods near Steelpoort, Limpopo Province. Rayten Engineering Solutions was appointed by EMA to conduct an Air Quality Impact Assessment for the construction and operational phases of the proposed Spitsvale mine. The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the development of the mine on ambient air quality in terms of the criteria air pollutants and dust fallout.

As part of the Air Quality Impact Assessment for Spitsvale mine, a baseline air quality assessment is undertaken through a review of meteorological monitoring data, available air quality monitoring data, air quality legislation and the identification of nearby sensitive receptors and existing emissions sources surrounding the project site. The potential impact of emissions from the proposed construction and operational activities on air quality is evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using AERMOD. Comparison of predicted concentrations for key criteria air pollutants is made with the South African Ambient Air Quality Standards and the South African National Dust Control Regulations, where applicable.

1.1 Project Description

The proposed Spitsvale mine will consist of two farm portions (Kennedy's Vale 361 KT and Spitskop 33KT) and three mining areas namely, Klarinet, Tubutse and Spitskop flats (FIGURE 1-1 and FIGURE 1-2). Each area will be mined separately over the life time of the mine of 35 years. It is anticipated that mining operations will commence at Klarinet and finish at Tubutse while maintaining a consistent production rate of 360,000 tons per year.

Mining operations at Spitsvale mine will include the following activities:

- Drilling;
- Blasting;
- Excavation;
- Bull dozing;
- Screening (*no crushing*);
- Material handling (loading and offloading, tipping, etc.);
- Hauling;
- Storage of ROM and temporary storage of Overburden.

Drilling and Blasting will be conducted in order to break up the hard overburden. Excavators will be used to remove the overburden and ore material. The overburden will be temporarily stored near the mining area. Once the ore has been extracted, the overburden will then be used to backfill the excavated area and used during the rehabilitation process. There will be very little topsoil as mining will take place along the contours of the *koppie* which is made up of hard rocky surface material. Thus there will be no topsoil stockpile.

Once the ore has been extracted it will then be hauled to the nearest stockpile area where it will go through a dry screening process using a mobile screening plant (683 Finlay 3 deck screen). There will be one screening plant at the mine which will move between the four designated stockpile areas depending on where mining is taking place. At present there are two existing ROM stockpile areas. It is proposed that an additional two ROM stockpiles will be developed at Spitkop farm portion. After screening, the product will then be stored at one of the ROM stockpiles before it is loaded onto a truck and exported offsite to Maputo Port (approximately 480 km from Spitsvale mine). It is anticipated that a total of 1000 tons of product will be hauled per day. Hauling will be conducted using 30T articulated dump trucks during the day (approximately 9 hours per day). No hauling will be conducted during the night.

There is currently existing infrastructure at the proposed mine which includes (FIGURE 1-2 and FIGURE 1-3):

- Unpaved hauling route;
- Workshop, buildings, offices, etc.;
- Two ROM Stockpile areas;
- Weigh bridge and other supporting infrastructure.

During the construction phase, it is proposed that additional facilities including a workshop, offices and buildings will be constructed at Spitskop farm using the same footprint as the existing infrastructure at Kennedy’s Vale. It is also proposed that a portion of the existing hauling road will be re-located and constructed (FIGURE 1-2). Emissions of dust are the main pollutant of concern associated with the construction and operation phases of the proposed Spitsvale mine and thus were assessed in this study.

A map indicating where the mining right areas are for Spitsvale mine is given in FIGURE 1-1. A site layout diagram for the mine is given in FIGURE 1-2.

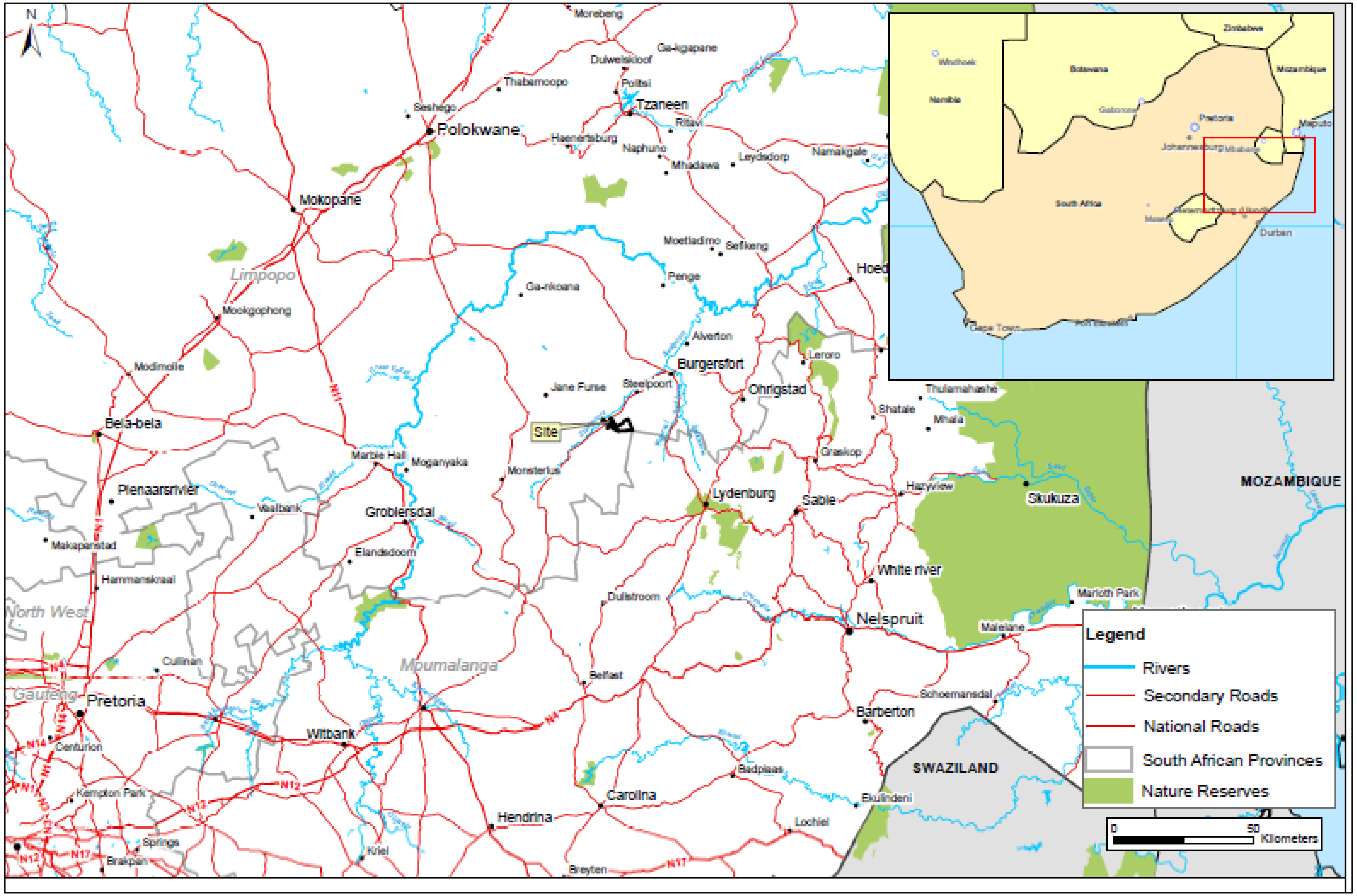


FIGURE 1-1: REGIONAL LOCALITY PLAN FOR SPITSVALE MINE. THE MINING RIGHT AREA FALLS WITHIN THE BLACK POLYGON (HIGHLANDS HYDROLOGY (PTY) LTD, 2015: 4).

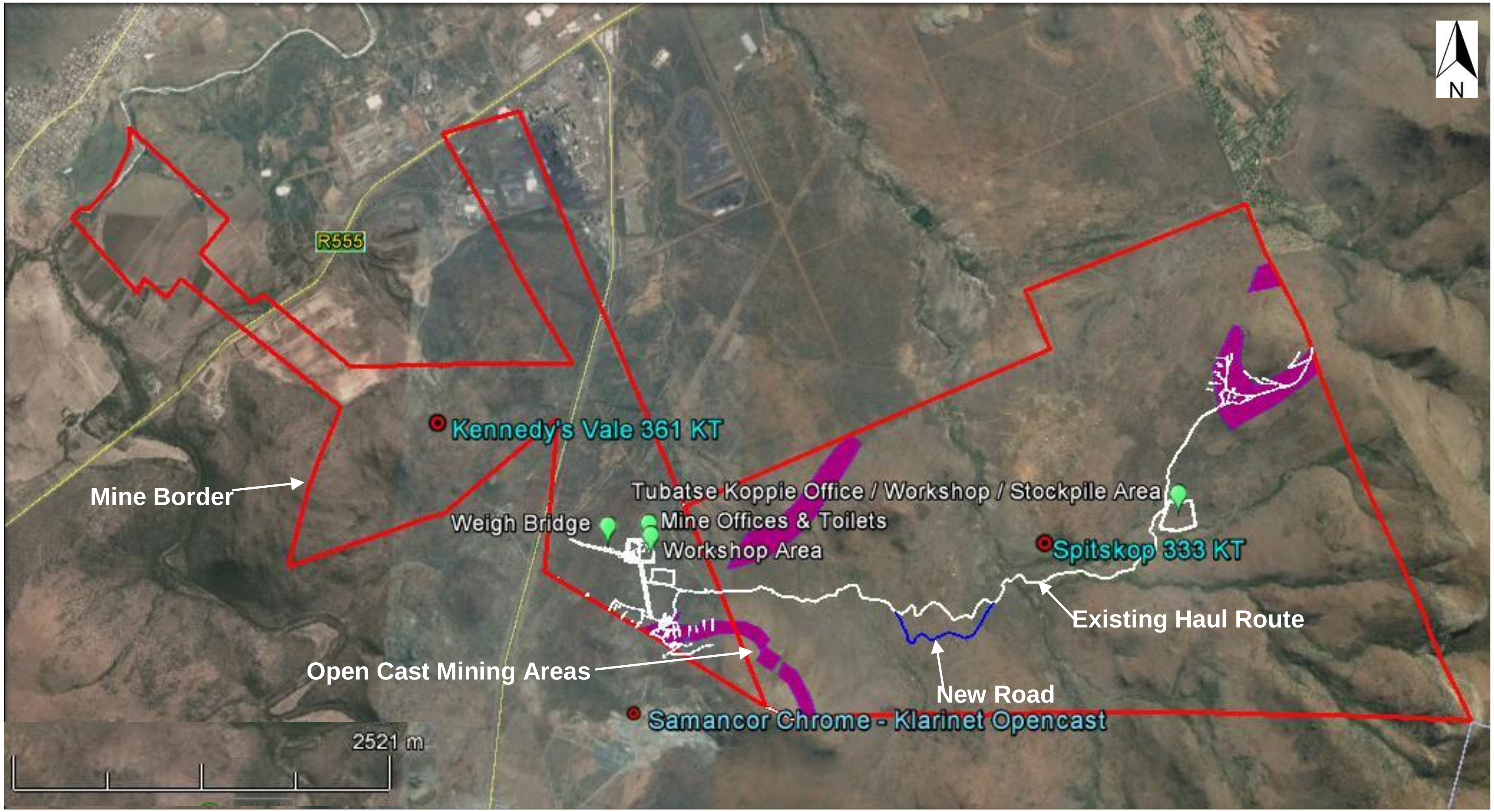


FIGURE 1-2: SITE LAYOUT PLAN FOR SPITSVALE MINE, KENNEDY'S VALE AND SPITSKOP OPERATIONS.

FIGURE 1-3: FOOTPRINT OF EXISTING INFRASTRUCURE AT KENNEDY'S VALE, SPITSVALE MINE.

1.2 Terms of Reference

The scope of work for the Air Quality Assessment for Spitsvale mine is as follows:

1.2.1 Air Quality Impact Assessment

- A review of the study site and proposed activities;
- An overview of the prevailing meteorological conditions in the area which influence the dilution and dispersion of pollutants in the atmosphere;
- The identification of existing sources of emissions;
- The identification of key air pollutants of concern that may be emitted from proposed activities (criteria air pollutants);
- Characterisation of the ambient air quality within the area using available air quality monitoring data;
- A review of the current South African legislative and regulatory requirements for air quality;
- The identification of sensitive receptors, such as local communities, surrounding the study area;
- The compilation of a detailed emissions inventory for sources of emissions;
- Dispersion modeling simulations of ground level particulate and gaseous emissions for incremental and cumulative impacts;
- Provision of recommendations for the mitigation and management of identified potential impacts.

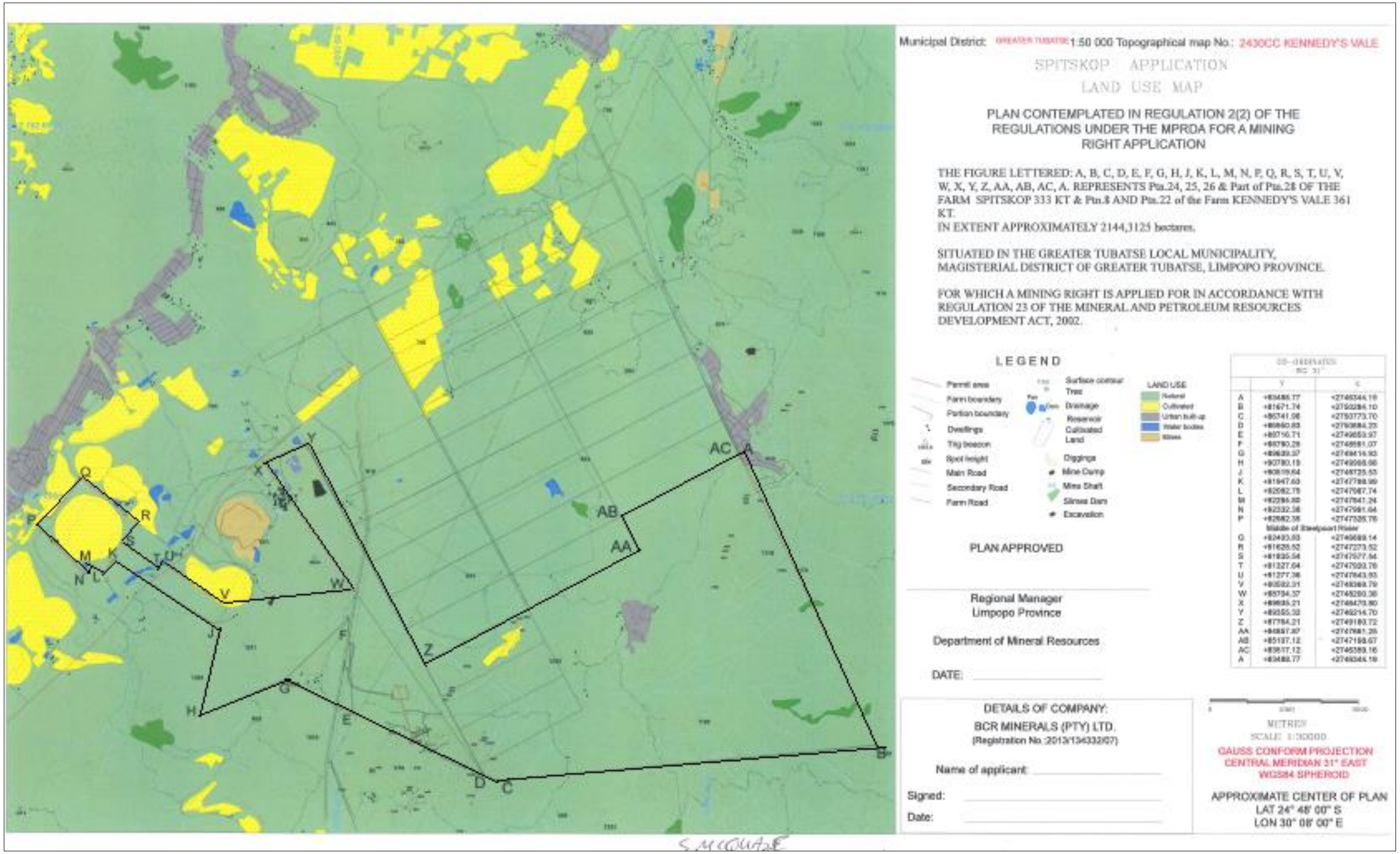
1.3 Outline of Report

An overview of the site location including surrounding receptors is given in **Section 2**. National ambient air quality standards, dust fallout regulations and associated health impacts for the relevant criteria pollutants are provided in **Section 3.** The local meteorological conditions and baseline air pollutants concentrations are provided in **Section 4**. Potential emissions and their impact on air quality associated with proposed operations are outlined in **Section 5.** Mitigation measures, recommendations and a summary report are provided in **Section 6.**

2 SITE CHARACTERISTICS

2.1 Site Location

The development of the Spitsvale Mine is located near Steelpoort in the Greater Tubatse Local Municipality, Limpopo Province, South Africa (24.849143º S; 30.129451º E). The centre of the project site is located approximately 5 km south-west of Steelpoort. The immediate land-use surrounding the mining site consists of predominantly open natural land, residential areas as well as agricultural and mining areas (FIGURE 2-1). Samancor Chrome Klarinet opencast is located just south of Spitsvale mine (< 1km). Samancor also have a second old opencast pit just north of the mine. Both of these opencast pits are no longer operational. A ferrochrome smelting plant as well as additional mining activities and associated infrastructure are located north-west of the centre of Spitsvale mine (FIGURE 1-2).



**Green = natural land *Yellow = Cultivated land *Grey = Urban built up *Blue = Water Bodies *Brown = Mining*

FIGURE 2-1: LANDUSE SURROUNDING SPITSVALE MINE.

2.2 Sensitive Receptors

A sensitive receptor is defined as a person or place where involuntary exposure to air pollutants released by the site's activities could take place. Sensitive receptors surrounding the project site (< 25km outside boundary) are given in TABLE 2-1 and FIGURE 2-2. There are also a couple of dwellings and small communities that are located within the project site towards the center of the mine and hauling route.

TABLE 2-1: SENSITIVE RECEPTORS SURROUNDING SPITSVALE MINE.

SENSITIVE RECEPTOR	TYPE OF RECEPTOR	APPROXIMATE DISTANCE (KM) FROM CENTRE OF MINE	DIRECTION FROM RECEPTOR
Steelpoort	Residential	5	NE
Ga Manapane	Residential	6.5	NW
Tukakgomo	Residential	12	N
Ga Mampuru	Residential	6.8	W
Ga Matate	Residential	9.5	NNW
Stocking	Residential	15	NNE
Sekele	Residential	15	NNW
Ga Masha	Residential	15	SW
Ga Malekan	Residential	15	SW
Schoonoord	Residential	16	NW
Tshehlwaneng	Residential	16	WNW
Ga Mogashoa	Residential	16	WNW
Makgane	Residential	19	W
Madiseng	Residential	26	N
Burgersfort	Residential	27	NE
Manganeng	Residential	27	NW
Manoke	Residential	30	NE
Ga Matlala	Residential	31	NW

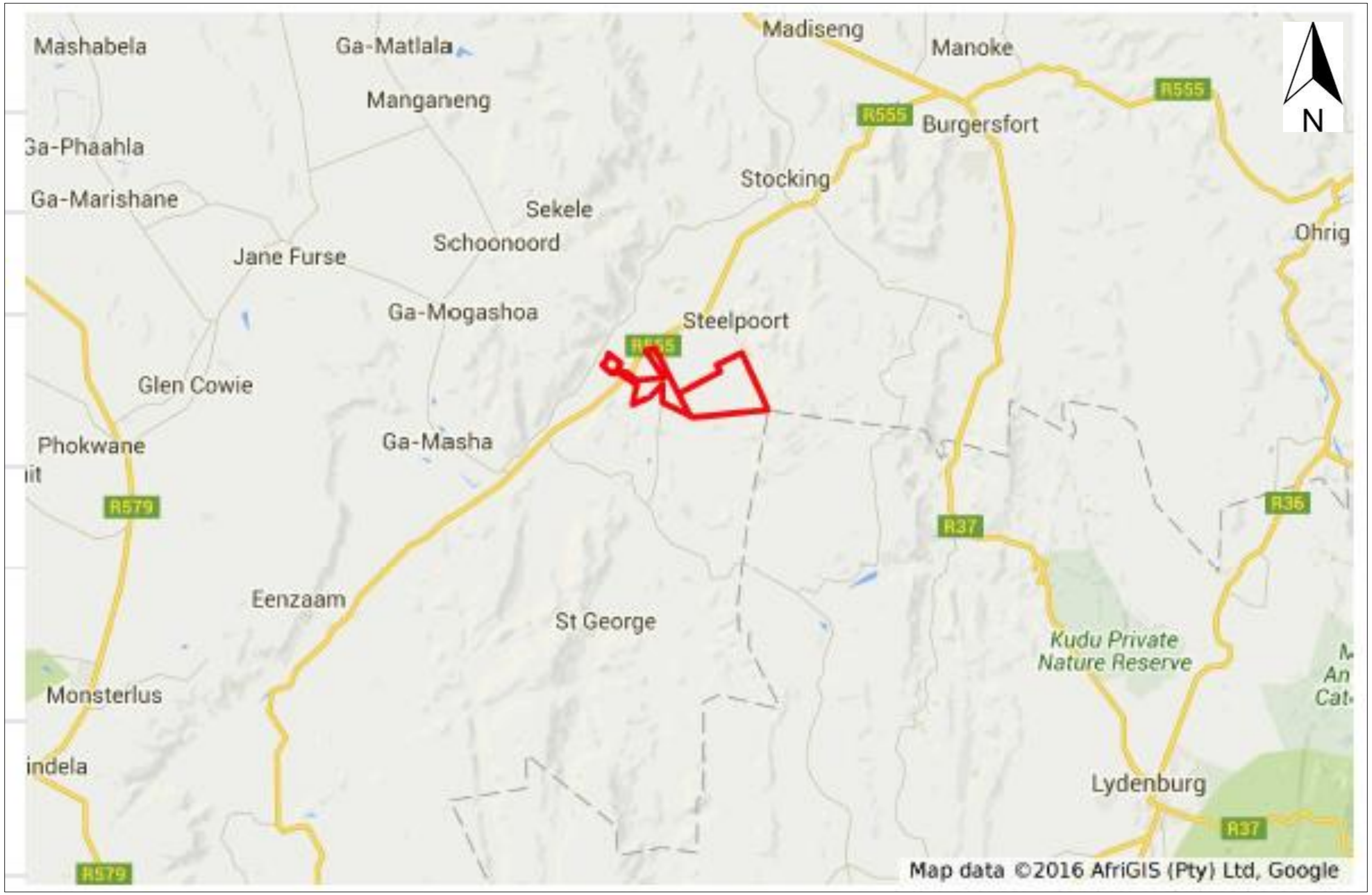


FIGURE 2-2: SENSITIVE RECEPTORS SURROUNDING SPITSVALE MINE.

3 LEGISLATION, POLICIES AND GUIDELINES

3.1 National Environmental Management: Air Quality Act

The National Environmental Management: Air Quality Act (AQA) No. 39 of 2004 and as amended Act No. 20 of 2014 has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to:

- Give effect to everyone's right 'to an environment that is not harmful to their health and well-being'
- Protect the environment by providing reasonable legislative and other measures that (i) prevent pollution and ecological degradation, (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The Act makes provision for the setting and formulation of National ambient air quality standards for 'substances or mixtures of substances which present a threat to health, well-being or the environment'. More stringent standards can be established at the provincial and local levels.

The control and management of emissions in the AQA relates to the listing of activities that are sources of emissions and the issuing of emission licences. Listed activities are defined as activities which 'result in atmospheric emissions and are regarded as having a significant detrimental effect on the environment, including human health'. Listed activities have been identified by the Minister of the Department of Environmental Affairs and atmospheric emission standards have been established for each of these activities. These listed activities now require an atmospheric emission licence to operate. The issuing of emission licences for Listed Activities will be the responsibility of the Metropolitan and District Municipalities.

In addition, the Minister may declare any substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to 'designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality'. The appointed Air Quality Officer is responsible for the issuing of atmospheric emission licences.

3.2 Listed Activities and Minimum Emission Standards

The Air Quality Act requires all persons undertaking listed activities in terms of Section 21 of the Act to obtain an Atmospheric Emission Licence. The Listed Activities and Associated Minimum Emission Standards was issued by the Department of Environmental Affairs on 31 March 2010 (Government Gazette No 33064). Amended List of Activiities were published on the 22 November 2013 (Government Gazette No 37054) and 21 June 2015 (Government Gazette No 38863).

Should the mine trigger any of the listed activities an Atmospheric Emission Licence would need to be applied for prior to the commencement of the activity. Minimum emission standards identified in terms of Section 21 of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) and stipulated in GNR 893 must be complied with for any listed activities that become relevant in the future.

South Africa launched an online national reporting system, reffered to as the National Atmospheric Emissions Inventory System (NAEIS), on the 30 September 2015. The AQA requires all emission source groups identified in terms of the National Atmospheric Reporting Regulations, GNR 283, to register and report emissions on the NAEIS. Mines are classified as Group C emitters and thus are required to comply with the National Atmospheric Reporting Regulations, GNR 283.

3.3 Ambient Air Quality Standards

National ambient air quality standards, including allowable frequencies of exceedance and compliance timeframes, were issued by the Minister of Water and Environmental Affairs on 24 December 2009 (TABLE 3-1). National standards for PM2.5 were established by the Minister of Water and Environmental Affairs on 29 June 2012.

TABLE 3-1: NATIONAL AMBIENT AIR QUALITY STANDARDS FOR CRITERIA POLLUTANTS. THE VALUES INDICATED IN BLUE ARE EXPRESSED IN PPB.

POLLUTANT	AVERAGING PERIOD	CONCENTRATION ($\mu g/m^3$)	FREQUENCY OF EXCEEDANCE
Sulphur dioxide (SO_2)	10 minutes	500 (191)	526
	1 hour	350 (134)	88
	24 hours	125 (48)	4
	1 year	50 (19)	0
Nitrogen dioxide (NO_2)	1 hour	200 (106)	88
	1 year	40 (21)	0
Particulate Matter (PM10)	24 hours	75	4
	1 year	40	0
Particulate Matter (PM2.5)	24 hours	40$^{(1)}$ 25$^{(2)}$	0
	1 year	20$^{(1)}$ 15$^{(2)}$	0
Ozone (O_3)	8 hours (running)	120 (61)	11
Benzene (C_6H_6)	1 year	10 (3.2) 5 (1.6)	0
Lead (Pb)	1 year	0.5	0
Carbon monoxide (CO)	1 hour	30 000 (26 000)	88
	8 hour (calculated on 1 hourly averages)	10 000 (8 700)	11

Notes:
(1) Compliance required by 1 January 2016 – 31 December 2029.
(2) Compliance required by 1 January 2030.

3.4 Dust Deposition Standards

The Department of Environmental Affairs has issued National dust control regulations on 1 November 2013 (TABLE 3-2). The purpose of the regulations is to prescribe general measures for the control of dust in all areas. The regulations prohibits activities which give rise to dust in such quantities and concentrations that the dust fall at the boundary or beyond the boundary of the premises where it originates exceeds -

a) 600 $mg/m^2/day$ averaged over 30 days in residential areas measured using reference method ASTM D1739.

b) 1200 $mg/m^2/day$ averaged over 30 days in non-residential areas measured using reference method ASTM D1739.

TABLE 3-2: SOUTH AFRICAN DUST FALLOUT REGULATIONS.

RESTRICTION AREAS	DUST FALLOUT RATE (D) (1)	REQUENCY OF EXCEEDANCE
Residential Areas	D < 600	Two within a year, no two sequential months (2)
Non-residential areas	600 < D < 1200	Two within a year, no two sequential months (2)

Notes:

(1) Averaged over 1 month (30 day average) ($mg/m^2/day$)
(2) Per dust fallout monitoring site.

Any person who has exceeded the dust fallout standard must, within three months after submission of a dust fallout monitoring report, develop and submit a dust management plan to the air quality officer for approval. The dust management plan must:

a) Identify all possible sources of dust within the affected site;
b) Detail the best practicable measures to be undertaken to mitigate dust emissions;
c) Develop and implementation schedule;
d) Identify the line management responsible for implementation;
e) Incorporate the dust fallout monitoring plan;
f) Establish a register for recording all complaints received by the person regarding dustfall, and for recording follow up actions and responses to the complainants.

The dust management plan must be implemented within a month of the date of approval. An implementation progress report must be submitted to the air quality officer at agreed time intervals.

3.5 Human Health Effects

3.5.1 Dust Fallout (TSP)

Dust fallout are particles with an aerodynamic diameter greater than 20µm that have been entrained into the air by a physical process such as wind, movement of vehicles, stack emissions and from fugitive dust. These particles are generally too heavy to remain in suspension in the air for any period of time and fall out of the air over a relatively short distance depending on a combination of various factors such as particle size, density, temperature (of the air and particle), emission velocity or method, ambient wind speed and humidity. These particles are therefore commonly known as “dust fallout”. Particulates in this range are generally classified as a nuisance dust and can cause physical damage to property and physical irritation to plants, animals and humans.

3.5.2 Particulates (PM10 & PM2.5)

Particles can be classified by their aerodynamic properties into coarse particles, PM10 (particulate matter with an aerodynamic diameter equal to or less than 10 µm) and fine particles, PM2.5 (particulate matter with an aerodynamic diameter equal to or less than 2.5 µm). The fine particles mostly contain secondary formed aerosols such as sulphates and nitrates, combustion particles and re-condensed organic and metal vapours. The coarse particles mostly contain earth crust materials and fugitive dust from roads and industries (Harrison *et al.,* 2014).

In terms of health impacts, particulate air pollution is associated with effects on the respiratory system (WHO, 2000). Particle size is important for health 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 do not penetrate deep into the lungs compared to smaller particles. 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).

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 µg/m^3). Morbidity effects associated with short-term exposure to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung function. 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). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children.

4 BASELINE ASSESSMENT

4.1 Meteorological Overview

Meteorological processes will determine the dispersion and dilution potential of pollutants emitted into the atmosphere. The vertical dispersion of pollution is governed by the stability of the atmosphere and the depth of the surface mixing layer. Horizontal dispersion of pollution is defined by dominant wind fields. Therefore meteorological parameters including temperature, precipitation, wind speed and wind direction are of significance as they will influence the degree to which pollution will accumulate or disperse in the atmosphere.

As per the Code *of Practice for Air Dispersion Modelling in Air Quality Management in South Africa* (DEA, 2014), representativeness of the meteorological data is influenced by the following four factors:

- Proximity of the meteorological site to the area being modelled;
- Complexity of the terrain;
- Exposure of the meteorological measurement site;
- Time period of data collection.

As a comprehensive meteorological data set, taking into account the above mentioned factors, for the project area could not be obtained use was made of MM5 modeled meteorological data for the Steelpoort project area. MM5 meteorological data was obtained from Lakes Environmental for the period January 2012 to December 2014. MM5 is a PSU/NCAR meso-scale model used to predict meso-scale and regional-scale atmospheric circulation. The model makes use of available meteorological data from nearby weather stations and applies interpolation techniques to provide integrated model meteorological data which can be used in a wide range of applications. This model is often used to create weather forecasts and climate projections.

4.1.1 Local Wind Field

FIGURE 4-1 provides the period wind rose plot for Spitsvale mine for the period January 2012 to December 2014. The predominant wind directions for the period are observed from the north-north-east (13% of the time) and north-east (13% of the time). Moderate to fast winds are also observed from the south-westerly and southerly sectors. Wind speeds for the three year period are generally moderate to fast with calm conditions, defined as wind speeds less than 1 m/s, observed for 11.05% of the time (FIGURE 4-1).

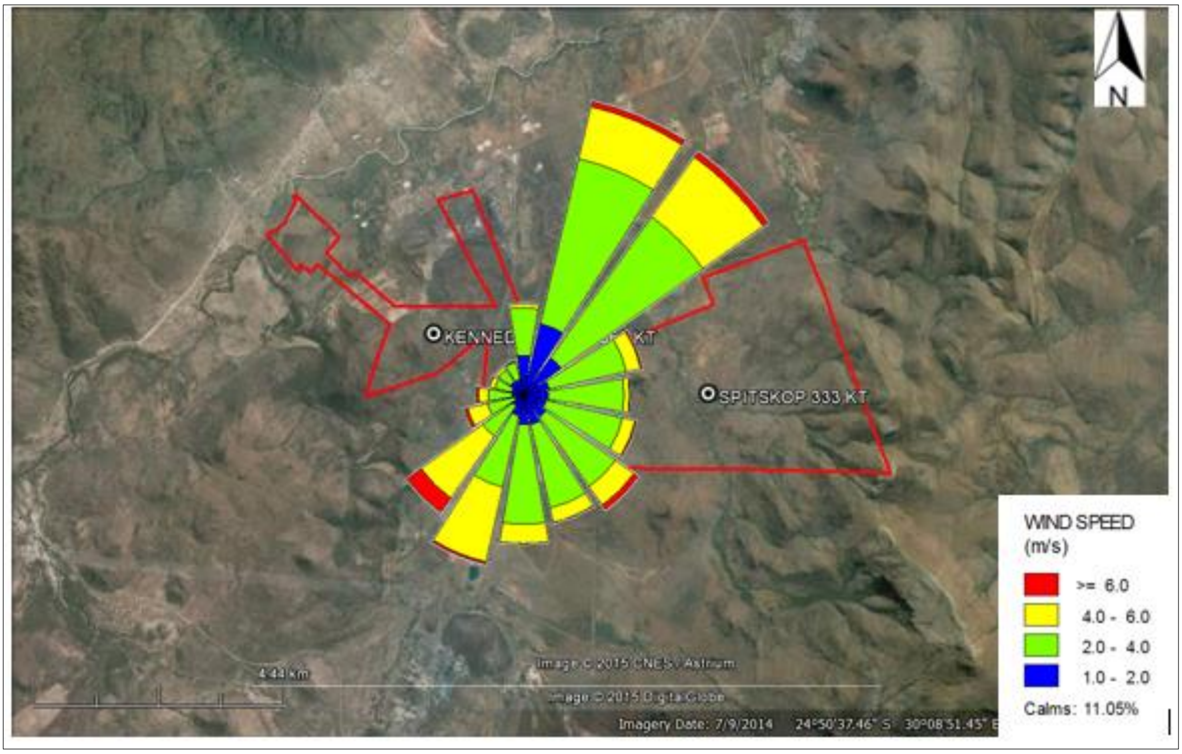


FIGURE 4-1: PERIOD WIND ROSE FOR SPITSVALE MINE FOR THE PERIOD JANUARY 2012 – DECEMBER 2014.

The day and night time wind rose plots for the period January 2012 to December 2014 show diurnal variation in the wind field data. During the day, a high frequency of winds are observed from the south, south-west and south-east sectors (FIGURE 4-2). During the night time, the southerly component is largely reduced with a high frequency of winds observed from the north-east and north-north-east (FIGURE 4-3). Furthermore, a higher percentage of calmer winds occur during the day compared to the night. The difference in day and night time wind patterns is likely due to anabatic and katabatic winds. During the day as the surface warms anabatic winds will flow upslope and during the night as the surface cools katabatic winds will flow downslope.

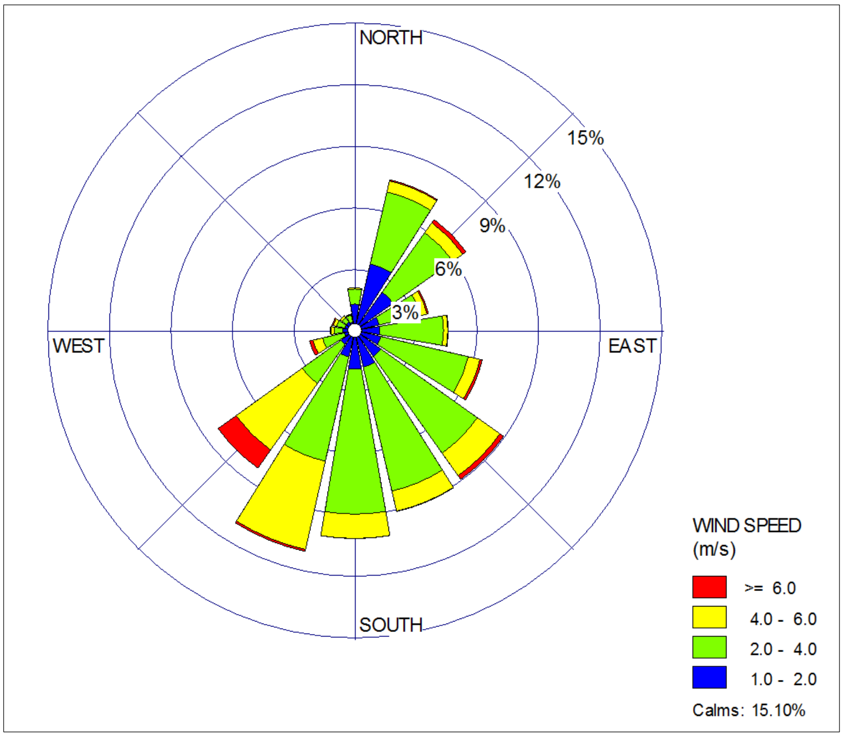


FIGURE 4-2: PERIOD DAY TIME (00:00 – 12:00) WIND ROSE FOR SPITSVALE MINE FOR THE PERIOD JANUARY 2012 – DECEMBER 2014.

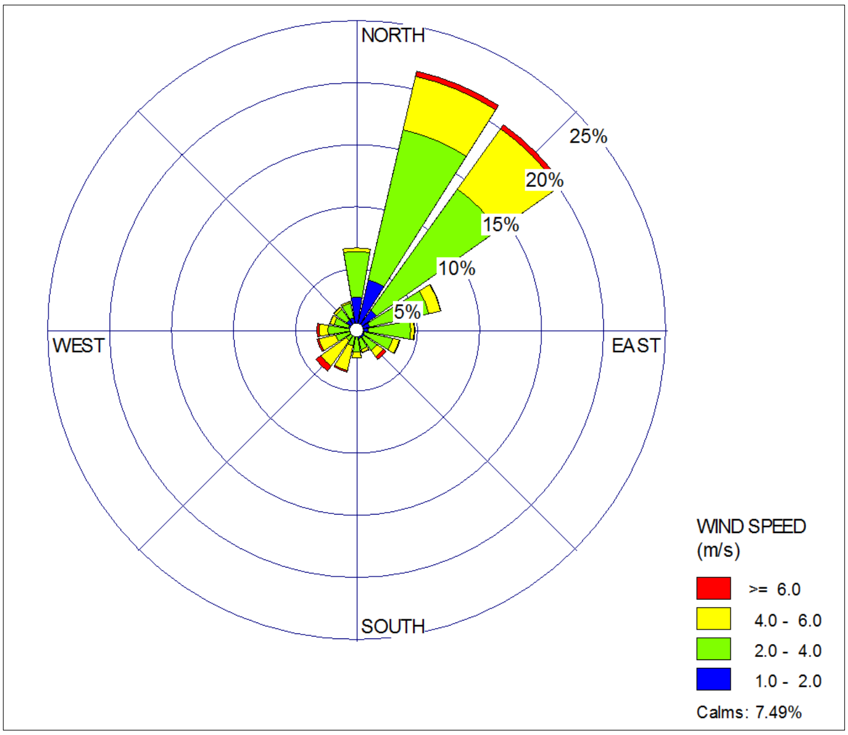


FIGURE 4-3: PERIOD NIGHT TIME (12:00 – 23:00) WIND ROSE FOR SPITSVALE MINE FOR THE PERIOD JANUARY 2012 – DECEMBER 2014.

Seasonal variation in winds for Spitsvale mine is shown in FIGURE 4-4. During the spring and summer seasons, winds originate predominantly from the north-east and north-north-east. During the autumn and winter seasons, winds from the north-east are reduced and a stronger south-westerly and south-south-westerly component is established. Slightly stronger wind speeds are also observed during the winter and spring seasons compared to the summer and autumn seasons.

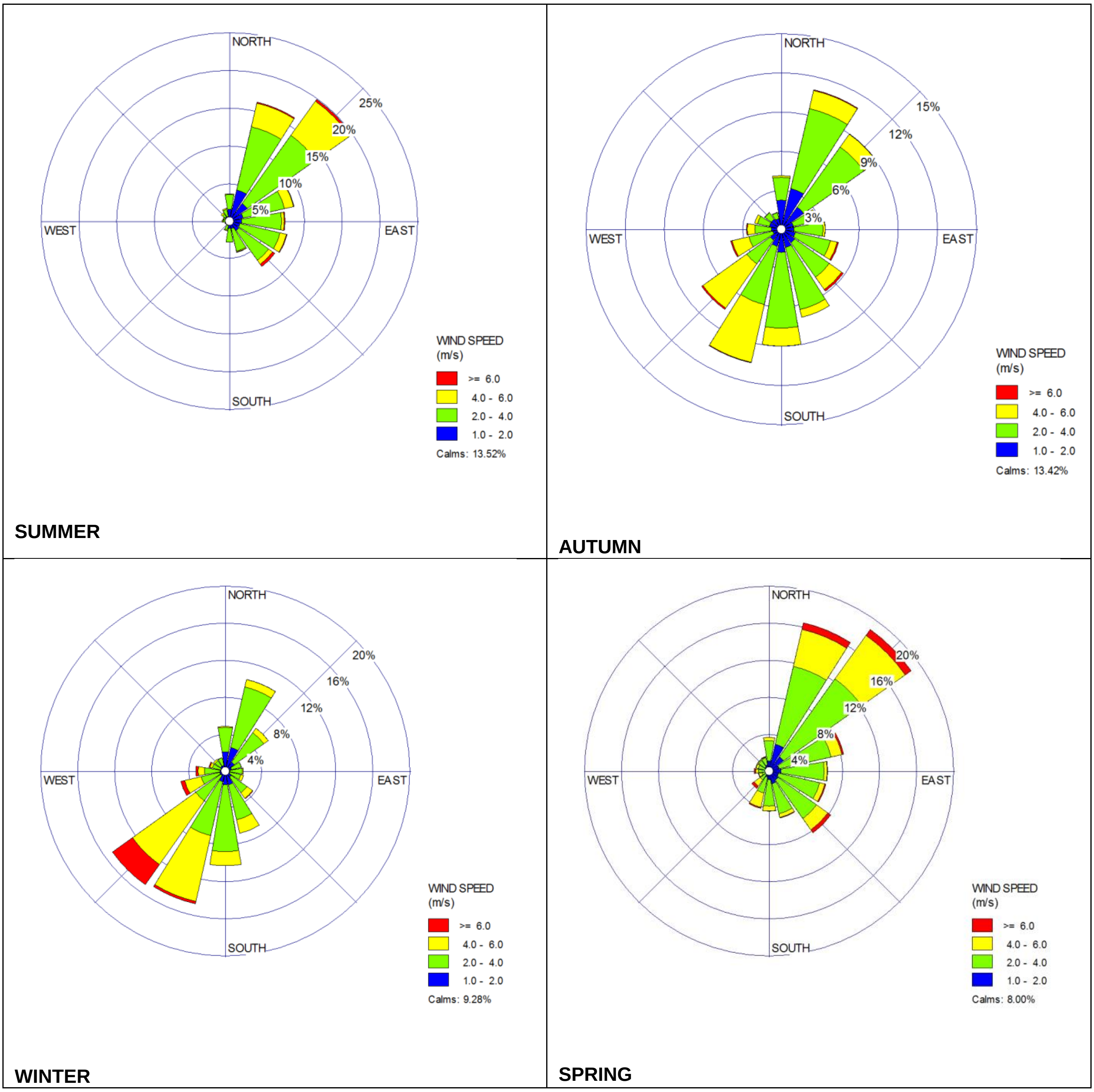


FIGURE 4-4: SEASONAL VARIATION OF WINDS FOR SPITSVALE MINE FOR THE PERIOD JANUARY 2012 - DECEMBER 2014.

Based on the prevailing wind fields for the period January 2012 to December 2014, emissions from proposed operations at Spitsvale mine will likely be transported towards the south-west and north-east. During the day time emissions are likely to be transported in a north-easterly and northerly direction. In the night time emissions are likely to be transported in a south-westerly direction. Moderate to fast wind speeds observed during all time periods may result in effective dispersion and dilution of emissions from Spitsvale mine.

4.1.2 Temperature and Relative Humidity

Temperature affects the formation, action and interactions of pollutants in various ways. Temperature provides an indication of the rate of development and dissipation of the mixing layer, which is largely controlled by surface inversions. Surface temperature inversions play a major role in air quality, especially during the winter months when these inversions are the strongest. Higher ambient temperatures will facilitate the dispersion of air pollutants which can result in lower ambient concentrations.

Chemical reaction rates also tend to increase with temperature and the warmer the air, the more water it can hold and therefore the higher the humidity. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles. This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids.

Limpopo generally experiences warm to very hot and dry summers and mild winters. FIGURE 4-5 shows monthly average temperatures and relative humidity profiles at Spitsvale mine for the period January 2012 to December 2014. Average monthly temperatures range from 12.3 – 21.7 ^{o}C (TABLE 4-1). Highest temperatures are observed during the summer months (December – February) and minimum temperatures are observed during the winter months (June – August). Relative humidity is highest during the warmer summer and spring seasons and lowest during the winter period.

TABLE 4-1: HOURLY MINIMUM, MAXIMUM AND MONTHLY AVERAGE TEMPERATURES FOR SPITSVALE MINE FOR JANUARY 2012 TO DECEMBER 2014.

MINIMUM, MAXIMUM AND MONTHLY AVERAGE TEMPERATURES (^{o}C)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Minimum	14.2	13.4	11.4	8.6	6.9	3.8	3.5	1.6	6.6	6.6	8.2	11.6
Maximum	31.0	31.8	30.0	27.9	26.4	22.9	23.2	24.9	28.5	29.5	31.1	30.6
Average	21.66	21.7	20.2	17.0	14.9	12.7	12.3	13.9	16.8	17.7	20.3	21.1

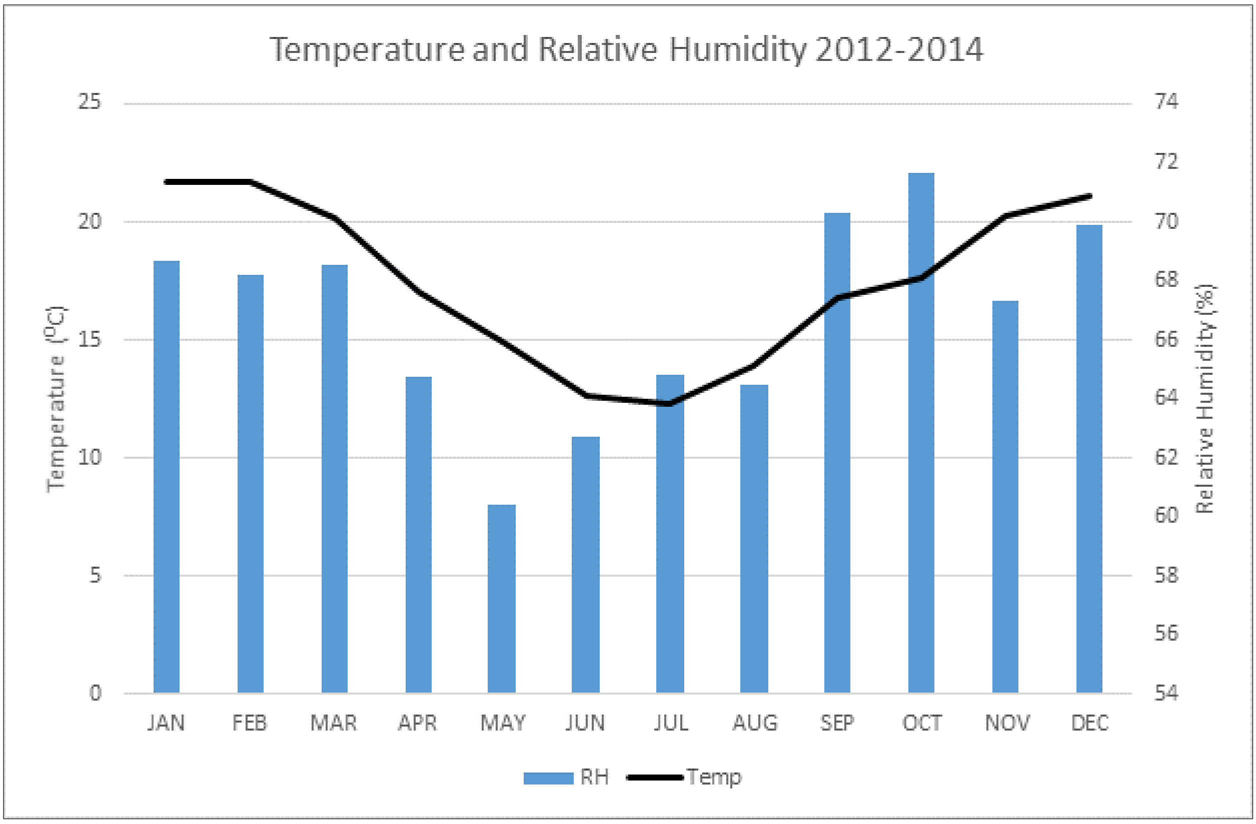


FIGURE 4-5: MONTHLY AVERAGE TEMPERATURE (°C) AND RELATIVE HUMIDITY (%) PROFILES FOR SPITSVALE MINE FOR THE PERIOD JANUARY 2012 – DECEMBER 2014.

4.1.3 Precipitation

Precipitation has an overall dilution effect and cleanses the air by washing out particles suspended in the atmosphere. FIGURE 4-6 shows monthly total rainfall at Spitsvale mine for the period January 2012 to December 2014. The area receives most of its rainfall during the spring and summer seasons during months September - February. Little to no rainfall is observed during the late autumn and winter seasons from May to August (TABLE 4-2). Removal of particulates via wet depositional processes would be evident during the spring and summer seasons thus lower ambient concentrations of dust could be expected during these seasons. Over the remainder of the year higher ambient concentrations of dust could be expected.

TABLE 4-2: TOTAL MONTHLY RAINFALL FOR SPITSVALE MINE FOR JANUARY 2012 TO DECEMBER 2014.

TOTAL MONTHLY RAINFALL (mm)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2012	57.7	104.9	54.6	1.5	0	0.5	0	7.4	70.6	93.5	63.5	136.4
2013	237.2	45.9	11.9	23.4	1.5	0	3.05	14.9	28.2	49.8	124.7	166.1
2014	75.7	49	158.5	4.8	0	0.8	1.3	4.3	2.5	33.8	84.8	147.6

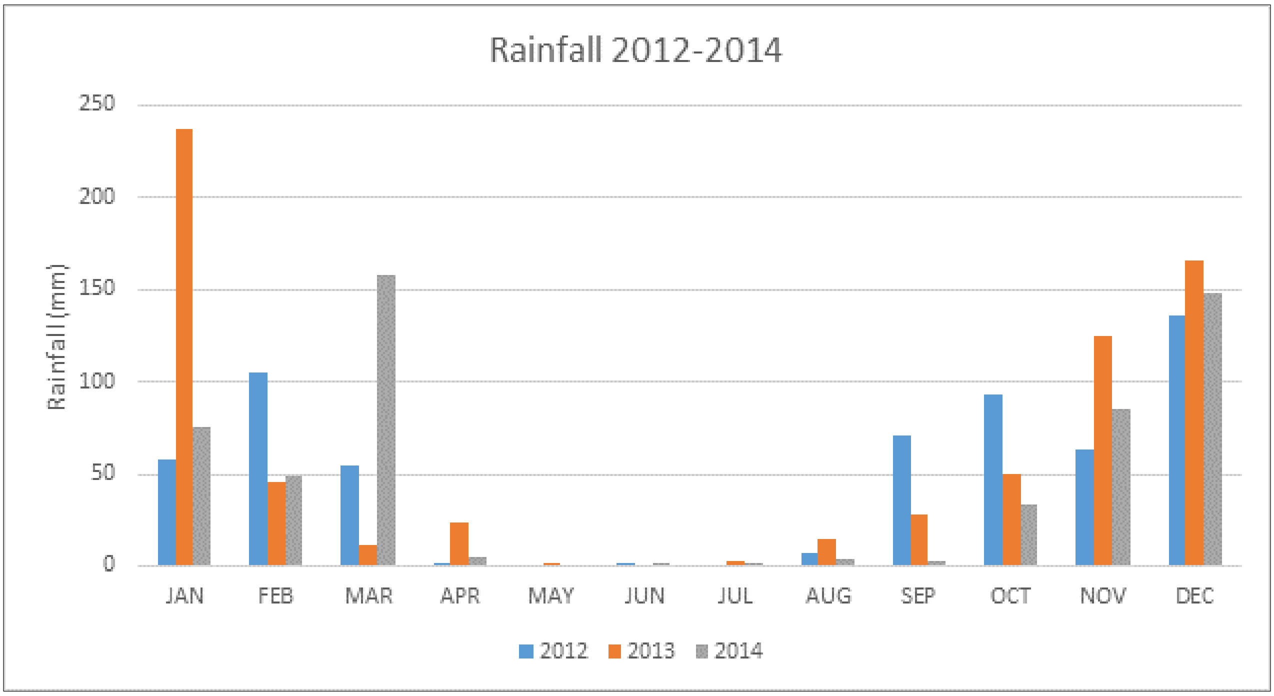
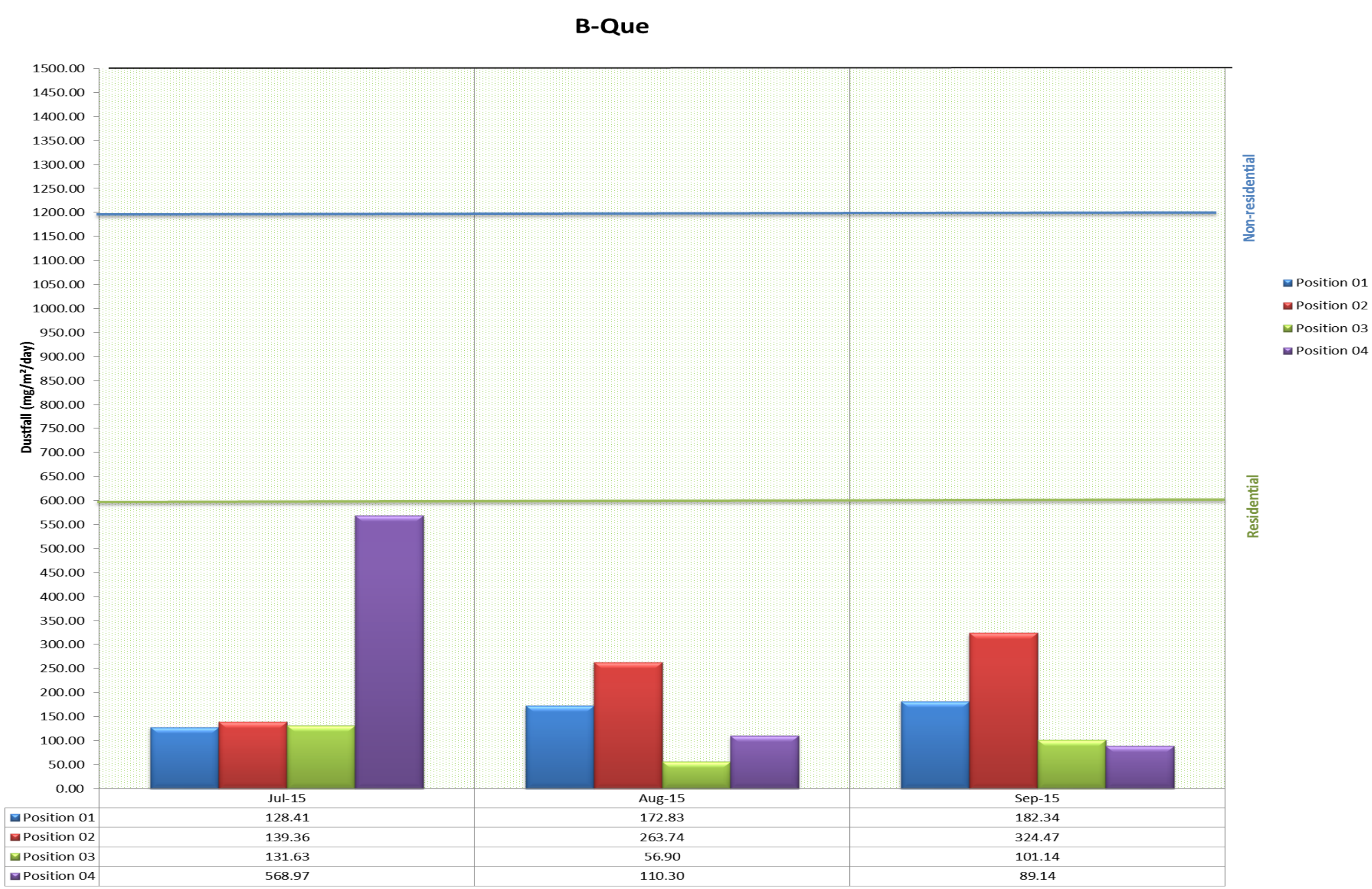


FIGURE 4-6: TOTAL MONTHLY AND AVERAGE RAINFALL (MM) FOR SPITSVALE MINE FOR THE PERIOD JANUARY 2012 – DECEMBER 2014.

4.2 Baseline Air Quality Concentrations

4.2.1 Dust Fallout

Dust fallout monitoring was conducted by NOHS Consultants at the proposed mine for three months (July – September 2015). Dust fallout monitoring was conducted using four dust buckets with wind shields. The results of the dust fallout monitoring are given in FIGURE 4-7. Dust fallout concentrations were relatively low and did not exceed the residential dust fallout standard of 600 mg/m^2/day and ranged from approximately 57 – 569 mg/m^2/day for the period. However, a comprehensive dust fallout monitoring dataset for the project site is not available. At least 12 months of dust fallout monitoring data is required in order to assess the cumulative impacts as provided in Section 5.4.2.



	Jul-15	Aug-15	Sep-15
Position 01	128.41	172.83	182.34
Position 02	139.36	263.74	324.47
Position 03	131.63	56.90	101.14
Position 04	568.97	110.30	89.14

FIGURE 4-7: DUST FALLOUT CONCENTRATIONS AT SPITSVALE MINE FOR THE PERIOD JULY – SEPTEMBER 2015.

4.2.2 Particulate Matter (PM10 and PM2.5)

Ambient air quality monitoring data for PM10 and PM2.5 concentrations could not be obtained from a station located in close proximity to the project study area. The nearest monitoring station to the project study site is the Phalaborwa monitoring station which is located approximately 142km north-east of the site. As such, the baseline concentrations for PM10 and PM2.5 could not be presented for the project site.

4.3 Surrounding Sources of Air Pollution

Existing key sources of air pollution surrounding the project site have been identified to be:

- Mining and Industrial Activity;
- Vehicle dust entrainment on unpaved roads;
- Wind erosion from exposed areas (e.g. opencast pits, stockpiles, cultivated land, etc.);
- Potentially Domestic fuel burning.

4.3.1 Mining and Industrial Activity

Emissions associated with existing mining and industrial activity surrounding the proposed project site potentially represent a significant source of particulate and gaseous air pollutants in the area. Particulate and gaseous emissions will result from the following mining and industrial activities:

- **Particulate Emissions (PM10, PM2.5 and TSP) associated with:**
    - Materials handling operations;
    - Conveying of ROM;
    - Transportation of ROM via hauling trucks;
    - Vehicle-entrainment of dust on unpaved roads;
    - Drilling and Blasting;
    - Material Storage Facilities (e.g. stockpiles, waste rock dumps, tailings, etc.);
    - Wind erosion from exposed areas (e.g. active or old opencast areas);
    - Crushing and Screening of ROM;
    - Processing of material (e.g. smelter).

- **Gaseous Emissions (SO_2, CO, CO_2, NO_x and VOCs) associated with:**
    - Processing of material (e.g. smelter);
    - Combustion processes;
    - Storage and handling of petroleum products, chemicals, etc.;
    - Vehicle, truck and equipment exhaust emissions.

4.3.2 Vehicle Entrainment on Unpaved Roads

The area surrounding Spitsvale mine is generally undeveloped with unpaved roads surrounding the site. Vehicle-entrained dust emissions from the surrounding unpaved roads in the area potentially represent a source of fugitive dust. When a vehicle or truck travels on an unpaved road, the force of the wheels on the road surface causes the pulverisation of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

4.3.3 Wind Erosion from Exposed Areas

There are several open exposed areas such as stockpiles, opencast areas, mining areas and cultivated land surrounding the proposed mining site which could represent a source of dust. Dust emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded. The threshold wind speed is dependent on the erosion potential of the exposed surface, which is expressed in terms of the availability of erodible material per unit area (mass/area). Any factor which binds the erodible material or otherwise reduces the availability of erodible material on the surface thus decreases the erosion potential of the surface. Studies have shown that when the threshold wind speeds are exceeded, particulate emission rates tend to decay rapidly due to the reduced availability of erodible material.

4.3.4 Domestic Fuel Burning

The burning of domestic fuels for heating and cooking purposes is likely to occur in the surrounding rural and informal areas surrounding the project area. Even in electrified areas, households make use of domestic fuels due to high electricity costs and the traditional use of such fuels.

Pollutants released from these fuels include CO, NO_2, SO_2, inhalable particulates and polycyclic aromatic hydrocarbons. Particulates are the dominant pollutant emitted from the burning of wood. Smoke from wood burning contains respirable particles that are small enough in diameter to enter and deposit in the lungs. These particles comprise a mixture of inorganic and organic substances including aromatic hydrocarbon compounds, trace metals, nitrates and sulphates. Polycyclic aromatic hydrocarbons are produced as a result of incomplete combustion and are potentially carcinogenic in wood smoke. The main pollutants emitted from the combustion of paraffin are NO_2, particulates, carbon monoxide and polycyclic aromatic hydrocarbons.

Domestic fuel burning shows a characteristic diurnal and seasonal signature. Periods of elevated domestic fuel burning, and hence emissions, occurs in the early morning and evening for space heating and cooking purposes. During the winter months, an increase in domestic fuel burning is recorded as the demand for space heating and cooking increases with the declining temperature.

5 AIR QUALITY IMPACTS ASSESSMENT

Dust is identified as one of the main air pollutants of concern associated with proposed operations at Spitsvale mine and will be emitted from the following key sources:

- **Dust and Particulate Emissions:**
  - Construction;
  - Drilling and Blasting;
  - Bull dozing;
  - Land clearing, top soil and overburden removal;
  - Loading and offloading operations;
  - Materials handling operations;
  - Transportation of material (trucks, etc.);
  - Material storage: Stockpiling;
  - Screening;
  - Wind erosion from exposed areas;
  - Vehicle-entrainment on unpaved roads due to hauling.

The above mentioned sources were identified for Spitsvale mine based on the information provided by the client. A detailed questionnaire was given to the client prior to modelling in order to obtain specific details needed for input into the model and for calculation of emission rates. The worst case scenario was assumed where information was not known for input into the model. Please refer to Section 5.4 for more details about the assumptions made in this study.

To investigate the potential impact of the development of the Spitsvale mine on local ambient air quality, the following criteria air pollutants were chosen in the quantification of emissions for the construction and operation phases of the mine:

- Dust Fallout (TSP);
- Particulate Matter (PM10 and PM2.5).

In the quantification of emissions for the construction and operational phases use was made of published predictive emission factor equations given in the United States Environmental Protection Agency (USEPA) AP-42 documents, Australian NPI and Missouri Department of Natural Resources, Haul Road Fugitive Emissions Worksheet Instructions. The South African Regulations regarding Air Dispersion Modelling recommends the use of published emission factors for national consistency, such as the USEPA AP-42 emissions factors.

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors are always expressed as a function of the weight, volume, distance or duration of the activity emitting the pollutant. The general equation used for the estimation of emissions is:

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

Where:

E = emission rate

A = activity rate

EF = emission factor

ER = overall emission reduction efficiency (%)

The emission factors and equations used in the assessment for Spitsvale mine are described in the section below. In this study two scenarios were modelled, **(a)** Construction Phase and **(b)** Operational Phase. The construction phase consisted of **construction activities**. The operational phase consisted of **mining activities**. A summary of activities modelled for each phase is given in TABLE 5-1.

TABLE 5-1: SOURCE OF EMISSIONS DUE TO PROPOSED OPERATIONS AT SPITSVALE MINE.

<table>
<tr><th rowspan="2">POLLUTANT</th><th colspan="2">SOURCES OF EMISSIONS</th></tr>
<tr><th>CONSTRUCTION PHASE</th><th>OPERATIONAL PHASE</th></tr>
<tr><td>Dust fallout (TSP)</td><td>• Construction activities:
o buildings,
o infrastructure,
o roads,
o Workshops,
o Etc.</td><td rowspan="2">• Mining:
o Drilling;
o Blasting;
o Material handling (loading/offloading operations);
o Excavators, bull dozers;
o Vehicle dust entrainment due to hauling;
o Stockpiles;
o Screening activities;
o Material Transfer operations (Tipping).</td></tr>
<tr><td>Particulate emissions (PM10 and PM2.5)</td><td></td></tr>
<tr><td colspan="3"><u>Notes</u>:
1) Dust suppression on the haul roads was assumed. The client specified that the haul route would be treated for dust with the use of a water browser (5 – 8000 l/h).
2) Construction activities assumed to occur 12 hours a day for 6 days a week.
3) Mining activities assumed to occur 19 hours a day and 300 days per year based on the information provided by the client.</td></tr>
</table>

5.1 Construction Phase

5.1.1 Construction Activities

The USEPA provides an emissions equation for general heavy construction operations. Dust is the main pollutant of concern emitted during heavy construction activities. The impact of dust emissions associated with heavy construction is generally limited to the period of construction where the impact is significantly reduced once construction activities have stopped. Dust emissions from construction activities is associated with land clearing, ground excavation, drilling and blasting, cut and fill operations, vehicle dust entrainment from trucks and the construction of infrastructure. Dust emissions from construction activities will vary depending on the level of activity and prevailing meteorological conditions (USEPA, 1995).

Emissions from the construction activities were calculated using the following equation:

$$E = 2.69 \text{ Mg/hectare/month of activity}$$

The emission factor and equation used to estimate emissions from construction activities were obtained from the USEPA AP-42 document, Section 13.2.3 Heavy Construction Operations (USEPA, 1995). The value is most applicable to construction operations with medium activity level, moderate silt contents and semi-arid climate. Construction was assumed to occur for 12 hours a day for 6 days a week. In addition it was assumed that no dust suppression measures would be implemented during construction activities. Input parameters for construction activities are summarised in TABLE 5-2. The input parameters were chosen based on the information and kml files provided by the client. Areas where construction is proposed to take place were represented as blocks (except for the new road). The dimensions were based on the existing buildings lay down footprint (kml files) provided by the client.

TABLE 5-2: INPUT PARAMETERS FOR CONSTRUCTION ACTIVITIES.

SOURCE	EMISSION SOURCE TYPE	LENGTH (M)	WIDTH (M)	EMISSION RATE (G/S)
				TSP
Construction Phase				
New road	Line Area	1160	14	4.032
Block 1	Area	50	40	0.498
Block 2	Area	8	8	0.016
Block 3	Area	18	8	0.036
Block 4	Area	20	9	0.045
Block 5	Area	25	15	0.093
Block 6	Area	4	3	0.003

5.2 Operation Phase

5.2.1 Drilling

Drilling into the overburden and the ore at the opencast mining areas will occur at Spitsvale mine during the operational phase. The USEPA provides an emissions equation specifically for drilling. During the operational phase a total of 10 holes will be drilled per day. It was assumed that drilling at the mine will occur for 19 hours per day, six days a week, 300 days per year. Fugitive dust emissions from drilling into the overburden at the mine were calculated using the following equation taken from the USEPA, AP-42 document, Section 11.9 western surface coal mining and Table 11.9.4:

$$E_{TSP} = 0.59\frac{kg}{hole}/day$$

Where:

E = emission factor (kg/hole/day)

E_{PM10} = 50% of TSP

$E_{PM2.5}$ = 3% of TSP

Emission rates for TSP, PM10 and PM2.5 from drilling operations during the operational phase at the mine are given in TABLE 5-3.

TABLE 5-3: DRILLING ACTIVITIES AT SPITSVALE MINE.

SOURCE	DIAMETER OF DRILL HOLE [1]	EMISSION SOURCE TYPE	EMISSION RATE (G/S) PER DRILL HOLE		
			TSP	PM10	PM2.5
Operational Phase					
Drilling at opencast mining area (10 holes per day)	127 mm	Area	0.009	0.004	0.001
Notes: 1) Dimensions of drill hole and number of drill holes were provided by the client					

5.2.2 Blasting

Blasting overburden and ore will occur at Spitsvale mine during the operational phase. During the operational phase, an area of 1800 m^2 will be blasted at the opencast mining area three times a month. In this study it was assumed that blasting would occur once a week from 14:00 – 15:00. Fugitive dust emissions from blasting activities at the mine were calculated using the following equations taken from the USEPA, AP-42 document, Section 11.9 western surface coal mining and Table 11.9.2:

$$E_{TSP} = 0.00022\ x\ (A)^{1.5}$$

$$E_{PM10} = 0.00022\ x\ (A)^{1.5}\ x\ 0.52$$

$$E_{PM2.5} = 0.00022\ x\ (A)^{1.5}\ x\ 0.03$$

<u>Where:</u>

E = emission factor (kg/blast/day)

A = Size of area blasted (m^2)

Emission rates for TSP, PM10 and PM2.5 from blasting activities at Spitsvale mine are given in TABLE 5-4.

TABLE 5-4: BLASTING ACTIVITIES AT SPITSVALE MINE

SOURCE	DIMENSIONS OF BLASTING AREA(1)	EMISSION SOURCE TYPE	EMISSION RATE (G/S)		
			TSP	PM10	PM2.5
Operational Phase					
Blasting at opencast mining area	1800 m^2	Area	4.667	0.128	0.016
Notes: 1) Dimensions of blast area were provided by the client.					

5.2.3 Excavation, Front-end-loaders & Tipping

Surface mining operations often make use of excavators and front-end-loaders to remove and transfer (load) overburden and ore which results in fugitive dust emissions. The tipping of material from one area (e.g. truck) to another (e.g. stockpile) also results in fugitive dust emissions. Excavation, front-end-loading and tipping activities will be conducted at the mine. The USEPA does not have an emission factor or equation specific for calculating emissions from excavators, front-end-loaders or shovels. The Australian NPI, however, provides the same equation as for tipping to be applied to excavators, shovels and front-end-loaders. Excavation, loading and tipping activities were assumed to occur for 19 hours a day, six days a week for 300 days a year. An hourly material throughput of 63.16 tons per hour of material was assumed for the operational phase. The client specified that a total of two excavators would be used at the opencast mining area. It was assumed that a total of three front-end-loaders will be used at the mine.

Emissions of TSP, PM10 and PM2.5 due to excavation, front-end-loading and tipping activities were quantified using the NPI emission factors for excavators, shovels and front-end-loaders on overburden where the following equation was used:

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

<u>Where:</u>

E = emission factor (kg/ton)

U = mean wind speed (m/s)

M = material moisture content (%)

K = particle size multiplier (dimensionless) (K_{TSP} = 0.74, K_{PM10} = 0.35 & $K_{PM2.5}$ = 0.053)

A moisture content of 2% was applied for the material, which was based on the information provided during discussions with the soil specialist that is working on the project. The mean wind speed was calculated to be 2.8 m/s (January 2012 to December 2014). Emission rates for TSP, PM10 and PM2.5 from excavation, front-end-loading and tipping activities at Spitsvale mine are given in TABLE 5-5.

TABLE 5-5: EXCAVATION, FRONT-END-LOADING & TIPPING ACTIVITIES AT SPITSVALE MINE.

SOURCE	DIMENSIONS OF SOURCE (M)			EMISSION SOURCE TYPE	EMISSION RATE (G/S)		
	WIDTH	LENGTH	HEIGHT[1]		TSP	PM10	PM2.5
Operational Phase							
Excavation [2] at opencast mining area	4.1	4.6	8	Volume	0.0284	0.0134	0.002
Front-end-loader [3] : loads ore into Screening Plant	2.4	6.2	3.7	Area	0.009	0.0043	0.0006
Front-end-loader: loads ROM onto Trucks for export at ROM stockpile area					0.0284	0.0134	0.002
Front-end-loader: loads overburden onto truck at mining area					0.0284	0.0134	0.002
Tipping of ore from truck [4] at stockpile by screening mobile plant	2.7	10	5.6	Area	0.0284	0.0134	0.002
Tipping of overburden from truck at overburden storage area by the mining area					0.0284	0.0134	0.002

Notes:
1) Maximum Loading Height
2) Dimensions were assumed based on the specifications provided by Richy Specs for a Hitachi ZX87OH-3 (82T) excavator.
3) Dimensions were assumed based on the specifications provided by Richy Specs for a Caterpillar 950 wheel loader.
4) Dimensions were assumed based on the specifications provided by Richy Specs for a Caterpillar AD30 (30T) adt (articulated dump truck).

5.2.4 Bulldozing

Bull dozing is proposed to occur at Spitsvale mine during the operational phase. The USEPA provides an emissions equation specifically for activities from bulldozers since this equation takes silt content and moisture into account. Bulldozing was assumed to occur at the opencast mining area and at the ROM stockpiles for 19 hours a day, six days a week and 300 days a year. Fugitive dust emissions from bulldozing activities at the mine were calculated using the following equations taken from the USEPA, AP-42 document, Section 11.9 western surface coal mining and Table 11.9.2:

$$E_{TSP} = 2.6 \text{ x } \frac{(\mathrm{s})^{1.2}}{(\mathrm{M})^{1.3}} \qquad E_{PM10} = 0.45 \text{ x} \frac{(\mathrm{s})^{1.5}}{(\mathrm{M})^{1.4}} \text{ x } 0.75 \qquad E_{PM2.5} = \ 2.6 \text{ x} \frac{(\mathrm{s})^{1.2}}{(\mathrm{M})^{1.3}} \text{ x } 0.105$$

Where:

E = Emission rate (kg/hr)

M = material moisture content (2%)

s = material silt content (5%)

A moisture content of 2% and a silt content of 5% was applied, which was based on the information provided during discussions with the soil specialist that is working on the project. Emission rates for TSP, PM10 and PM2.5 from bulldozing operations at Spitsvale mine are given in TABLE 5-6.

TABLE 5-6: BULLDOZING ACTIVITIES AT SPITSVALE MINE.

SOURCE	DIMENSIONS OF SOURCE[1]		EMISSION SOURCE TYPE	EMISSION RATE (G/S)		
	WIDTH	LENGTH		TSP	PM10	PM2.5
Operational Phase						
Bulldozing activities	3 m	6 m	Area	7.284	1.430	0.765

Notes:

1) Dimensions were based on specifications provided by Richy Specs for a Caterpillar D8R Crawler Tractor.

5.2.5 Material Handling Operations (loading, offloading & transfer)

Material handling operations, including the transfer of material by means of material transfer, tipping, loading and offloading, at the mine are predicted to result in fugitive dust emissions. The quantity of dust which will be generated from such operations will depend on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature (moisture content) and volume of the material handled. Fine particulates are more readily disaggregated and released to the atmosphere during the material transfer process, as a result of exposure to strong winds. Increase in the moisture content of the material being transferred would decrease the potential for dust emission, since moisture promotes the aggregation and cementation of fines to the surfaces of larger particles (USEPA, 1995).

The following emission factors (low moisture content ores) were used to calculate TSP, PM10 and PM2.5 emissions due to material transfer from the screening mobile plant to the stockpile area and were taken from the Australian NPI emission factors for metalliferous mines. The emission factors can be found in Section 5.2.2, Table 3 (Handling, Transferring and Conveying material):

$$E_{TSP} = 0.06 \text{ kg/t} \qquad E_{PM10} = 0.03 \text{ kg/t}$$

<u>Where:</u>

E = Emission rate (kg/hr)

$E_{PM2.5}$ = assumed to be 3% of TSP

Emission rates for TSP, PM10 and PM2.5 from material transfer activities associated with the mobile screening plant at Spitsvale mine are given in TABLE 5-7.

TABLE 5-7: MATERIAL TRANSFER ACTIVITIES AT SPITSVALE MINE.

SOURCE	DIMENSIONS OF SOURCE[1]			EMISSION SOURCE TYPE	EMISSION RATE (G/S)		
	WIDTH	LENGTH	HEIGHT		TSP	PM10	PM2.5
Operational Phase							
Material Transfer	2 m	2 m	6 m	Volume	0.333	0.167	0.010

<u>Notes:</u>

1) Dimensions were assumed based on a typical conveyor transfer point.

5.2.1 Screening

Dry screening of ore will occur at the ROM stockpile areas with the use of one mobile screening plant. The mobile plant will move between the stockpile areas throughout the life time of the mine. In this study screening was assumed to occur at the proposed stockpile area 3 and 4. The following emission factors (low moisture content ores) were used to calculate TSP, PM10 and PM2.5 emissions due to dry screening activities during the operational phase at Spitsvale mine. The emission factors were obtained from the Australian NPI document, Section 5.2.2 emission factors for metalliferous mines, Table 3 (Screening):

$$E_{TSP} = 0.08\,kg/t \qquad E_{PM10} = 0.06\,kg/t \qquad E_{PM2.5} = 3\%\ of\ TSP$$

<u>Where:</u>

E = Emission rate (kg/hr)

Emission rates for TSP, PM10 and PM2.5 from screening activities during the operational phase at Spitsvale mine are given in TABLE 5-8.

TABLE 5-8: SCREENING ACTIVITIES AT SPITSVALE MINE.

SOURCE	DIMENSIONS (M) (1)			THROUGH PUT (TONS/H)	EMISSION SOURCE TYPE	EMISSION RATE (G/S)		
	WIDTH	LENGTH	LOADING HEIGHT			TSP	PM10	PM2.5
Operational Phase								
Screening	2	17	4	20 (2)	Volume	0.44	0.33	0.01

<u>Notes:</u>

1) Dimensions for the mobile screening plant were provided by the client.
2) Hourly throughput was provided by the client

5.2.2 Vehicle Entrainment on Unpaved Roads

Vehicle-entrained dust emissions from the movement of hauling trucks on unpaved haul roads represent a significant source of fugitive dust. The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. In addition to the volume of traffic, emissions also depend on source parameters which characterise the condition of a particular road and the associated vehicle traffic. These parameters include vehicle speeds, mean vehicle weight, average number of wheels per vehicle and road surface moisture (EPA, 1995). Although vehicle entrainment on unpaved roads has been found to result in high fugitive dust emissions, these impacts are often limited to close to the source.

Fugitive dust emissions from hauling trucks at Spitsvale mine were quantified using the following equations provided in the Missouri Department of Natural Resources, Haul Road Fugitive Emissions Worksheet Instructions (Missouri Department of Natural Resources, 2009):

$$E = K \left(\frac{s}{12}\right)^{a} x \left(\frac{W1 + W2}{6}\right)^{b}$$

$$Annual\ VMT = \frac{2\ x\ (length\ of\ haul\ road)\ x\ (annual\ amount\ hauled)}{(average\ weight\ of\ material\ per\ load)}$$

<u>Where:</u>

E = emission factor (lb/VMT) (lb/VMT x 281.9 = g/VKT)

VMT = Vehicle miles travelled

VKT = Vehicle kilometres travelled

s = surface material silt content (5%)

K = empirical constant (K_{TSP}, K_{PM10} & $K_{PM2.5}$)

a = empirical constant (a_{TSP}, a_{PM10} & $a_{PM2.5}$)

b = empirical constant (b_{TSP}, b_{PM10}, $b_{PM2.5}$)

W1 = Weight of unloaded truck

W2 = Weight of loaded truck

The surface material silt content for the haul roads at Spitsvale mine was set to 5%. During the operational phase, 30T haul trucks will be used at Spitsvale mine. The weights of the trucks were chosen based on the information provided by the client. The empirical constants K, a and b were chosen for industrial roads based on the values provided in the USEPA, AP-42 document, Section 13.2 unpaved haul roads (TABLE 5-9). A summary of input parameters for the hauling trucks at Spitsvale mine is given in

TABLE 5-10. Emission rates for TSP, PM10 and PM2.5 due to vehicle dust entrainment from hauling trucks during the operational phase at Spitsvale mine are given in TABLE 5-11.

The mine proposes to use a water browser to control dust emissions from hauling activities at the mine. It is proposed that 5 – 8000 litres of water will be used per hour, depending on the weather conditions and operational activities, to suppress dust on the haul route. It should be noted that hauling of ore on the main haul route was only considered in this study. Hauling of overburden was not included as:

a) hauling of overburden will occur in close proximity to the opencast mining area;
b) there are no designated hauling routes for overburden as the overburden will be temporarily stored in close proximity to the mining area (there is no designated overburden stockpile);and
c) Hauling of overburden and ore is unlikely going to occur simultaneously.

TABLE 5-9: EMPIRICAL CONSTANTS USED IN THE CALCULATION FOR DUST EMISSIONS FROM HAULING TRUCKS (USEPA, 1995: SECTION 13.2, TABLE 13.2.2).

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

TABLE 5-10: INPUT PARAMETERS FOR TRUCKS AT SPITSVALE MINE.

SOURCE	TRUCK PARAMETERS				
	UNLOADED WEIGHT (TON)	LOADED WEIGHT (TON)	LENGTH (M)	WIDTH (M)	HEIGHT (M)
Operational Phase					
Hauling at the mine	30	60	10	2.7	5.6

Notes:
1) Parameters were based on the specifications provided by Richie Specs for a Caterpillar AD30 Articulated Dump Truck (30T capacity).

TABLE 5-11: VEHICLE DUST ENTRAINMENT DUE TO TRUCK HAULING ACTIVITIES AT SPITSVALE MINE.

SOURCE	VKT	EMISSION SOURCE TYPE	EMISSION RATE (G/S)		
			TSP	PM10	PM2.5
Operational Phase					
Hauling at the mine (x3 adt's)	136 800	Line Volume	9.0	4.0	0.2

Notes:

1) 65% control efficiency applied due to water suppression (>2 l/m^2/hr). The percentage controlled efficiency was obtained from the Australian NPI document.

5.2.1 Wind Erosion from Stockpiles

Stockpiles are potentially a significant source of dust emissions. Physical properties namely the shape, size, height, the surface area coverage, moisture content and the surface compaction of the stockpiles together with prevailing meteorological conditions will influence the rate at which dust is emitted.

The size, height, width and shape of the stockpiles will alter wind field patterns and surface boundary layer interactions thus influencing the dispersion and dilution potential of the dust plume. The moisture content, surface compaction and surface coverage area will affect the quantity of dust emitted from the stockpiles. Overtime the water content of the stockpiles will decrease due to varying ambient temperatures and relative humidity, thus if the area is not treated for dust suppression it may be a substantial source of fugitive dust emissions. Significant amounts of dust will be eroded from the stockpiles under wind speeds greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s). Fugitive dust generation resulting from wind erosion under high winds (i.e. > 5.4 m/s) is directly proportional to the wind speed.

In the estimation of fugitive dust emissions from the stockpiles, use was made of the emission factors given by the NPI for wind erosion from other exposed areas (not coal), Appendix A, Section 1.1.18.

$$E_{TSP} = 0.4 \text{ kg/Ha/hr}$$

$$E_{PM10} = 0.2 \text{ kg/Ha/hr}$$

Where:

E = Emission rate (Kg/Hectare/hour)

$E_{PM2.5}$ = 3% of TSP

Source parameters for the stockpiles and emission rates for TSP, PM10 and PM2.5 are given in TABLE 5-12. Although there is no dedicated storage area for the overburden at the proposed mine, for modelling purposes an overburden stockpile was included to account for emissions from the temporary storage of overburden. Therefore the dimensions for the overburden stockpile were assumed.

TABLE 5-12: STOCKPILES AT SPITSVALE MINE.

SOURCE	HEIGHT (M)	AREA (Ha)	EMISSION RATE (G/S)		
			TSP	PM10	PM2.5
Operational Phase					
ROM Stockpile area 1	8	2.2	0.244	0.122	0.007
ROM Stockpile area 2	8	1.95	0.217	0.108	0.007
ROM Stockpile area 3	8	3	0.333	0.167	0.01
ROM Stockpile area 4	8	3	0.333	0.167	0.01
Overburden temporary storage area (1)	5	0.01	0.028	0.083	0.001

Notes:
1) Dimensions assumed
2) Height and areas were provided by the client for the stockpiles

5.3 Model Overview

5.3.1 AERMOD View

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.

- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

AERMOD includes Plume Rise Model Enhancements (PRIME) building downwash algorithms which provide a more realistic handling of building downwash effects. PRIME algorithms were designed to address two fundamental features associated with building downwash; enhanced plume dispersion coefficients due to the turbulent wake and to reduce plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.

AERMOD is suitable for a wide range of near field applications in both simple and complex terrain. The evaluation results for AERMOD, particularly for complex terrain applications, indicate that the model represents significant improvements compared to previously recommended models (USEPA, 2005).

AERMOD has been used in various dispersion modelling studies in the United States and around the world (Perry *et al*., 2004). Ventrakam (2003) investigated the ability of AERMOD to model the dispersion of an inert gas, released as a line source, in an urban environment. Comparing monitored and modelled concentrations at 24 receptor locations it was found that the model over predicted average 30 minute concentrations near source and under predicted concentrations further away. The study also found that at night the correlation of measured and modelled concentrations at the closest receptor points to the source were poor. However, the agreement improved with distance (Holmes and Morawska, 2006).

5.3.2 Model Requirements

The approach to this dispersion modelling study is based on the Code *of Practice for Air Dispersion Modelling in Air Quality Management in South Africa* (DEA, 2014). As per the *Code of Practice*, this assessment is considered to be a Level 2 assessment. Level 2 assessments should be used for air quality impact assessment in standard/generic licence or amendment processes where:

- The distribution of pollutant concentrations and depositions are required in time and space;
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. Although more complicated processes may be occurring, a more complicated model that explicitly treats these processes may not be necessary depending on the purposes of the modelling and the zone of interest.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

Data input into the model includes MM5 modelled surface and upper air meteorological data with wind speed, wind direction, atmospheric pressure, solar radiation, relative humidity, temperature, cloud cover and precipitation for 01 January 2012 – 31 December 2014 which was obtained from Lakes Environmental in the USA. Terrain data at a resolution of 90 m (SRTM90) was used to input into the model, as generated by the terrain pre-processor, AERMAP. A modelling domain of 25km × 25km was used for modelling. A multi-tier grid was used with a grid receptor spacing's of 100m, 250m and 1000m (3 tiers).

A summary of the key variables input into the AERMOD model is given in TABLE 5-13.

TABLE 5-13: KEY VARIABLES USED IN THE MODELLING STUDY.

PARAMETER	MODEL INPUT
Model	
Assessment Level	Level 2
Dispersion Model	Aermod Version 9.0
Supporting Models	Aermet Version 9.0 Aermap Version 9.0
Emissions	
Pollutants modelled	Dust Fallout (TSP), PM10 & PM2.5
Scenarios	Construction and Operation
Chemical transformation (NO_2/NO_x)	n/a
Exponential decay	Rural
Settings	
Terrain setting	Elevated
Terrain data	SRTM90
Terrain data resolution (m)	90
Land characteristics (bowen ratio, surface albedo, surface roughness)	Rural
Grid Receptors	
Modelling domain (km)	25 * 25
Fine grid resolution (m)	100 (5 km distance from centre)
Medium grid resolution (m)	250 (10 km distance from centre)
Large grid resolution (m)	1000 (25 km distance from centre)

5.4 Dispersion Modelling Simulations

Dispersion simulations were undertaken for the following scenario to determine the following:

- Predicted ground-level impacts from all key sources for TSP (as dust fallout), PM10 & PM2.5 for construction and operation activities associated with Spitsvale mine.

The *Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa* (DEA, 2014), recommends the use of the 99^{th} percentile concentrations for short-term assessment with the National Ambient Air Quality Standards since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime.

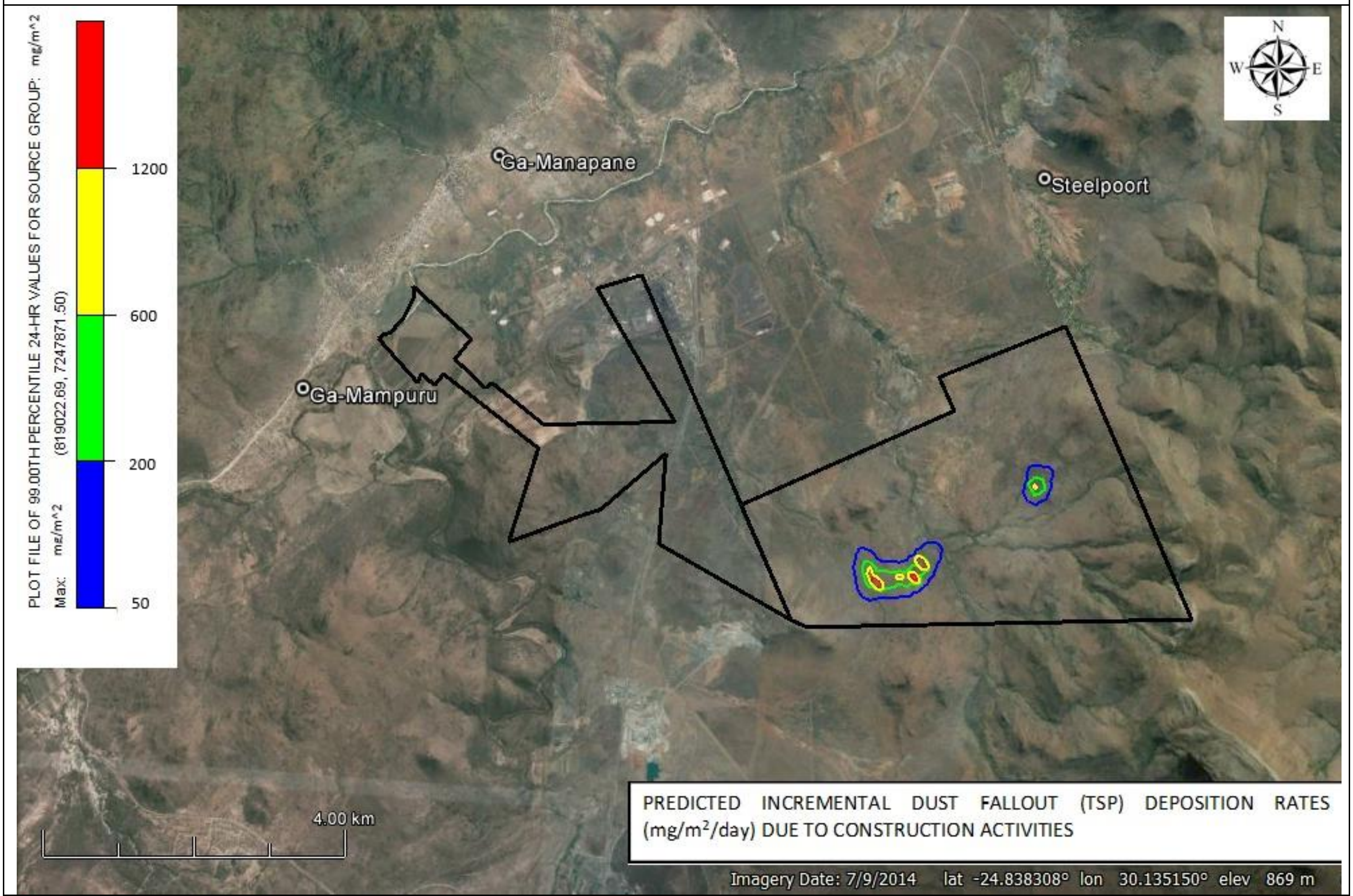
Isopleth plots of predicted concentrations for daily and annual average dust fallout, PM10 & PM2.5 concentrations for the construction and operation phase are given in FIGURE 5-1 – FIGURE 5-6. For short term averaging periods, the predicted 99^{th} percentile concentrations are provided. Comparison of the predicted ambient PM10 and PM2.5 concentrations has been made with the South African National ambient air quality standards to determine compliance. Comparison of the predicted TSP (as dust fallout) concentrations is made with the South African National Dust Control Regulations to determine compliance.

5.4.1 Construction Phase

5.4.1.1 Dust Fallout

Predicted incremental dust fallout rates associated with heavy construction activities during the construction phase at Spitsvale mine are within the allowable dust fallout limit of 600 $mg/m^2/day$ for residential areas and 1200 $mg/m^2/day$ for non-residential areas beyond the mines boundary (FIGURE 5-1). Predicted incremental dust fallout rates exceed the allowable dust fallouts of 600 $mg/m^2/day$ and 1200 $mg/m^2/day$ at the source (area of construction). Predicted dust fallout rates at all the surrounding sensitive receptors beyond the mines boundary are in compliance (TABLE 5-14).

Predicted Dust Fallout (TSP) Deposition Rates – Construction Phase



COMMENTS:	**GRID SIZE:** 25 x 25 km	**MODEL:** AERMOD View
No exceedances of the residential area standard of 600 mg/m²/day observed beyond the mine's boundary.	**GRID:** Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Deposition Rates
	NUMBER OF SOURCES: X 7 area sources	**ASSUMPTIONS:** Worst case scenario – No dust suppression measures.
	EXCLUSIONS:	**DUST FALLOUT STANDARD:** 1200 mg/m²/day (non-residential areas) 600 mg/m²/day (residential areas)
		DATE: 22/01/2016

FIGURE 5-1: PREDICTED DUST FALLOUT RATES AT SPITSVALE MINE – CONSTRUCTION PHASE.

5.4.1 Operational Phase

5.4.1.1 Dust Fallout

Predicted incremental dust fallout rates associated with mining operations during the operation phase at Spitsvale mine are within the allowable dust fallout limit of 600 mg/m^2/day for residential areas and 1200 mg/m^2/day for non-residential areas beyond the mines boundary (FIGURE 5-2). Predicted incremental dust fallout rates exceed the allowable dust fallouts of 600 mg/m^2/day and 1200 mg/m^2/day near to the source of activity. Predicted dust fallout rates at all the surrounding sensitive receptors beyond the mines boundary are in compliance (TABLE 5-14).

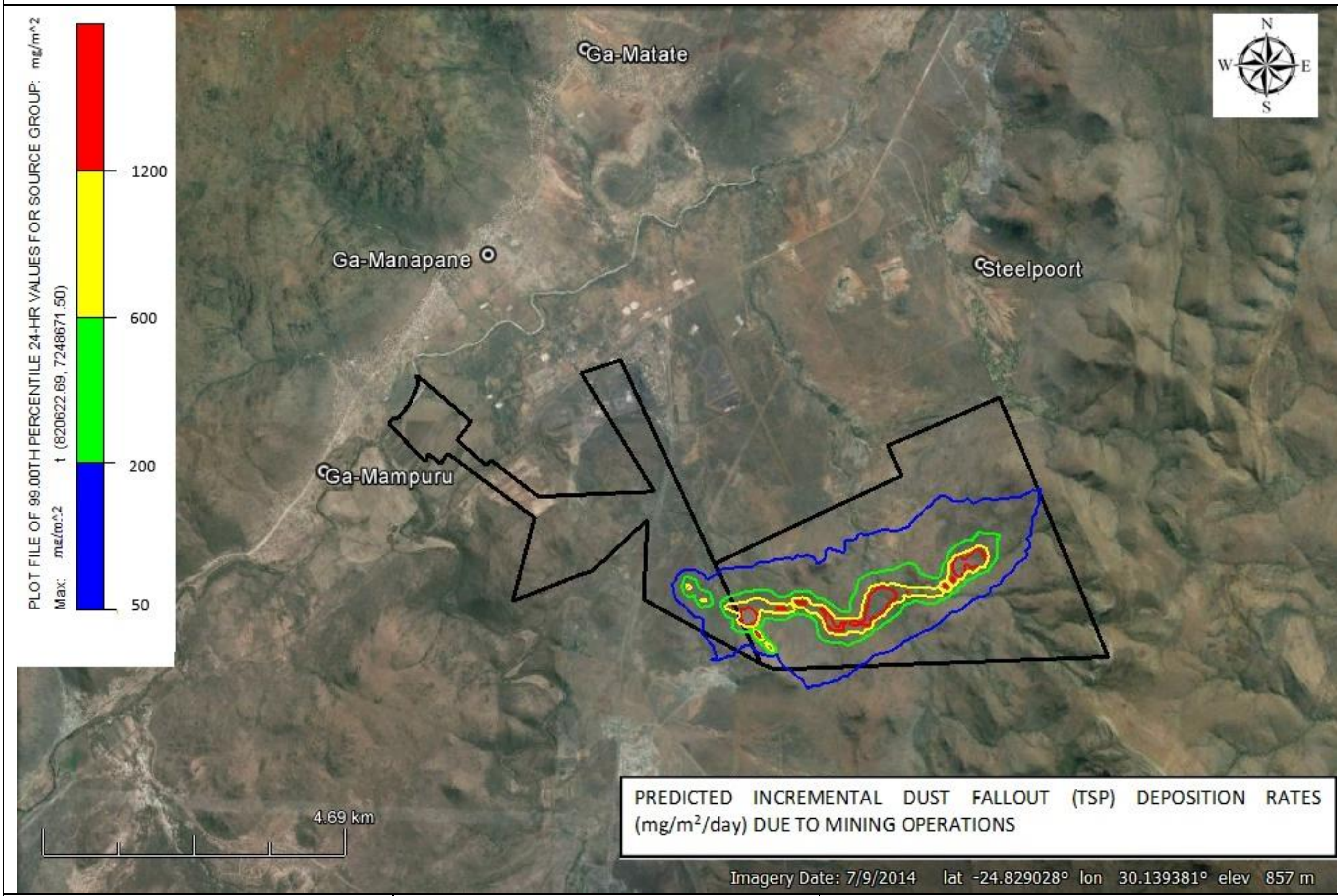
5.4.1.2 PM10 Concentrations

Predicted incremental daily and annual average PM10 concentrations associated with activities during the operational phase are in compliance with the daily average standard of 75 µg/m^3 and the annual average standard of 40 µg/m^3 beyond the mines boundary (FIGURE 5-3 and FIGURE 5-4). Low PM10 concentrations are predicted to occur at nearby surrounding sensitive receptors (TABLE 5-14).

5.4.1.3 PM2.5 Concentrations

Predicted incremental daily and annual average PM2.5 concentrations associated with activities during the operational phase are in compliance with the daily average standard of 40 µg/m^3 and annual average standard of 20 µg/m^3 beyond the mines boundary (FIGURE 5-5 and FIGURE 5-6). PM2.5 concentrations at nearby surrounding sensitive receptors are predicted to be within the acceptable limits (TABLE 5-14).

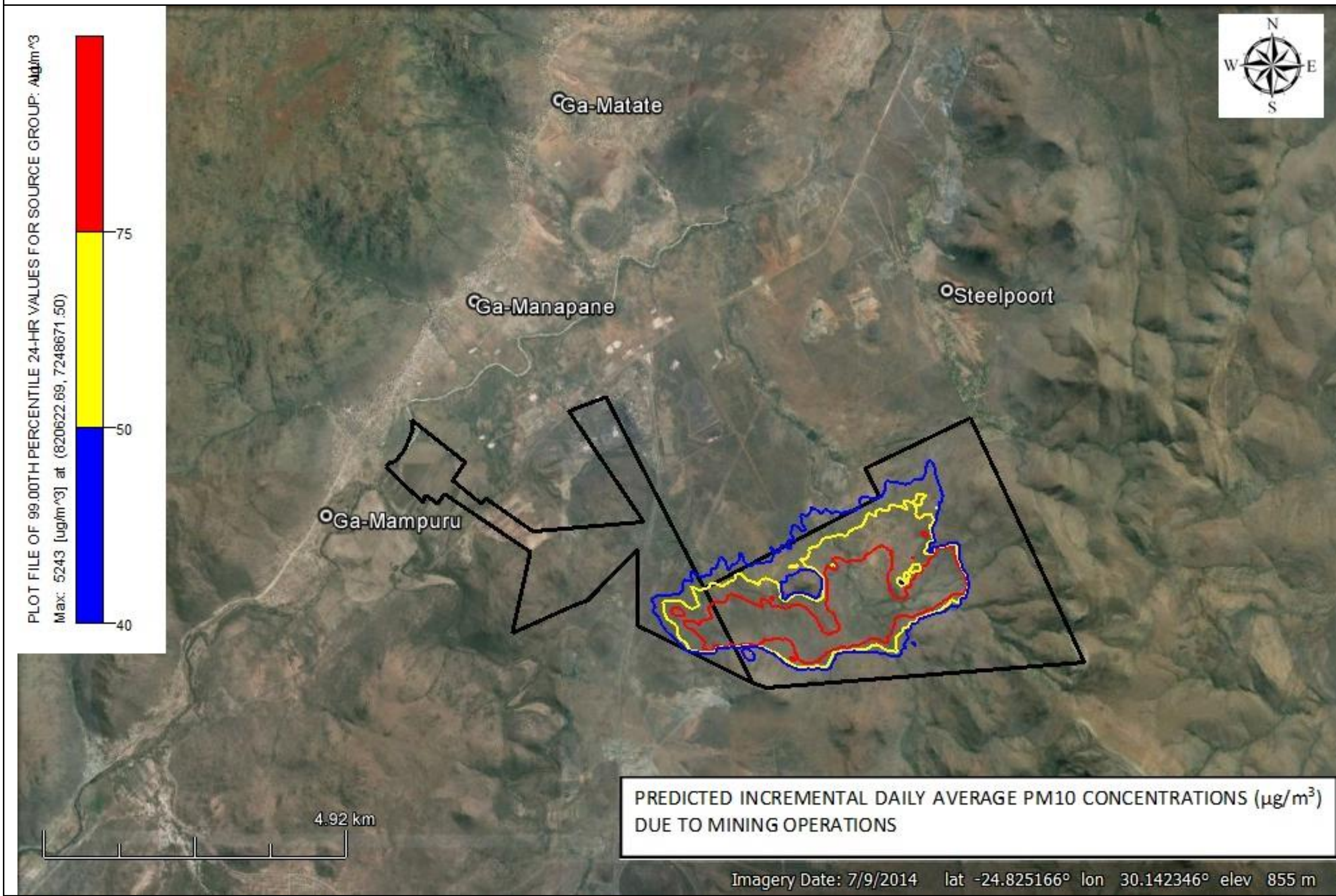
Predicted Dust Fallout (TSP) Deposition Rates – Operation Phase



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the residential area standard of 600 mg/m²/day observed beyond the mine's boundary.	25 x 25 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Deposition Rates
	NUMBER OF SOURCES: X 15 area sources X 4 line volume source X 3 volume sources	**ASSUMPTIONS:** Dust suppression on hauling route (65% reduction)
	EXCLUSIONS: Hauling overburden	**DUST FALLOUT STANDARD:** 1200 mg/m²/day (non-residential areas) 600 mg/m²/day (residential areas)
		DATE: 25/01/2016

FIGURE 5-2: PREDICTED DUST FALLOUT RATES AT SPITSVALE MINE – OPERATION PHASE.

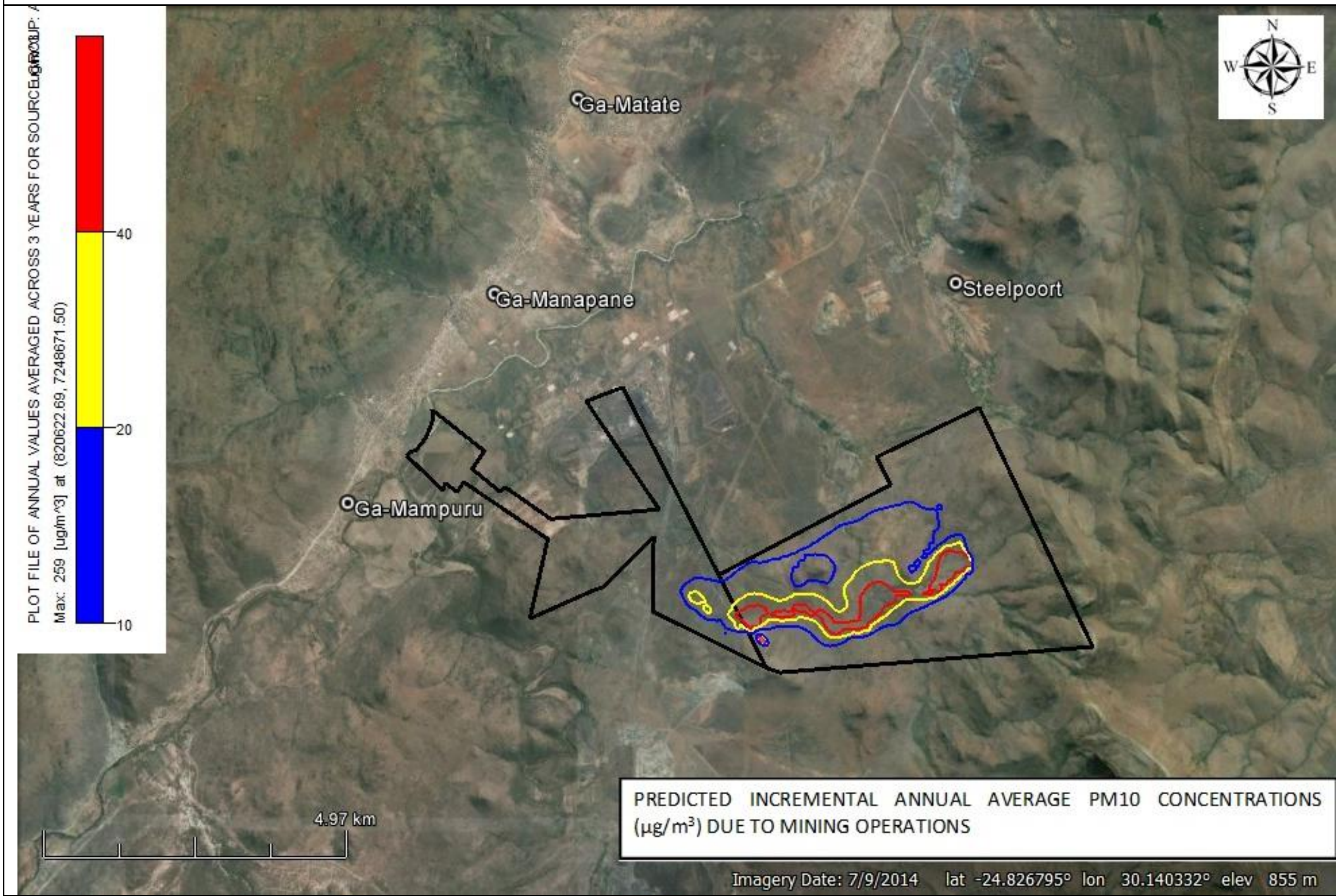
Predicted 24-Hour PM10 Concentrations – Operation Phase



COMMENTS:	**GRID SIZE:**	**MODEL:**
Red Band – exceedance of SA 24-H PM10 standard of 75 µg/m³. No exceedances observed beyond the mine boundary.	25 x 25 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 15 area sources X 4 line volume source X 3 volume sources	**ASSUMPTIONS:** Dust suppression on hauling route (65% reduction)
	EXCLUSIONS: Hauling overburden	**AMBIENT STANDARD:** 75 µg/m³ (SA 24-Hour standard)
		DATE: 22/01/2016

FIGURE 5-3: PREDICTED DAILY AVERAGE PM10 CONCENTRATIONS AT SPITSVALE MINE – OPERATION PHASE.

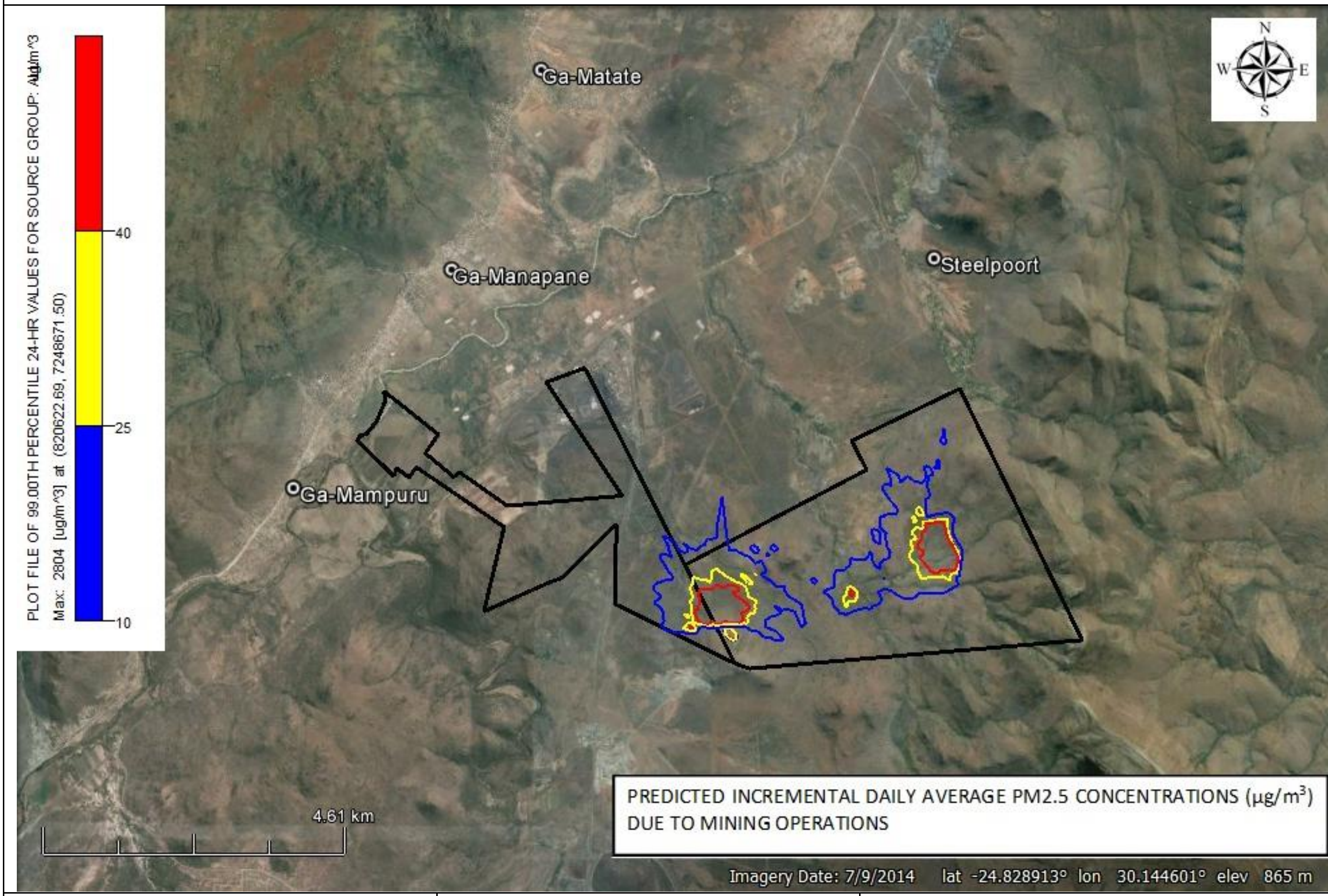
Predicted Annual PM10 Concentrations – Operation Phase



COMMENTS: Red Band – exceedance of SA annual PM10 standard of 40 µg/m³. No exceedances observed beyond the mine boundary.	**GRID SIZE:** 25 x 25 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** Ground Level Concentrations
	NUMBER OF SOURCES: X 15 area sources X 4 line volume source X 3 volume sources	**ASSUMPTIONS:** Dust suppression on hauling route (65% reduction)
	EXCLUSIONS: Hauling overburden	**AMBIENT STANDARD:** 40 µg/m³ (SA annual standard)
		DATE: 22/01/2016

FIGURE 5-4: PREDICTED ANNUAL AVERAGE PM10 CONCENTRATIONS AT SPITSVALE MINE – OPERATION PHASE.

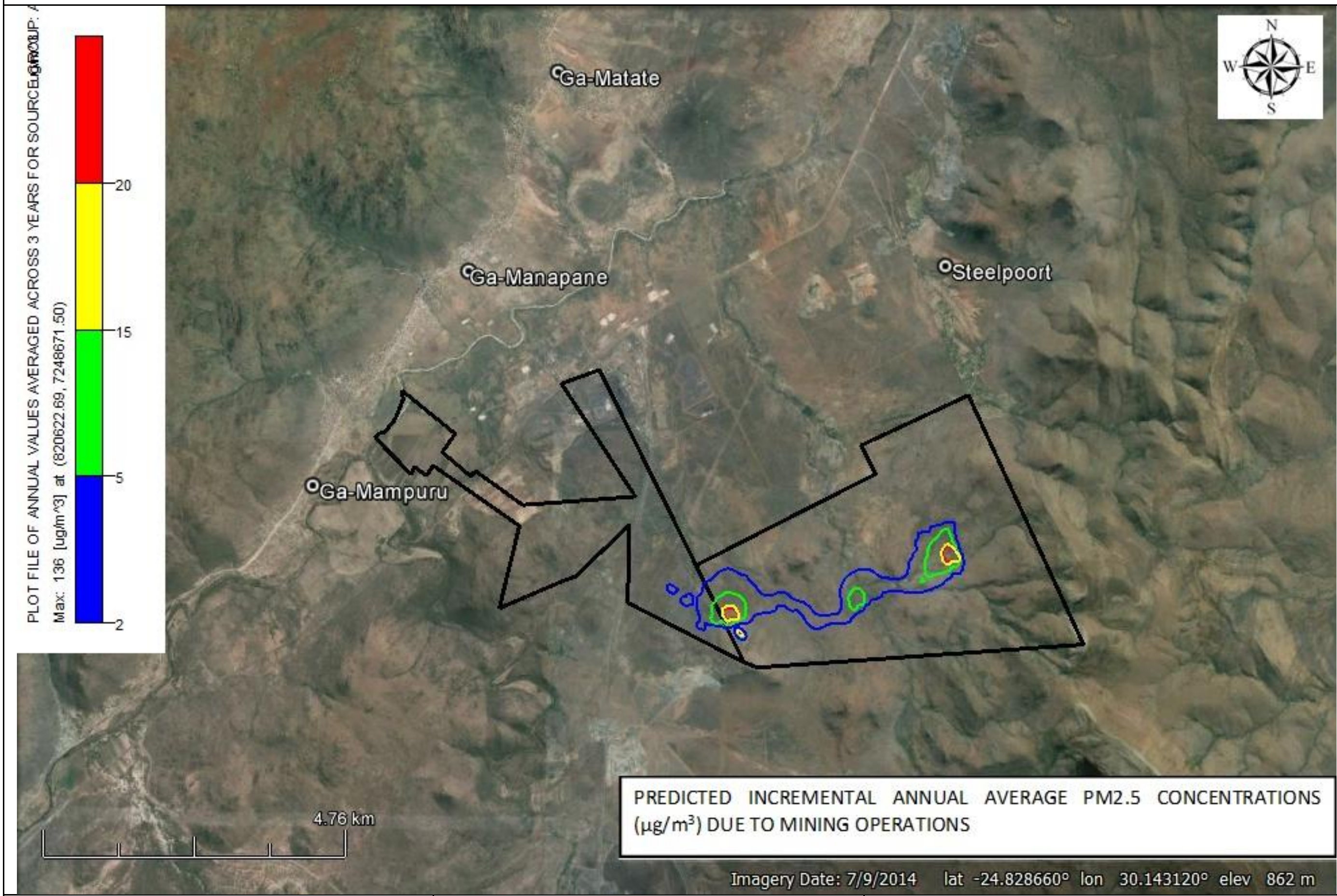
Predicted 24-Hour PM2.5 Concentrations – Operation Phase



COMMENTS:	**GRID SIZE:** 25 x 25 km	**MODEL:** AERMOD View
Red Band – exceedance of the current SA 24-Hour PM2.5 standard of 40 µg/m³. No exceedances of the current standard observed beyond the mine boundary.	**GRID:** Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 15 area sources X 4 line volume source X 3 volume sources	**ASSUMPTIONS:** Dust suppression on hauling route (65% reduction)
	EXCLUSIONS: Hauling overburden	**AMBIENT STANDARD:** 40 µg/m³ (SA 24-Hour standard) (current) 25 µg/m³ (SA 24-Hour standard) (By 1 Jan 2030)
		DATE: 22/01/2016

FIGURE 5-5: PREDICTED DAILY AVERAGE PM2.5 CONCENTRATIONS AT SPITSVALE MINE – OPERATION PHASE.

Predicted Annual PM2.5 Concentrations – Operation Phase



COMMENTS:	GRID SIZE: 25 x 25 km	MODEL: AERMOD View
Red Band – exceedance of the current SA annual PM2.5 standard of 20 µg/m³. No exceedances of the current standard observed beyond the mine boundary.	GRID: Multi-tier – 3 tiers	OUTPUT TYPE: 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 15 area sources X 4 line volume source X 3 volume sources	ASSUMPTIONS: Dust suppression on hauling route (65% reduction)
	EXCLUSIONS: Hauling overburden	AMBIENT STANDARD: 20 µg/m³ (SA annual standard) (Current) 15 µg/m³ (SA annual standard) (By 1 Jan 2030)
		DATE: 22/01/2016

FIGURE 5-6: PREDICTED ANNUAL AVERAGE PM2.5 CONCENTRATIONS AT SPITSVALE MINE – OPERATION PHASE.

The maximum predicted incremental PM10, PM2.5 and dust fallout concentrations at nearby sensitive receptors (located along the boundary or within 10 km from the center of the mine) for operations at Spitsvale mine are given in TABLE 5-14 for the construction and operational phases. The approximate maximum predicted incremental concentrations at the mine boundary are given in TABLE 5-15.

TABLE 5-14: MAXIMUM PREDICTED INCREMENTAL PM10, PM2.5 and DUST FALLOUT CONCENTRATIONS AT SENSITIVE RECEPTORS.

INCREMENTAL CONCENTRATIONS (µG/M^3)					
SENSITIVE RECEPTOR	PM10		PM2.5		DUST FALLOUT (MG/M^2/DAY)
	DAILY AVERAGE	ANNUAL AVERAGE	DAILY AVERAGE	ANNUAL AVERAGE	
STANDARD (µG/M^3)	75	40	40	20	Residential: 600 mg/m^2/day Non-residential: 1200 mg/m^2/day
Operation Phase					
Steelpoort	22.20	2.91	2.57	0.30	<10
Ga Mampuru	5.61	0.61	0.78	0.07	<10
Ga Manapane	6.33	0.85	1.00	0.09	<10
Ga Matate	6.38	0.78	0.67	0.07	<10
Construction Phase					
Steelpoort	*	*	*	*	<10
Ga Mampuru	*	*	*	*	<10
Ga Manapane	*	*	*	*	<10
Ga Matate	*	*	*	*	<10

TABLE 5-15: SUMMARY OF PREDICTED MAXIMUM MODELLED CONCENTRATIONS AT SPITSVALE MINE BOUNDARY LINE.

POLLUTANT	AVERAGING TIME	MAXIMUM MODELLED CONCENTRATION (µG/M³) (3)	COMPLIANCE	
			FOE (4)	AIR QUALITY STANDARD (µG/M³)
Construction Phase				
Dust Fallout(1)	Daily	~20	0	1200(2)
Operation Phase				
PM10	Daily	~40	0	75
	Annual	~8	*	40
PM2.5	Daily	16	0	40
	Annual	<2	*	20
Dust Fallout(1)	Daily	~90	0	1200(2)

Notes:

(1) Dust fallout given in $mg/m^2/day$

(2) Non-residential area dust fallout standard

(3) Considered the approximate maximum concentration that falls along the boundary

(4) Frequency of exceedance outside the boundary

5.4.2 Cumulative Impacts

Emissions from sources need to be assessed in terms of the cumulative impacts in an area. The *Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014),* outlines the following for isolated sources that are not significantly influenced by background concentrations e.g. in isolated areas:

- For annual averages, the highest predicted concentration must be less than the National ambient air quality standards, no exceedances allowed;
- For short-term averages (24 hours or less), sum of the 99th percentile concentrations and background concentrations must be less than the National ambient air quality standards. Wherever one year is modelled, the highest concentrations shall be considered.

In determining the cumulative impacts, predicted incremental concentrations (as determined beyond the sites boundary) should be added to the measured concentrations for the applicable pollutant averaging periods. Inside the site boundary, air pollutant concentrations are required to comply with occupational health standards.

A comprehensive ambient air quality monitoring dataset for the study area is not available therefore cumulative impacts on PM10 and PM2.5 cannot be assessed. Although a comprehensive dust fallout monitoring dataset is not available for the study area, the cumulative impact on dust fallout (TSP) is summarized in TABLE 5-16 for the construction and operational activities. It is recommended that dust fallout monitoring at the site is continued and reported on a monthly basis.

TABLE 5-16: SUMMARY OF CUMULATIVE IMPACTS ASSOCIATED WITH OPERATIONS AT SPITSVALE MINE.

POLLUTANT	AVERAGING PERIOD	HIGHEST CONCENTRATION (µG/M^3)		SUM OF C_B AND C_P	AIR QUALITY STANDARD (µG/M^3)
		BACKGROUND (1) (C_B)	PREDICTED (2) (C_P)		
Construction Phase					
Dust Fallout (TSP)	Daily	569	20	589	1200(3) mg/m^3/day 600(4) mg/m^3/day
Operation Phase					
Dust Fallout (TSP)	Daily	569	90	659	1200(3) mg/m^3/day 600(4) mg/m^3/day

Notes:

(1) Please refer to section 4.2. for more details on the background air quality data.
(2) Considered the approximate maximum predicted concentration outside the mine boundary.
(3) Non-residential area standard
(4) Residential area standard

The level of impact of construction and operational activities associated with Spitsvale mine is assessed below (TABLE 5-17). The method for determining the level of impact was based on an impacting rating method developed by Enviro Dynamics Environmental Consulting Company and is summarized in TABLE 5-18 and TABLE 5-19.

TABLE 5-17: SUMMARY OF AIR QUALITY IMPACTS ASSOCIATED WITH CONSTRUCTION AND OPERATION ACTIVITIES AT SPITSVALE MINE.

POTENTIAL IMPACT	AVERAGING PERIOD	STATUS/ NATURE	EXTENT	DURATION	INTENSITY	PROBAB-ILITY	DEGREE OF CONFIDE-NCE	SIGNIFICANCE		
								PRE-MITIGATION	MITIGATION / ENHANCEMENT	POST - MITIGATION
Construction Phase										
Dust Fallout (TSP)	1 month	Negative impact to ambient air quality through emissions	Limited impact – limited to near the area of activity	Short term – limited to the period of construction	Low impact – predicted concentrations are below the non-residential area and residential area standards outside the boundary.	Probable	Medium	Low	Mitigation measures not assessed in this study	*
Operational Phase										
PM10	daily	Negative impact to ambient air quality through emissions	Predicted Local impact – limited to near the area but potential for long range transport	Long term – can be significantly reduced after operation if stockpiles/dumps/ opencast/exposed areas are removed and/or rehabilitated and the mine is fully rehabilitated.	Low impact – predicted concentrations are below the SA standards beyond the boundary & at sensitive receptors	Probable	Medium	*	Dust suppression on the main haul route (at least 65% emission reduction efficiency) (Level 2 watering (>2 litres/m^2/hr).	Low – only if dust suppression is applied on the main haul route on a daily basis to maintain at least 65% emission reduction efficiency
	annual									
PM2.5	daily	Negative impact to ambient air quality through emissions	Predicted Local impact – limited to near the area but potential for long range transport	Long term – can be significantly reduced after operation if stockpiles/dumps/ opencast/exposed areas are removed and/or rehabilitated and the mine is fully rehabilitated.	Low impact – predicted concentrations are below the SA standards beyond the boundary & at sensitive receptors	Probable	Medium	*		
	annual									

Dust Fallout (TSP)	1 month	Negative impact to ambient air quality through emissions	Limited impact – limited to near the source	Long term – can be significantly reduced after operation if stockpiles/dumps/ opencast/exposed areas are removed and/or rehabilitated and the mine is fully rehabilitated.	Low impact – predicted concentrations are below the non-residential area and residential area standards outside the boundary.	Probable	Medium	*	Dust suppression on the main haul route (at least 65% emission reduction efficiency) (Level 2 watering (>2 litres/m^2/hr).	Low – only if dust suppression is applied on the main haul route on a daily basis to maintain at least 65% emission reduction efficiency

Note: It should be emphasized that the mitigation measures that were chosen to be modelled in this study exclude other potential control measures that are highlighted under Section 6 of this report. Post mitigation evaluation here is only considering the mitigation measures modelled.

TABLE 5-18: DESCRIPTION OF TERMINOLOGY.

	DESCRIPTION
NATURE	Reviews the type of effect that the proposed activity will have on the relevant component of the environment and includes "what will be affected and how?"
EXTENT	Geographic area. Indicates whether the impact will be within a limited area (on site where construction is to take place); local (limited to within 25km of the area); regional (limited to ~200km radius); national (limited to the borders of Namibia); or international (extending beyond Namibia's borders).
DURATION	Whether the impact will be temporary (during construction only), short term (1-5 years), medium term (5-10 years), long term (longer than 10 years, but will cease after operation) or permanent.
INTENSITY	Establishes whether the magnitude of the impact is destructive or innocuous and whether or not it exceeds set standards, and is described as none (no impact); low (where natural/ social environmental functions and processes are negligibly affected); medium (where the environment continues to function but in a noticeably modified manner); or high (where environmental functions and processes are altered such that they temporarily or permanently cease and/or exceed legal standards/requirements).
PROBABILITY	Considers the likelihood of the impact occurring and is described as uncertain, improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of prevention measures).
SIGNIFICANCE	Significance is given before and after mitigation. Low if the impact will not have an influence on the decision or require to be significantly accommodated in the project design, Medium if the impact could have an influence on the environment which will require modification of the project design or alternative mitigation (the design can be used, but with deviations or mitigation) High where it could have a "no-go" implication regardless of any possible mitigation.
STATUS OF THE IMPACT	A statement of whether the impact is positive (a benefit), negative (a cost), or neutral. Indicate in each case who is likely to benefit and who is likely to bear the costs of each impact.
DEGREE OF CONFIDENCE IN PREDICTIONS	Is based on the availability of specialist knowledge and the availability of other information in relation to the project.

TABLE 5-19: CRITERIA FOR LEVEL OF SIGNIFICANCE.

SIGNIFICANCE RATING	CRITERIA
LOW	Where the impact will have a negligible influence on the environment and no modifications or mitigations are necessary for the given development description. This would be allocated to impacts of any severity/ magnitude, if at a local scale/ extent and of temporary duration/time.
MEDIUM	Where the impact could have an influence on the environment, which will require modification of the development design and/or alternative mitigation. This would be allocated to impacts of moderate severity/magnitude, locally to regionally, and in the short term.
HIGH	Where the impact could have a significant influence on the environment and, in the event of a negative impact the activity(ies) causing it, should not be permitted (i.e. there could be a 'no-go' implication for the development, regardless of any possible mitigation). This would be allocated to impacts of high magnitude, locally for longer than a month, and/or of high magnitude regionally and beyond.

5.5 Assumptions and Limitations

The following key assumptions and limitations of the study are given below:

Assumptions:

- Data/information provided by the Client and used as input into the model was assumed to be accurate and complete at the time of modelling;
- Dimensions for the different sources were based on the information and kml/kmz files provided by the client and was assumed to be accurate and complete at the time of modelling;
- A summary of assumptions made in this study is given in TABLE 5-20.

TABLE 5-20: SUMMARY OF ASSUMPTIONS MADE.

ASSUMPTIONS MADE	ASSUMPTIONS BASED ON:
Locality of the offices, buildings, workshop, etc.	The exact locations of the offices, laydown areas, buildings, workshop, etc. that are proposed to be constructed at Spitskop farm portion were not known at the time of the modelling. The footprint of the proposed construction areas was however known, as it will be the exact same footprint as the existing infrastructure. The general locality of the proposed construction areas was also known. Thus the locality of the buildings was assumed to be just north of the Stockpile 3 and 4.
Details of the Hauling Trucks (Model & loaded and unloaded weights).	The number of trucks were assumed based on the details provided in the equipment list for each mining area as well based on the information provided by the client. The client also provided details of the capacity of the trucks (i.e. 30T for ore). Truck details were assumed based on the specifications provided by Richy specs for a Caterpillar AD30 Articulated Dump Truck (30T). The capacities of the trucks were known and were provided by the client therefore typical hauling trucks with those capacities were assumed.
Material Parameters (silt content and moisture content)	Details for surface material silt content, material silt content and moisture contents were based on the values provided during discussions with a soil specialist who is working on the project.
Locality of material handling operations and details of mining equipment (e.g. number of bull dozers, front-end-loaders, excavators, number of trucks, dimensions, etc.)	Details were assumed based on information provided in the equipment list for the mining areas. The table provided details on quantities and capacities (in some instances) of equipment to be used. Assumptions were also based on information provided by the client and previous knowledge and experience of mining operations. Dimensions of the equipment were based on the specifications provided by Richy specs for similar sized equipment.
Overburden Storage Area	There is no dedicated storage area for overburden at the proposed mine. The overburden will be temporarily stored near the mining area in the form of stockpiles before it is used to backfill the mined out areas during rehabilitation. Backfilling will occur throughout the life time of the mine. Therefore, for modelling purposes, an overburden storage area was included. The dimensions for the storage area were assumed.

Exclusions:

The following exclusions were made:

I. Hauling of overburden was not included as:

   a) hauling of overburden will occur in close proximity to the opencast mining area;
   b) there are no designated hauling routes for overburden as the overburden will be temporarily stored in close proximity to the mining area (there is no designated overburden stockpile);and
   c) Hauling of overburden and ore is unlikely going to occur simultaneously.

6 MITIGATION MEASURES

The recommendations provided below are only briefly outlined within a general context and are not compulsory. A detailed air quality management plan, using the recommendations provided as a tool, would need to be developed and compiled specifically for the project. The choice of mitigation measures for inclusion in the air quality management plan will depend on several factors such as the availability of resources, practicality, effectiveness and affordability.

6.1 Operational Phase

A number of methods are available to reduce dust emissions from mining and processing operations. Most dust control techniques use wet suppression, although there are other methods such as the use of chemical agents. Recommended control measures and their efficiency for reduced dust emissions are given in TABLE 6-1.

Dust generated from material handling operations and mining operations can be significantly reduced by wet suppression with the use of water sprays. However, the combined use of water sprays with chemical surfactants provide more extensive wetting making it a more effective technique than water suppression alone. The loading, transfer and discharge of materials should take place with a minimum height of fall and be shielded against the wind.

Controls to reduce emissions from unpaved roads can include vehicle restrictions which limit the speed, weight and number of vehicles on the road, surface improvements (paving or adding gravel to the road) and surface treatments (wet suppression or surface treatments) (USEPA, 1996). However, reducing the vehicle speeds is not always feasible as it decreases the overall mine productivity while paving is not economically attractive as many of the haul roads are not permanent. The use of materials with low silt content (such as gravel) also requires regular maintenance and replacement. Wet suppression increases the moisture content which causes particles to agglomerate, thereby decreasing the likelihood of particles becoming suspended due to vehicle entrainment. However, the efficiency of watering depends on the amount of water added during each application, the application frequency, the weight, speed and number of vehicles travelling on the road and the prevailing meteorological conditions. Other methods such as chemical suppression reduce emissions by changing the physical characteristics of the existing road surface. However, chemical suppressants can be costly but they have less frequent reapplication requirements. A control efficiency of approximately 80% can be achieved when applied at a regular interval of 2 weeks to 1 month (USEPA, 1996).

Wind erosion from stockpiles and open areas can be minimised through the use of water sprays, wind breaks, vegetation and enclosures.

TABLE 6-1: CONTROL MEASURES TO CONTROL DUST EMISSIONS DURING OPERATION (NPI, 2012).

SOURCE	RECOMMENDED CONTROL MEASURES	CONTROL EFFICIENCY (%)
Offloading trucks	Water sprays	70
Loading stockpiles	Variable height stacker	25
	Water sprays	50
	Telescopic chute with sprays	75
	Total enclosure	99
Unloading from stockpiles	Water Sprays	50
	Wind breaks	30
Loading to trains/rail wagons	Enclosure	70
	Enclosure and use of fabric filters	99
Miscellaneous transfer and conveying	Water sprays with chemicals	90
	Enclosure	70
	Enclosure and use of fabric filters	99
Hauling	Level 1 watering (2 litres/m^2/hr)	50
	Level 2 watering (>2 litres/m^2/hr)	75
	Sealed or salt encrusted roads	100
Wind erosion from stockpiles	Water sprays	50
	Wind breaks	30
	Total enclosure	99
	Rock armour and/or topsoil applied	30
Wind erosion	Primary rehabilitation	30
	Secondary rehabilitation	60
	Vegetation	40
	Re-vegetation	90
	Fully rehabilitated	100

In order to reduce emissions associated with hauling activities, the following recommendations are made:

- Implement strict vehicle restrictions such as speed limits, weight and number of trucks on the road per given time;
- Hauling activities should be strictly restricted to designated hauling routes;
- Regular maintenance of the vehicles/trucks (engines) should be undertaken to ensure optimal efficiency of the engine;
- Regular maintenance of hauling routes and surface improvements (where necessary) should be undertaken;
- Regular sweeping and cleaning of tarred/paved road surfaces to prevent the accumulation of dust;
- Immediate clean-up of any spillage of material on the hauling routes;
- Regular inspections should be carried out on the vehicles/trucks (engines, tyres, etc.) and the route to ensure both are in good quality;
- All material transported should be covered, where possible, and not left exposed during transportation;
- Engines of the trucks should not be left running whilst not in use;
- Clean fuels and fuel efficient vehicles/trucks/mobile equipment should be considered for use where possible.

A summary of recommendations made and air quality monitoring requirements is provided in TABLE 6-2.

6.2 Recommendations

TABLE 6-2: SUMMARY OF RECOMMENDATIONS AND MONITORING REQUIREMENTS.

POLLUTANT	ACTIVITIES	MITIGATION MEASURE	MONITORING PROGRAM			
			MONITORING	TIMEFRAME		
				Pre - operation	During - operation	Post – operation
Fugitive Dust – TSP, PM10 & PM2.5	Material handling operations, screening, material transfer, drilling, bulldozing, blasting, excavation, Storage of material	I. A fugitive dust management plan will need to be developed prior to the commencement of any onsite activities. II. Dust control measures need to be assessed in detail and incorporated into the design. III. The plan must include appropriate mitigation measures as described in Table 6-1 for all dust emission sources. IV. The plan should be implemented once operations commence. V. Designated areas for the storage of overburden should be considered and incorporated into the design.	Monthly dust fallout monitoring as per the National Dust Control Regulations (2013) and reporting. Monthly PM10 and PM2.5 ambient monitoring and reporting. This is also recommended to obtain baseline concentrations.	X	X	X (until fully rehabilitated)

Fugitive Dust – TSP, PM10 & PM2.5	Vehicle dust entrainment	I. All main hauling roads should be treated for dust suppression to maintain at least 65% emission reduction efficiency. II. Regular cleaning and maintenance of hauling routes. III. Immediate clean-up of any spillage. IV. All material that is being transported should be covered during transport (where possible). V. Control the number of trucks on the road, weight of trucks and the travelling speed. VI. Conduct regular maintenance and checks for haul road surfaces. VII. Implement strict vehicle speed limits. VIII. Conduct regular maintenance and quality checks (engines/tires) for all heavy mobile equipment/trucks. IX. Consider use of cleaner fuel types and fuel efficient vehicles/mobile equipment/trucks. Should be implemented upon commencement of activities on site.		X	X	X (until fully rehabilitated)

6.3 PM10, PM2.5 and Dust Fallout Monitoring

Ambient air quality monitoring of PM10 and PM2.5 and dust fallout monitoring is recommended for the proposed mine. It is recommended that monitoring commences before any onsite activities start, including construction activities, in order to obtain at least 12 months of baseline data for the study area. The below recommendations are made for a dust fallout and PM10 and PM2.5 monitoring program for the proposed Spitsvale Mine.

Dust Fallout Monitoring

It is recommended that dust fallout monitoring is conducted at eight potential monitoring sites with the use of the single dust bucket units, each with a windshield (FIGURE 6-1). It is recommended that dust fallout monitoring is conducted in accordance with the ASTMD1739-98 (reapproved 2010) standard as the ASTMD1739-70 standard can no longer be obtained. The potential dust fallout monitoring sites are given in FIGURE 6-3. Please note that the general area is provided not the exact locality. The recommended sites may change depending on accessibility, security, practicality, etc. These potential sites were chosen based on the proposed locality of emission sources and activities, existing sensitive receptors, terrain, prevailing wind directions and the output of the modelling assessment. Dust fallout monitoring should be conducted and reported on a monthly basis.

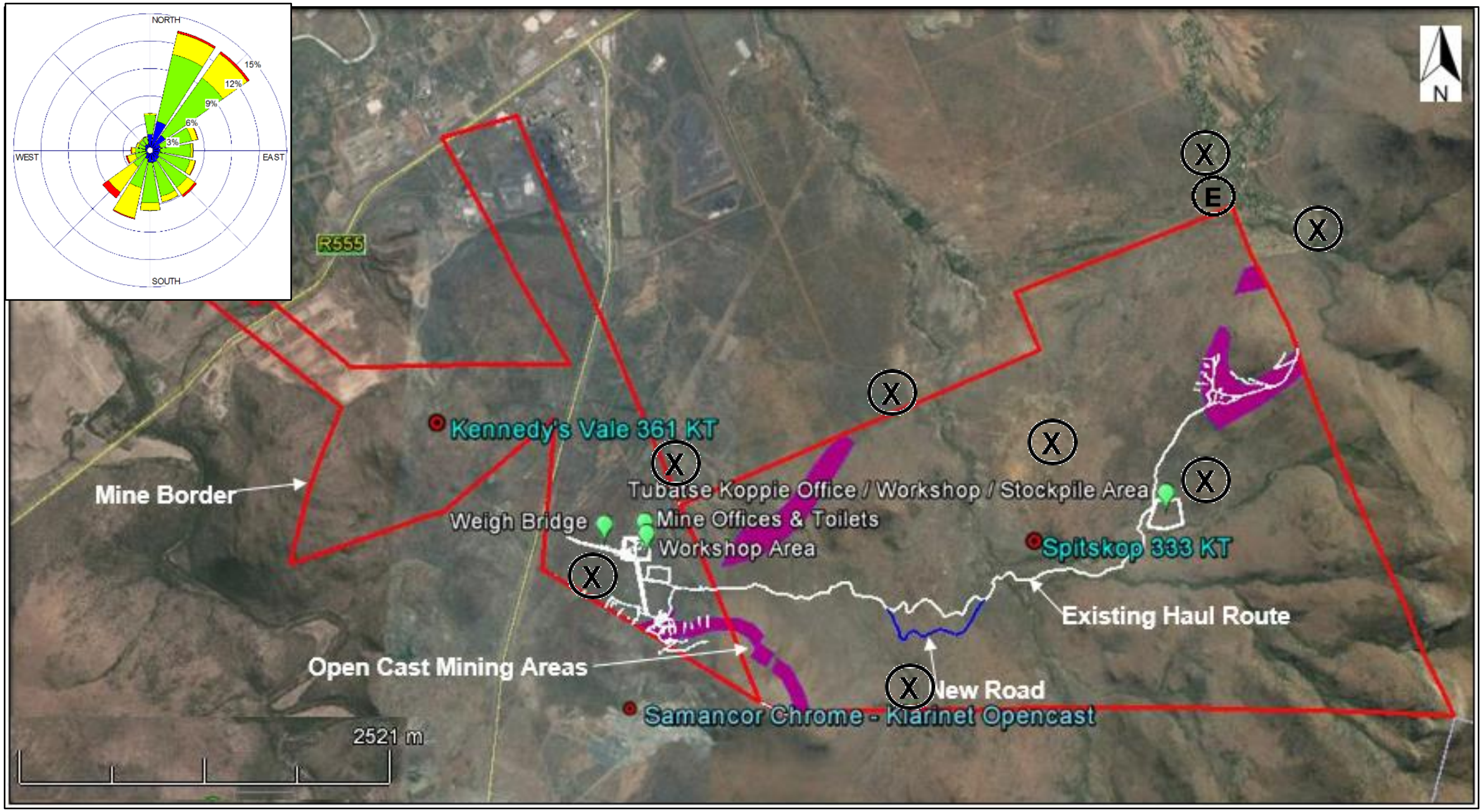
FIGURE 6-1: EXAMPLE OF A SINGLE DUST FALLOUT BUCKET UNIT WITH A WINDSHIELD.

PM10 and PM2.5 Monitoring

It is recommended that PM10 and PM2.5 ambient air quality monitoring is conducted at the proposed Spitsvale mine with the use of two E-Sampler units. The E-Sampler is not capable of measuring PM10 and PM2.5 simultaneously thus two E-Sampler units would need to be purchased. The E-Sampler is recommended as it does not require an enclosed, air conditioned shelter unit and is considered an outdoor instrument. The recommended potential locality of the PM10 and PM2.5 monitoring station at Spitsvale mine is shown in FIGURE 6-3. The monitoring station is generally positioned along the border of the mine and near a sensitive receptor. Therefore it is recommended that the station be located at the north-east corner of Spitsvale Mine by the Steelpoort residential area. Steelpoort is located in close proximity (along) the mine border. The prevailing wind direction in the day time (00: -12:00) is also observed from the south-western sectors. Therefore Steelpoort can be considered a sensitive receptor as it is located downwind from daytime emissions and is positioned along the mine border. Alternatively, the station could be located at the existing village which is located within the mine boundary.

Below is an example of a PM10 and PM2.5 monitoring station at an existing mine. This type of station is recommended for remote locations where access to electricity can be problematic. The Cage unit is used to prevent vandalism and theft. The unit is also connected to an alarm system and sends a message and email to the relevant person notifying them of any attempt of theft. The unit also does not require any supply of electricity as it uses solar power. The solar panels are built into the cage unit to prevent theft. The E-Samplers can also be linked to an online remote data management system that allows continuous access to real time online data thus there is no need for manual downloading.

FIGURE 6-2: EXAMPLE OF PM10/PM2.5 MONITORING STATION SUITABLE FOR REMOTE LOCATIONS.



X = *potential dust fallout monitoring sites*

E = *potential E-Sampler monitoring station*

FIGURE 6-3: RECOMMENDED POTENTIAL MONITORING LOCATIONS.

6.4 Summary and Conclusions

Rayten Engineering Solutions was appointed by EMA to conduct an Air Quality Impact Assessment for the Spitsvale Chrome Mine, Kennedys Vale and Spitskop proposed operations. The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the proposed Spitsvale mine on ambient air quality.

As part of the Air Quality Impact Assessment, a Baseline Air Quality Assessment was undertaken to determine the prevailing meteorological conditions at the site, establish baseline concentrations of key air pollutants of concern, identify existing sources of emissions and identify key sensitive receptors surrounding the project site. Use was made of modelled MM5 meteorological data for the period 2012 – 2014. Baseline concentrations for dust fallout were analysed with the use of dust fallout monitoring data provided by the client for the period July – September 2015. A comprehensive air quality monitoring dataset was not available. It is recommended that baseline monitoring of dust fallout, PM10 and PM2.5 is conducted at the site for a period of at least 12 months.

The Air Quality Impact Assessment consisted of an emissions inventory and subsequent dispersion modelling simulations to determine TSP (as dust fallout), PM10 and PM2.5 concentrations associated with the construction and operational phases of the proposed Spitsvale mine. Comparison of the modelled concentrations was made with the South African Ambient Air Quality Standards and the South African National Dust Control Regulations in order to determine compliance.

The main conclusions based on the information obtained during the Baseline Assessment can be summarised as follows:

- Based on the prevailing wind fields for the period January 2012 to December 2014, emissions from proposed operations at Spitsvale mine will likely be transported towards the south-west and north-east. During the day time emissions are likely to be transported in a north-easterly and northerly direction. In the night time emissions are likely to be transported in a south-westerly direction. Moderate to fast wind speeds observed during all time periods may result in effective dispersion and dilution of emissions from Spitsvale mine.
- A comprehensive air quality monitoring dataset for PM10 and PM2.5 concentrations was not available and could not be presented for the study area. Dust fallout concentrations at the proposed mine for the period July to September 2015 were relatively low and did not exceed the residential dust fallout standard of 600 mg/m^2/day and ranged from approximately 57 – 569 mg/m^2/day. However, a more comprehensive dust fallout monitoring dataset is required to assess the baseline dust fallout rates for the study area.

- Existing sources of emissions surrounding the proposed Spitsvale Mine are mainly associated with exiting mining operations, vehicle dust entrainment on unpaved roads, wind erosion from exposed areas and potentially domestic fuel burning in surrounding residential areas.
- There are residential areas located within close proximity (<10 km) and along the proposed mine's boundary line. These include Steelpoort, Ga-Mampuru, Ga-Manapane and Ga-Matate. There are also a couple of small dwellings and communities located within the mine's boundary line near the centre of the haul route.

The main conclusions of the Impact Assessment for the mine can be summarised as follows for the construction and operational phases:

- Based on the dispersion modelling plots for the construction phase the following conclusions can be made:
    - Predicted incremental dust fallout rates beyond the mine boundary are in compliance with the allowable dust fallout limit of 1200 mg/m^2/day for non-residential and 600 mg/m^2/day for residential areas.

- Based on the dispersion modelling plots for the operational phase the following conclusions can be made:
    - Predicted incremental dust fallout rates beyond the mine boundary are in compliance with the allowable dust fallout limit of 1200 mg/m^2/day for non-residential and 600 mg/m^2/day for residential areas.
    - Predicted incremental PM10 concentrations beyond the mine boundary are in compliance with the daily average standard of 75 µg/m^3 and the annual average standard of 40 µg/m^3.
    - Predicted incremental PM2.5 concentrations outside the mine's boundary are in compliance the daily average standard of 40 µg/m^3 and the annual average standard of 20 µg/m^3.
- Although the predicted concentrations due to proposed operations are expected to be low beyond the mine boundary, it should be noted that exceedances of the dust fallout, PM10 and PM2.5 standards were observed inside the mine boundary along the main haul route and near the mining areas. There are some small communities and dwellings that reside within the mine's boundary and near to the haul route. There are also communities that are located near to the mine boundary. Steelpoort for instance is located in close proximity to the Tubutse mining area (north-east of Spitkop farm). Therefore, it is recommended that a detailed dust management plan is developed and incorporated during the design stages of the mine. The plan should focus on sources of dust located in close proximity to the residential receptors located within and along the mine boundary.
- Furthermore, the possibility of looking at an alternative site for the Tubutse operations should be investigated. There are residential receptors that are located along the north-eastern boundary of

the mine and in close proximity (< 500m) to the Tubutse mining area that may be effected by dust emissions during the day.

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APPENDIX A –

SPECIALIST DETAILS & CVs

NAME	ROLES AND RESPONSIBILITIES
Claire Wray *Managing Director* *(Member)*	Manage and co-ordinate all projects within Rayten
Clive Wray *Engineering Manager* *(Member)*	Manage and co-ordinated all engineering related projects within Rayten Lead project manager and engineer for abatement equipment, stack emissions monitoring, Air Quality Impact Assessments and ambient air quality monitoring stations
Sophia Valsamakis *Environmental Scientist*	Air quality monitoring and reporting, co-ordination of air quality impact assessments and monitoring projects, AEL's, GHG inventory and reporting.

Please see separate attached pdf documents for CVs.

APPENDIX B –

COMPANY PROFILE

Rayten
ENGINEERING SOLUTIONS
Environmental and Engineering Consultants

Rayten Engineering Solutions – Professional Environmental and Engineering Consulting Services.

Rayten was established as an independent consultancy in 2009 providing expertise in all aspects of air quality to a wide range of mines, industries, government departments and environmental consultancies. Rayten key personnel are registered Engineers and Scientists with a combined working experience of over 60 years. At Rayten we are committed to providing turn-key solutions to meet the requirements of air quality legislation.

Rayten Engineering has also expanded into a leading design, project management, procurement and construction company; servicing industries with engineering solutions in the mechanical, plate-work, structural and piping fields. We adopt a practical approach to problem solving. Rayten Engineering utilises a small multi-disciplined crew covering new installations and upgrades/retrofits to existing operations.

Our key environmental services are summarised below.

AIR QUALITY MONITORING AND MANAGEMENT

- Air quality consulting and advice
- Air Quality Impact Assessments
- Air Quality Management Plans
- Dispersion modelling
- Ambient air quality monitoring
- Emission monitoring
  - Isokinetic monitoring
  - Gaseous monitoring
- Passive monitoring
- Dust fallout monitoring
- Meteorological monitoring
- Remote data acquisition and online display of monitored data
- Emissions inventories
- Greenhouse gas inventories
- Atmospheric Emission License applications (AEL)
- Emission Impact Reports
- Installation and commissioning of extraction systems in order to carry out emission monitoring
- Procurement, installation and commissioning of abatement equipment

ENVIRONMENTAL IMPACT ASSESSMENTS

- Environmental Impact Assessments and Scoping Reports
- Basic Assessment Reports
- Environmentally Related Permit Applications
- Environmental Appeals and Objections
- Water Use Licence Applications
- Waste Licence Applications

HEALTH SURVEYS

- Indoor air quality assessments
- Noise assessments

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APPENDIX C –

CHECKLIST

(Please refer to separate attached document)