BAUBA A HLABIRWA MOEIJELYK PROJECT - BAUBA A HLABIRWA MINING INVESTMENTS (PTY) LTD

BASELINE AIR QUALITY ASSESSMENT

PROPERTY MOEIJELYK 412KS, LIMPOPO PROVINCE

REPORT

ENVIRONMENTAL & PROJECT MANAGEMENT PROFESSIONALS

2015

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ENVIRONMENTAL & PROJECT MANAGEMENT PROFESSIONALS

DISCLAIMER

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DEFINITION OF TERMS

Assessment	A systematic, independent and documented review of operations and practises to ensure that relevant requirements are met. Qualified professionals with relevant auditing experience should conduct audits and, where possible, independent external auditors should also be used.
Construction	The time period that corresponds to any event, process, or activity that occurs during the Construction phase (e.g., building of site, buildings, and processing units) of the proposed project. This phase terminates when the project goes into full operation or use.
Director-General	means the Director-General of the Department;
Environmental Component	An attribute or constituent of the environment (i.e., air quality; marine water; waste management; geology, seismicity, soil, and groundwater; marine ecology; terrestrial ecology, noise, traffic, socio-economic) that may be impacted by the proposed project.
Environmental Impact	A positive or negative condition that occurs to an environmental component as a result of the activity of a project or facility. This impact can be directly or indirectly caused by the project's different phases (i.e., Construction, Operation, and Decommissioning).
Operation	The time period that corresponds to any event, process, or activity that occurs during the Operation (i.e., fully functioning) phase of the proposed project or development. (The Operation phase follows the Construction phase, and then terminates when the project or development goes into the Decommissioning phase.)
Record of Decision	Is an environmental authorisation issued by a state department.
Responsible authority	in relation to a specific power or duty in respect of water uses, means - (a) if that power or duty has been assigned by the Minister to a catchment management agency, that catchment management agency; or (b) if that power or duty has not been so assigned, the Minister;

ABBREVIATIONS

CA:	Competent Authority
CARA :	Conservation of Agricultural Resources Act, 43 of 1983
DEA :	Department of Environmental Affairs (The former Department of Environmental Affairs and Tourism)
DMR :	The Department of Mineral Resources (The former Department of Minerals and Energy)
DWA :	Department of Water Affairs (Is now referred to the Department of Water and Sanitation – DWS)
EIA :	Environmental Impact Assessment
EMP :	Environmental Management Plan
EMPr :	Environmental Management Programme
EMS:	Environmental Management System
I&AP's:	Interested and Affected Parties
ISO:	International Standards Organisation
IWUL:	Integrated Water Use License
IWWMP:	Integrated Water and Water Management Plan
MPRDA :	Mineral and Petroleum Resources Development Act, 28 of 2002
NAAQS:	National Ambient Air Quality Standards
NEMA :	National Environmental Management Act, 107 of 1998
NEMAQA :	National Environmental Management: Air Quality Act, 39 of 2004
NEMBA :	National Environmental Management: Biodiversity Act, 10 of 2004
NEMWA :	National Environmental Management: Waste Act, 59 of 2008
NHRA :	National Heritage Resources Act, 25 of 1999
NWA :	National Water Act, 36 of 1998
PM2.5:	Fine Particulate Matter
ppm:	parts per million
ROD:	Record of Decision
SLP :	Social and Labour Plan
WSA :	Water Services Act, 108 of 1997
WUL :	Water Use Licence

CHAPTER 1: PROJECT INFORMATION

Key Project Information	
Project Title:	Bauba A Hlabirwa Moeijelyk Project
Farm Description:	Farm Moeijelyk 412KS, Limpopo Province
Mining Right Reference:	LP 30/5/1/2/2/10096 MR
District Municipality:	Greater Sekhukhune District Municipality
Local Authority:	Fetakgomo Local Municipality
Nearest Town:	Ga-nkoana (25km)
Site Midpoint Coordinates:	South: 24° 17' 00" East 29° 58' 37"

Project applicant:	Bauba A Hlabirwa Mining Investments (Pty) Ltd		
Trading name (if any):	Bauba A Hlabirwa Mining		
Industry:	Chrome mining		
Contact person:	Nicole Upton		
Physical address:	Farm Moeijelyk 412KS, Limpopo Province		
Postal address:	PO Box: 1658, Witkoppen,2068		
Postal code:	2068	**Cell:**	082 059 3714
Telephone:	011 699-5720	**Fax:**	011 462-6184
E-mail:	nicole@menco.co.za		
EAP:	Henno Engelbrecht for Eco Elementum (Pty) Ltd		
Contact person:	Vernon Siemelink (Project Manager)		
Postal address:	26 Greenwood Crescent, Lynnwood Ridge, Pretoria		
Postal code:	0040	**Cell:**	072 196 9928
Telephone:	012 348 5214	**Fax:**	086 714 5399
E-mail:	vernon@ecoelementum.co.za / info@ecoelementum.co.za		
Qualifications & relevant experience	Master's Degree specializing in Environmental Management 10 Years' experience in Environmental Consultancy		
Professional affiliation(s) (if any)	International Association for Impact Assessment South African Affiliation		
Contact person:	Vernon Siemelink and Henno Engelbrecht		
Assessment:	Baseline Air Quality Assessment		
Mining Activities:	Mining, blasting, crushing, screening, loading, transporting.		
Products:	Chrome		

CHAPTER 2: INTRODUCTION

Eco Elementum (Pty) Ltd has been appointed by M2 Environmental Connections on behalf of the applicant Bauba A Hlabirwa Mining investments (Pty) Ltd to undertake the Baseline Air Quality Assessment for the necessary authorisation applications and gather all the necessary information needed for the proposed mining operations on the farm Moeijelyk 412 KS. The mining right area is situated on the farm Moeijelyk 412 KS in the Magisterial District of Greater Sekhukhune District Municipality. The mining right area subjected to this Baseline Air Quality Assessment is also situated on the farm Moeijelyk 412 KS. It is approximately 85km directly south east from central Polokwane, 56km South-south- east of Tzaneen, 42km south of Misty Crown (and Haernertsburg), 25km east north east of Ga-nkoana and 50km North-north-west of Steelpoort (and Burgersfort). It is adjacent to the local towns / settlements of Jibeng.

World resources are estimated to be greater than 12 billion tons of shipping-grade chromite, sufficient to meet demand for centuries. In the region of 95% of the world's chromium resources are concentrated in Southern Africa and Kazakhstan. South Africa is the world's largest producer of ferrochrome. The country holds about 70% of the world's total chrome reserves, mostly located in the Bushveld Igneous Complex (BIC) ores, and produces 75% of the world's ferrochrome. India and Kazakhstan are other major producers. Chromite is mined primarily from the UG2, and LG and MG chromitite seams of which the UG2 also contains significant amounts of PGE's. Thus several platinum mines produce chromite as a by-product. There are several primary chrome mines, specifically maintained to provide chromite feed to the developing ferrochrome industry. Most of South Africa's chrome mines are developed along the Eastern BIC, in the Steelpoort Valley. South Africa produced an estimated 9,600,000 t of chromium ore in 2009.

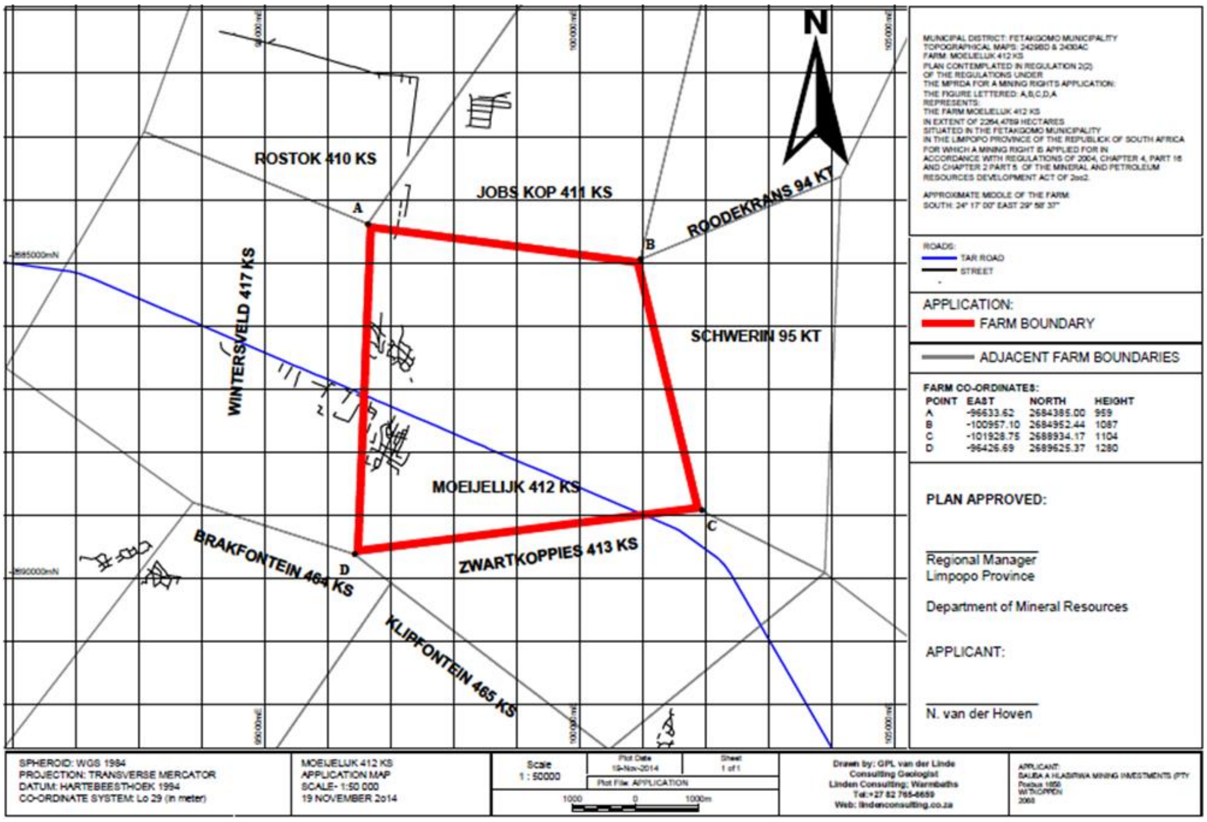

Figure 1: Location of the Moeijelyk 412 KS proposed project property

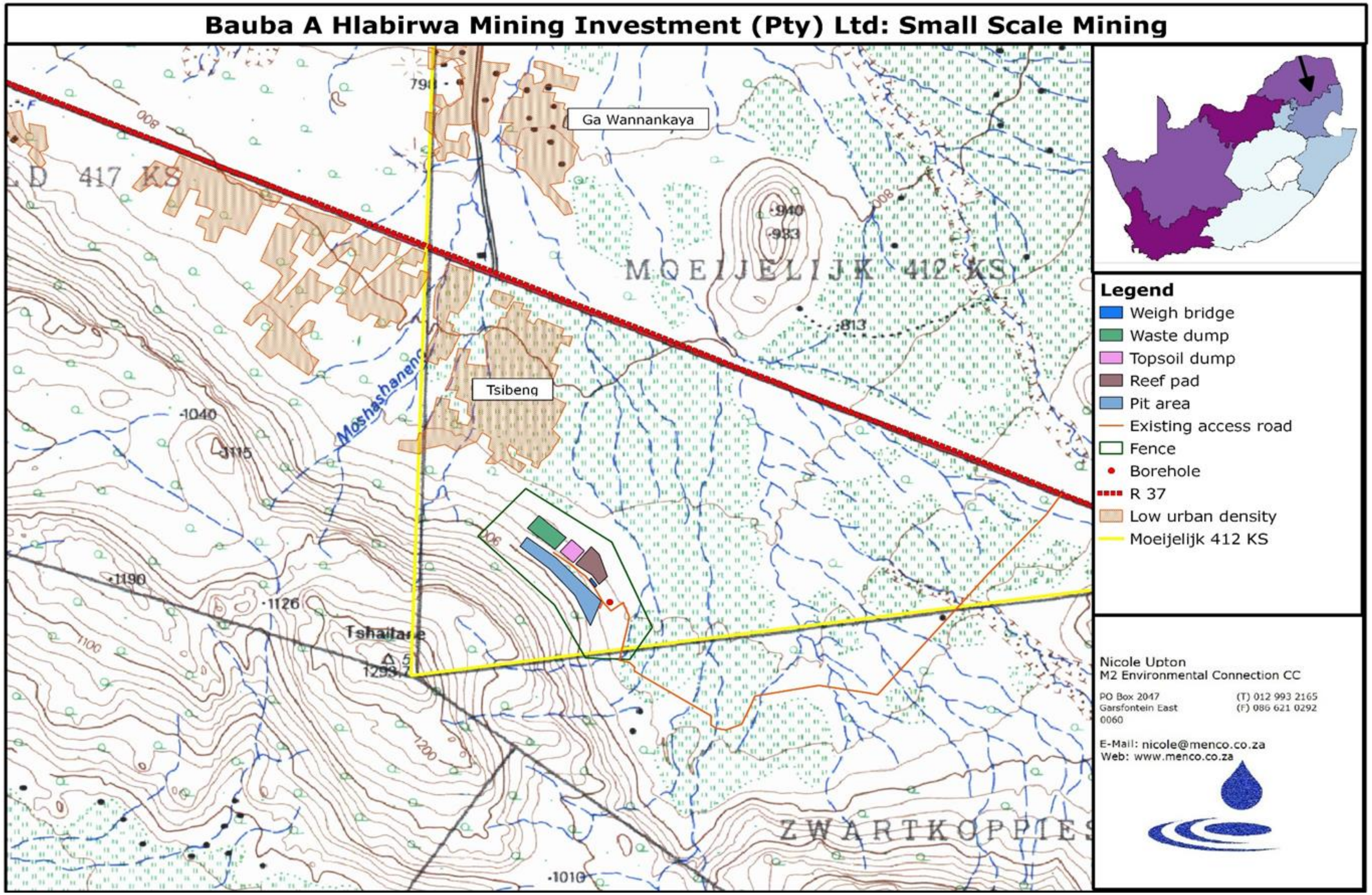

Figure 2: Map indicating the location of the proposed mining development site

CHAPTER 3: SCOPE OF WORK

BASELINE AIR QUALITY STUDY

A baseline air quality study has been conducted by Eco Elementum (Pty) Ltd as part of the Moeijelyk 412 KS environmental authorisations project.

The purpose of this baseline study is to:

- Study the available information relevant to the pre and post-development ambient air quality pollution concentrations in the environment;
- Identify the major existing air emission sources in the environment;
- Identify the existing sensitive air pollution areas in the environment;
- Estimate by means of measurements and integration of the results with those of any relevant existing information the present ambient air quality climate; and
- Identify the processes and equipment that will cause the major contribution to the future air quality impact.

From the historical mining evident on site, it is not clear whether a baseline air quality study for the area has ever been conducted, and therefore new measurements had to be taken in field to gather data for analysis.

CHAPTER 4: STUDY AREA

4.1 LOCATION

The study area is located in the Limpopo Province and lies between Polokwane and Steelpoort within the Sekhukhune District Municipality and Fetakgomo Local Municipality. Polokwane is located roughly 85km northwest of the study area and Burgersfort and Steelpoort 50km to the south-southeast. Tzaneen lies about 56km to the north-northeast. In terms of vegetation the study area falls within the Savannah Biome, which covers approximately 32.8% of South Africa (Mucina & Rutherfords 2006). The northern section and majority of the study area falls within the Sekhukhune Plains Vegetation type. This type of vegetation generally occurs between altitudes of 700 and 1100 metres above sea level and stretch from the lowlands surrounding Burgersfort and Steelpoort towards Legwareng. It also continues up the Olifants River basin to Tswaing. The Sekhukhune Plains Vegetation type is considered vulnerable and sections are threatened by Chrome and Platinum mining activities, as well as urbanisation. Erosion is high within this vegetation type and donga's often occur (Mucina & Rutherfords 2006).

A small section along the southern boundary of the study area falls within the Sekhukhune Mountain Bushveld vegetation type. This type of vegetation is associated with mountains and undulating hills above the Sekhukhune Plains Vegetation type, as well as steeper slopes of certain mountains in the area. The altitude at which this vegetation type occurs is between 900 and 1600 metres above sea level. Sekhukhune Mountain Bushveld is considered to be least threatened, although roughly 15% consists of transformed cultivation and urban built-up. Mining activities also play an increasing role in the transformation of this vegetation type. Erosion range between moderate to high levels and donga's occur in some places (Mucina &

Rutherfords 2006). Previous classifications (Acocks 1953) identified this vegetation type as Mixed Bushveld and Sourish Mixed Bushveld along the upper slopes.

Soils in the study area vary between shallow and very shallow course sandy lithosoils. The associated soil types are: Ae 229 and Ae 225.

The study area falls within the summer rainfall region while the rainy season generally stretches from October to April. Annual rainfall is about 559 mm generally in the form of thundershowers from the southwest, but light precipitation is often blown in from the east. No frost occur in the area. The annual average temperatures may vary between a maximum of 27.1 ºC and a minimum of 12.2 ºC. The study area is also part of a mountain range with an associated northeast breeze. This effect limits extreme temperatures.

In terms of topography the general study area falls on the base of a curvilinear chain of mountains of which the elevation ranges between 820m in the valley bottoms and 1399.5 metres above sea level on summits. The elevation of the project area is roughly 860 metres above sea level.

The study area falls within the Quarternary catchment B71B. The closest perennial river to the study area is the Olifants River which flows roughly 8.5km to the north. It should be noted that several non-perennial streams exist in the vicinity of the study area.

The residents of Tsibeng currently utilise the study area as grazing fields for their cattle. The area demarcated for development, however, is still in the process of being fenced-off. The area to the north of the study area is also used for cattle grazing, while the area to the southeast is occupied by another mine.

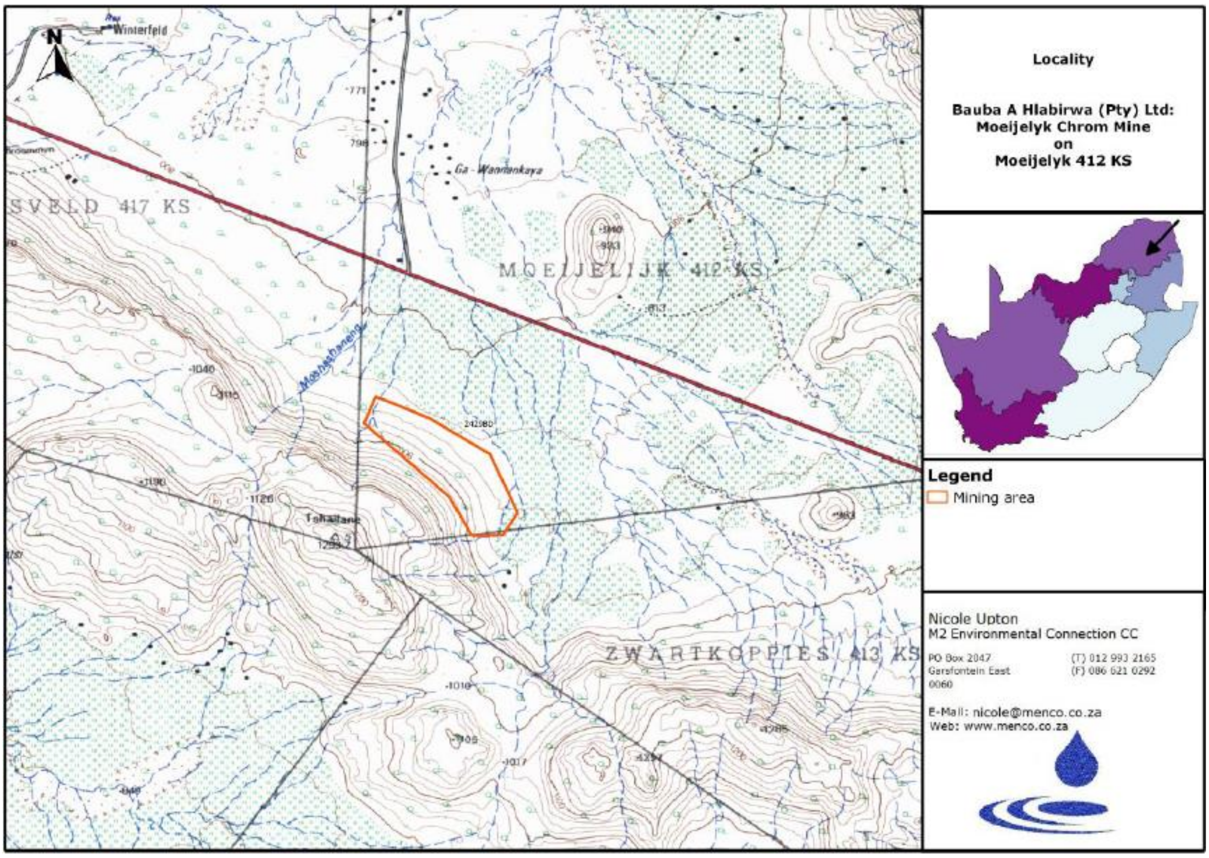

Figure 3: Map indicating the proposed mine's province and location

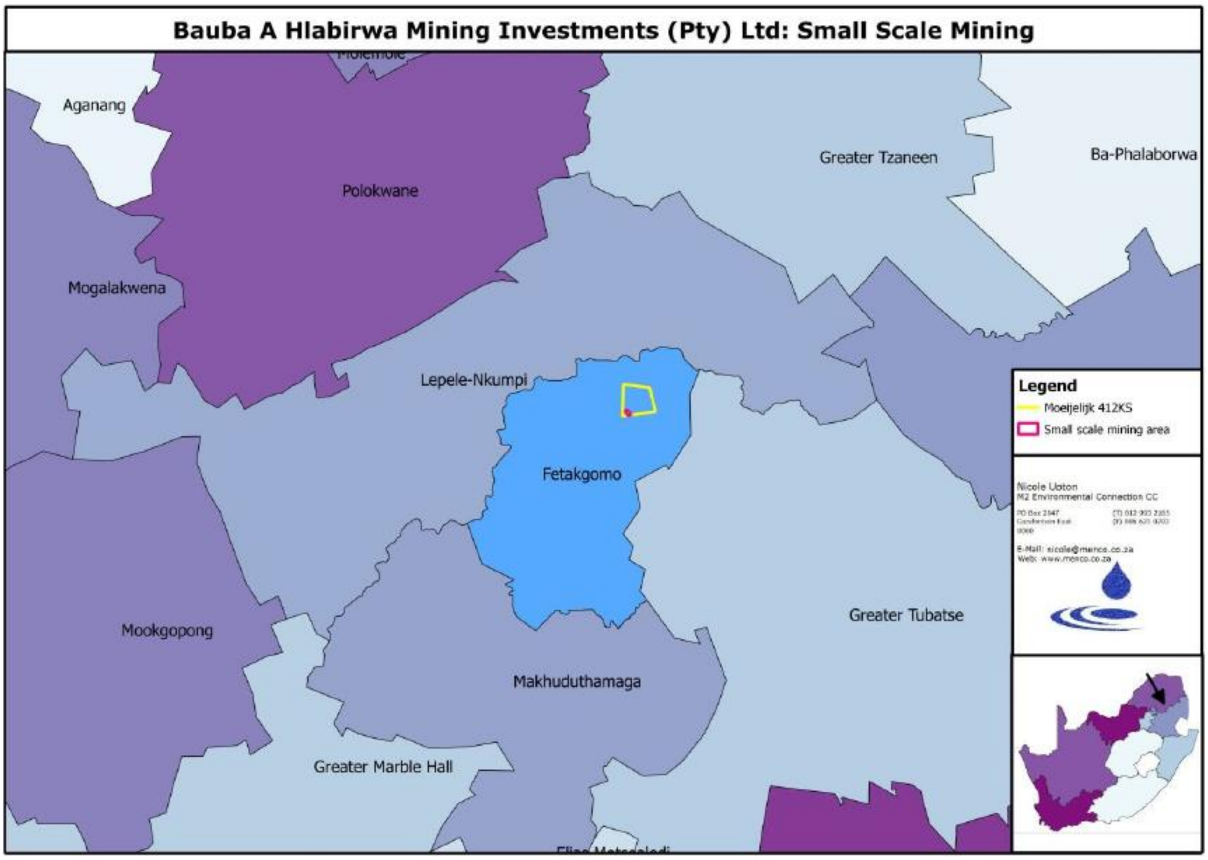

Figure 4: Map indicating the municipal areas related to the study area

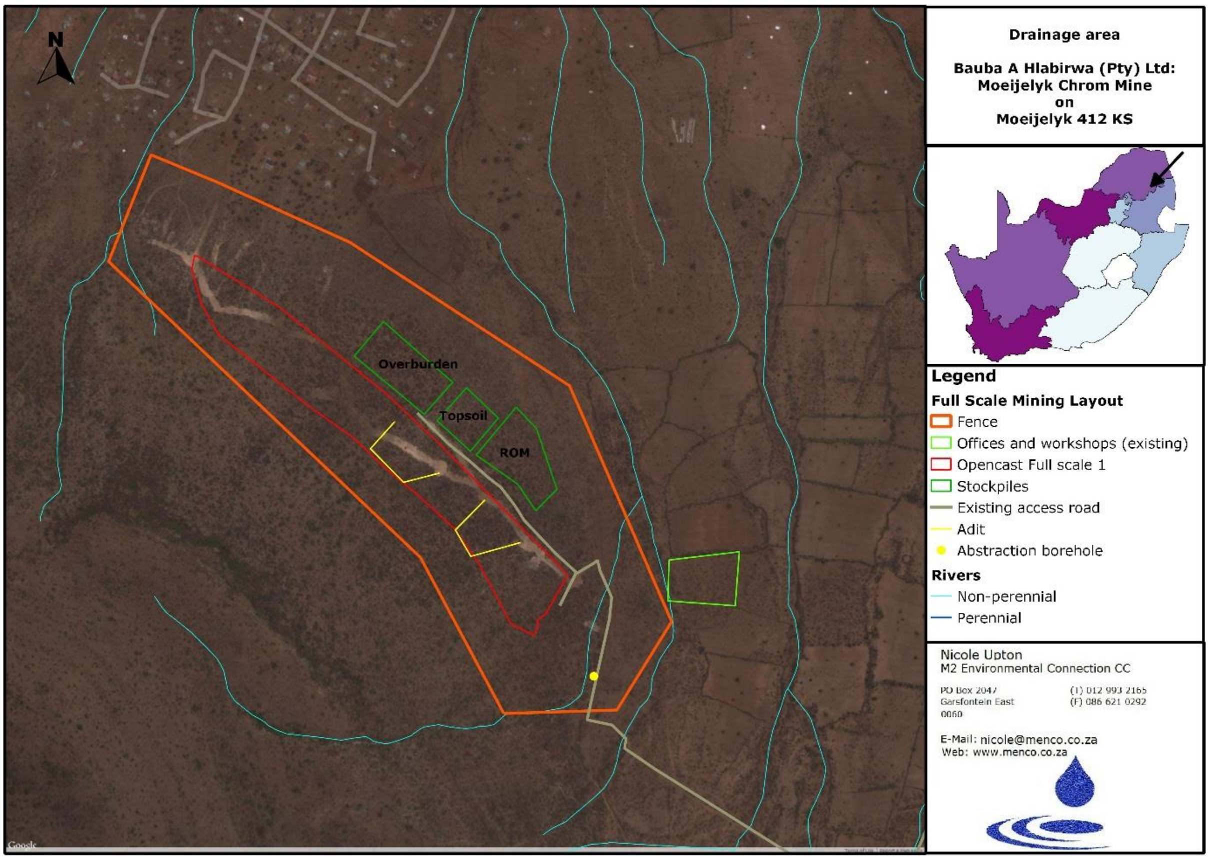

Figure 5: Spatial mining layout and main drainage lines

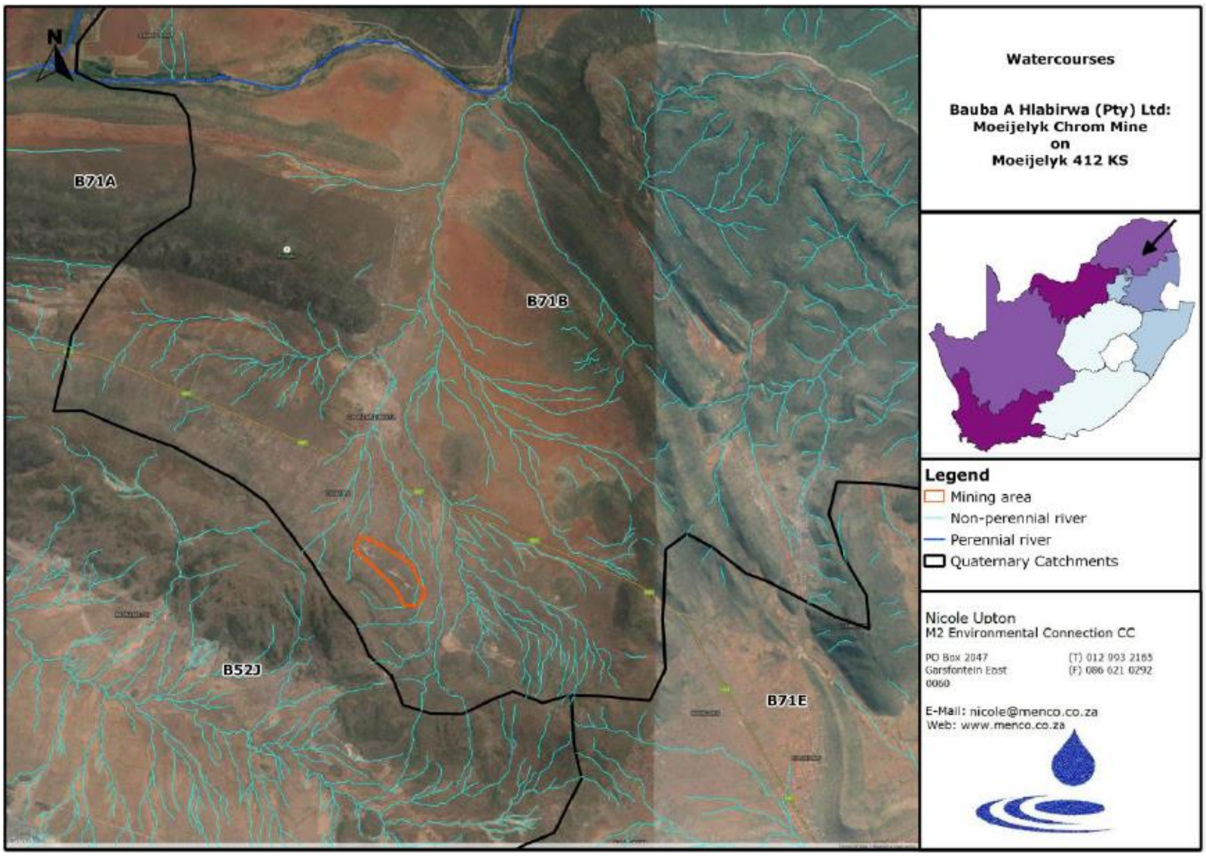

Figure 6: Topographical layout of study area indicating watercourses and catchments

4.2 METEOROLOGICAL DATA

4.2.1 REGIONAL AIR QUALITY

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

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

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

4.2.2 CLIMATE AND METEOROLOGICAL OVERVIEW

Ambient air quality in this region of South Africa is strongly influenced by regional atmospheric movements, together with local climatic and meteorological conditions. The most important of these atmospheric movement routes are the direct transport towards the Indian Ocean and the recirculation over the sub-continents.

The country experiences distinct weather patterns in summer and winter that affect the dispersal of pollutants in the atmosphere. In summer, unstable atmospheric conditions result in mixing of the atmosphere and rapid dispersion of pollutants. Summer rainfall also aids in removing pollutants through wet deposition. In contrast, winter is characterised by atmospheric stability caused by a persistent high pressure system over South Africa. This dominant high pressure system results in subsidence, causing clear skies and a pronounced temperature inversion over the northern part of South Africa. This inversion layer traps the pollutants in the lower atmosphere, which results in reduced dispersion and a poorer ambient air quality. Preston-Whyte and Tyson (1988) describe the atmospheric conditions in the winter months as highly unfavourable for the dispersion of atmospheric pollutants. The significant variation in the windfield in the Waterberg area is indicative of strong underlying topographical influence on the prevailing meteorological conditions. The Waterberg mountain range exercises its influence on the local scale, with its peaks and valleys.

The climate is semi-arid, with precipitation occurring as rain. Average annual rainfall is around 300 mm. Over 90% of the annual rainfall occurs between the months of October and March. The highest monthly averages typically occur in November and December, although January also receives precipitation above average. In terms of Koeppen Climate Classification, the area belongs to BSh (Arid Climate, Steppe, hot).

Precipitation reduces erosion potential by increasing the moisture content of materials. This represents an effective mechanism for removal of atmospheric pollutants and is therefore considered during air pollution studies. Rain-days are defined as days experiencing 0.25 mm or more rainfall.

Modelled meteorological data for the period January 2009 to December 2011 was obtained for a point near the proposed Moeijelyk site (24.095986 S, 28.968619 E). Data availability was 100%. The area is approximately 18km directly north of the proposed site.

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

The amount of particulate matter generated by wind is highly dependent upon the wind speed. Below the wind speed threshold for a specific particle type, no particulate matter is liberated, while above the threshold, particulate matter liberation tends to increase with the wind speed. The amount of particulate matter generated by wind is also dependent on the material's surface properties. This includes whether the material is crusted, the amount of non-erodible particles and the particle size distribution of the material.

Wind roses comprise 16 spokes which represent the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The figure given at the bottom of the legend described the frequency with which calms occurred, i.e. periods during which the wind speed was below 0.5 m/s.

The spatial and annual variability in the wind field for the Moeijelyk modelled data is clearly evident in the figure below. The predominant wind direction is from northeast, with the secondary component from the east northeast and east. Contributions from the NW and SE quadrant are observed. Calm conditions (wind speeds < 0.5 m/s) occurred for 4.2 % of the time. Wind class frequency distribution per sector is given in the following figure and table.

The spatial variability in the wind fields for the Moeijelyk modelled data is presented. The predominant wind direction is from the northeast, frequent winds mainly from the NW and SE quadrant. Although wind speeds are generally moderate during the period (average 3.66 m/s), predominant speeds between 3.6-5.4 m/s occurred 42 % of the time. Wind speeds greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s) have the ability to generate fugitive dust from open areas and storage piles. Wind speeds greater than 5.4 m/s in the Moeijelyk area account for 14.4% % during the period.

Diurnal variability in the wind fields for the Moeijelyk modelled data is presented. At night time, wind field conditions from the northeast (25.4% of the time) with secondary contributions from east northeast and east. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 53 % and 18 % of the time. The morning time is dominated by wind fields from the northeast, north northeast and north with secondary components from the east, east southeast directions. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 37 % and 18 % of the time.

In the afternoon, the predominant wind was blowing from the northwest direction (17%), with 13% coming from the north northwest direction. Secondary components were observed from the south east sector. The evening wind field conditions were different from what was observed in the afternoon, with winds from the northeast (18 %) and east northeast (16%) respectively. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 49 % and 13 % of the time.

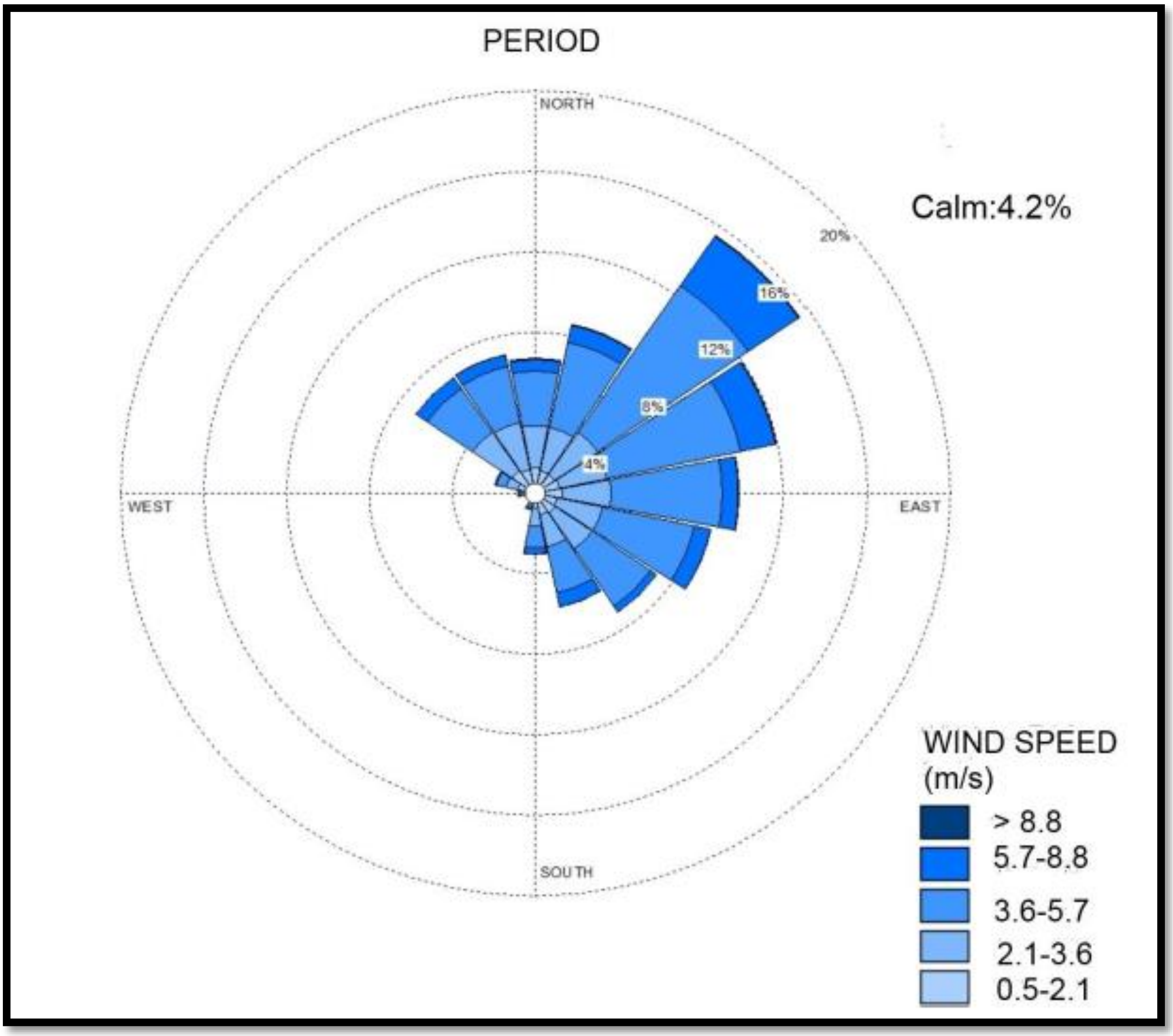

Figure 7: Surface wind rose modelled data (01 January 2009 – 31 December 2011)

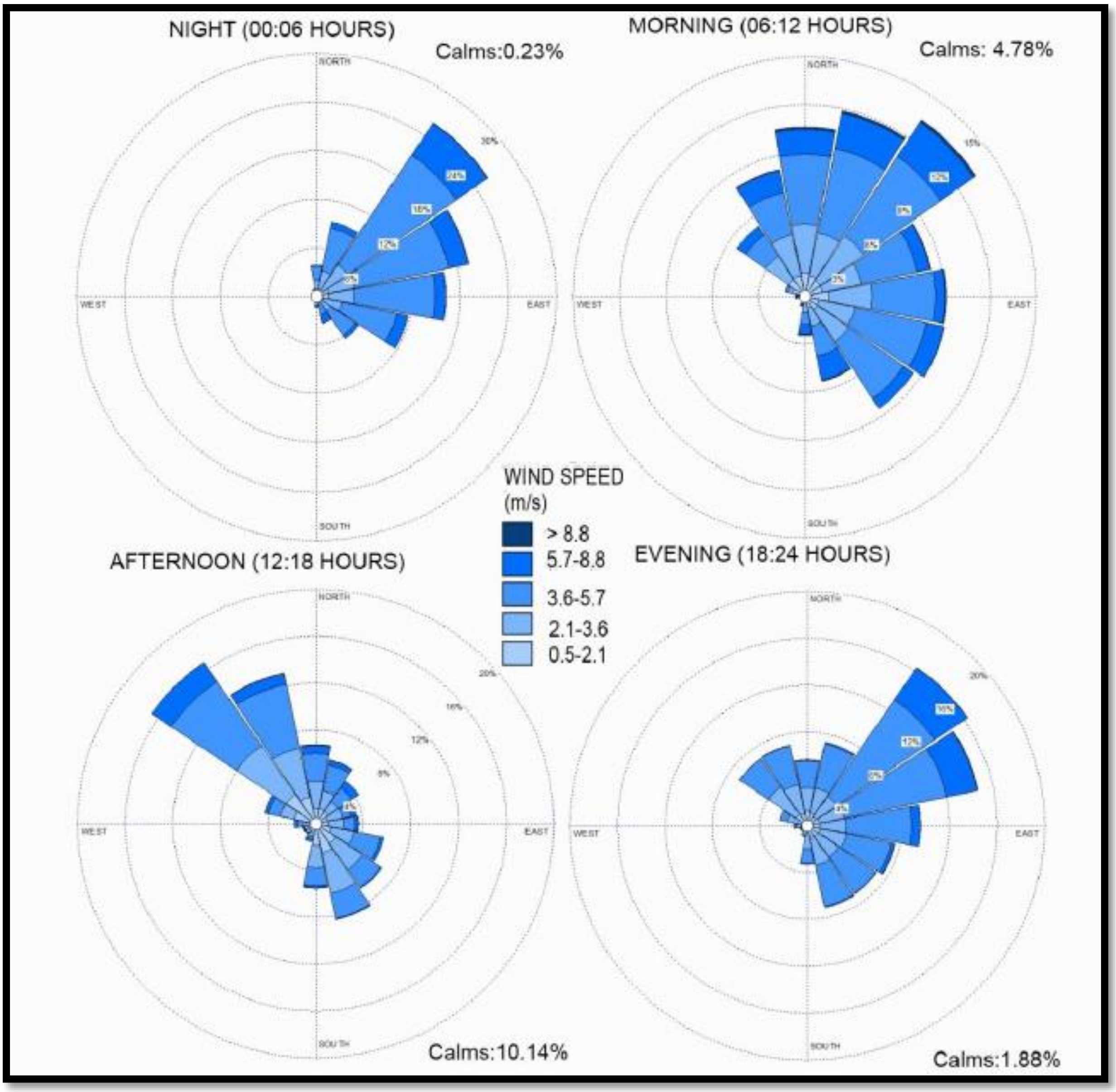

Figure 8: Diurnal variation of winds between Night time 00:00 – 06:00 (Top left), Morning 06:00 – 12:00 (top right), Afternoon 12:00 – 18:00 (Bottom left), Evening 18:00 – 24:00 (bottom right) and (modelled data 01 January 2009 – 31 December 2011)

The seasonal variability observed in wind regime is represented by the plots in Figure 9. In spring the predominant wind speed comes from the NE with secondary components from the NNE and ENE respectively. Less infrequent winds were observed from the N, NNW and NW. The predominant wind direction did not change significantly in summer. However, there were changes in the frequency of winds from the NE which was observed to have decrease and winds from ENE direction increased slightly.

In autumn, strong winds were coming from the E, ENE, NE, ESE in the order of dominance, with secondary components from the SE and NE respectively. In winter the influence from the NE sector diminished with the wind from the E, ESE, SE and SSE dominating.

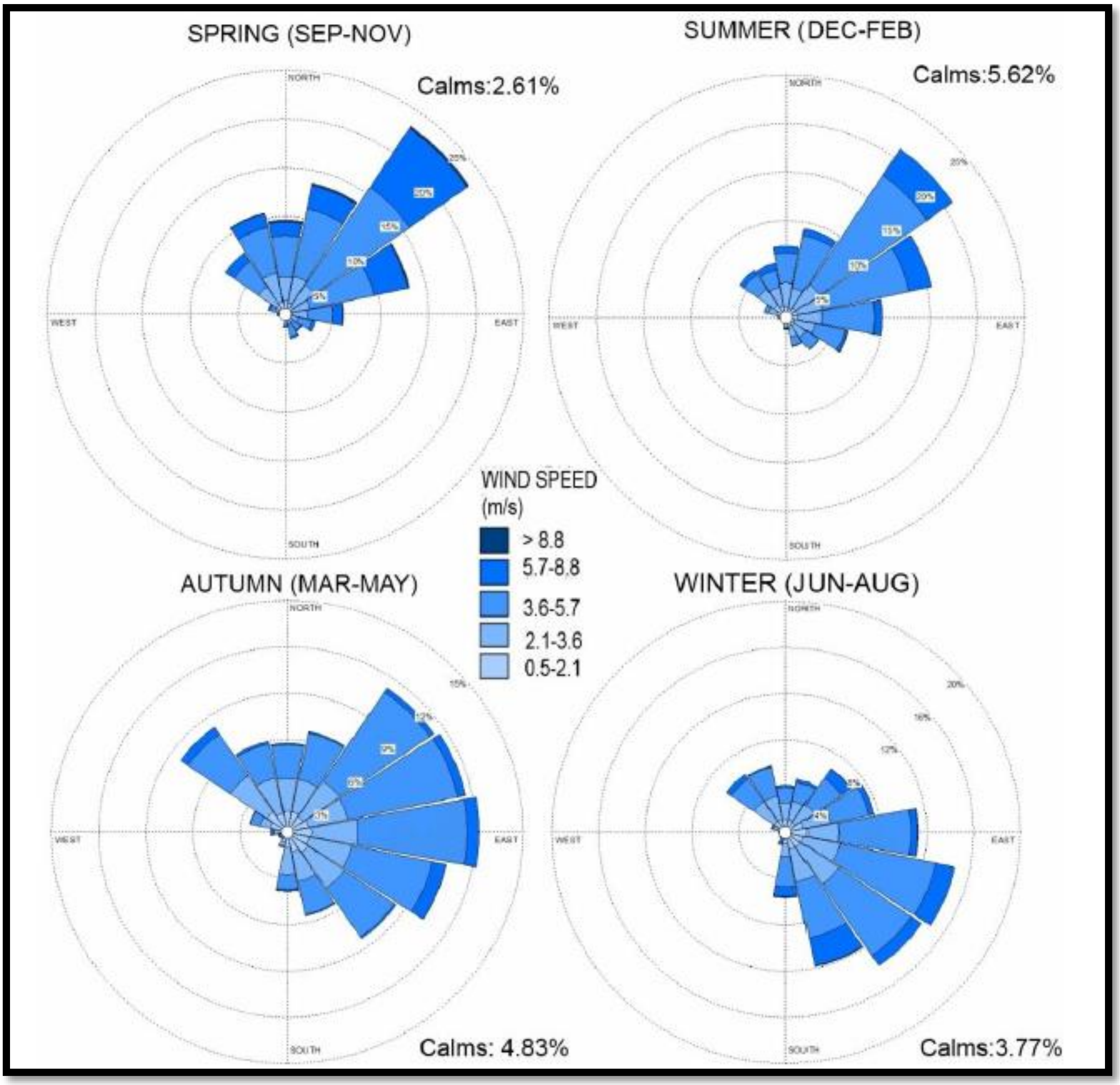

Figure 9: Seasonal variation of winds in spring season (September – November) (top left), summer season (December - February) (top right), autumn season (March – May) (bottom left) and winter season (June – August) (bottom right) (modelled data 01 January 2009 – 31 December 2011)

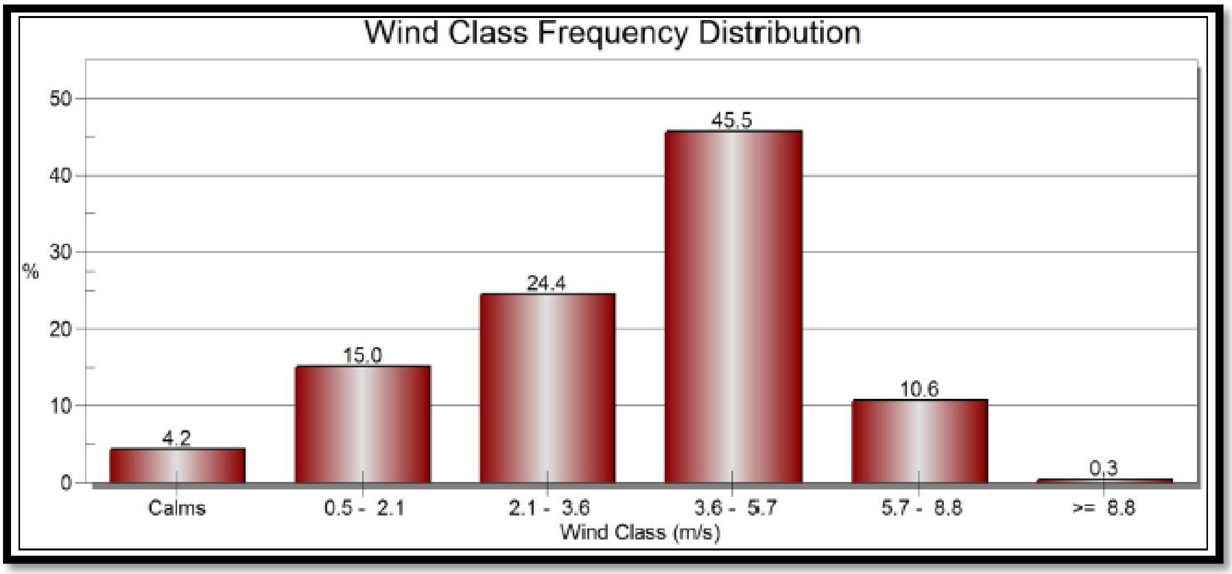

Figure 10: Wind Class Frequency Distribution for Moeijelyk modelled data, 01 January 2009 – 31 December 2011

Table 1: Wind Class Frequency Distribution per Direction for Moeijelyk modelled data, 01 January 2009 – 31 December 2011

	Directions (m/s)	Wind Classes (m/s)					
		0.5 - 2.1	2.1 - 3.6	3.6 - 5.4	5.4 - 8.8	>= 8.8	Total
1.00	N	1.26	2.09	2.58	0.70	0.05	6.69
2.00	NNE	1.16	2.18	3.99	1.18	0.05	8.56
3.00	NE	1.13	2.53	7.72	4.04	0.07	15.48
4.00	ENE	1.23	2.32	5.87	2.46	0.04	11.92
5.00	E	1.34	2.36	4.91	1.21	0.03	9.86
6.00	ESE	1.09	2.23	4.27	1.09	0.02	8.69
7.00	SE	1.17	2.16	3.25	0.56	0.00	7.14
8.00	SSE	1.09	1.62	2.19	0.86	0.02	5.77
9.00	S	0.72	0.92	0.99	0.38	0.03	3.03
10.00	SSW	0.37	0.26	0.14	0.10	0.00	0.86
11.00	SW	0.30	0.13	0.06	0.02	0.00	0.50
12.00	WSW	0.26	0.14	0.05	0.03	0.00	0.49
13.00	W	0.41	0.19	0.14	0.11	0.00	0.84
14.00	WNW	0.88	0.57	0.41	0.13	0.00	1.99
15.00	NW	1.37	2.30	2.46	0.83	0.00	6.96
16.00	NNW	1.23	2.36	2.69	0.72	0.02	7.02
	Sub-Total	14.99	24.36	41.72	14.40	0.32	95.80
	Calms						4.20
	Missing/Incomplete						0.00
	Total						100.00

4.2.3 ATMOSPHERIC STABILITY

The vertical component of dispersion is a function of the extent of thermal turbulence and the depth of the surface mixing layer. Unfortunately, the mixing layer is not easily measured, and must therefore often be estimated using prognostic models that derive the depth from some of the other parameters that are routinely measured, e.g. solar radiation and temperature. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground based inversions and the erosion of the mixing layer. The mixing layer ranges in depth from ground level (i.e. only a stable or neutral layer exists) during night-times to the base of the lowest-level elevated inversion during unstable, day-time conditions. Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in the table below;

Table 2: Atmospheric stability classes

A	very unstable	calm wind, clear skies, hot daytime conditions
B	moderately unstable	clear skies, daytime conditions
C	unstable	moderate wind, slightly overcast daytime conditions
D	neutral	high winds or cloudy days and nights
E	stable	moderate wind, slightly overcast night-time conditions
F	very stable	low winds, clear skies, cold night-time conditions

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

For low level releases, such as due to vehicle entrainment from unpaved roads, the highest ground level concentrations will occur during weak wind speeds and stable (night-time) atmospheric conditions. Wind erosion, on the other hand, requires strong winds together with fairly stable conditions to result in high ground level concentrations i.e. neutral conditions.

4.2.4 REGIONAL TEMPERATURE

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers.

South African Weather Service has an Automatic Weather Station (AWS) within the reasonable distance from the Moeijelyk Project site (Station Code: 06338827 – Mokopane). The data collected at this station were not considered to be fully representative of conditions on site, so the use was made of modelled data and trends were observed analysing the three years available (2009-2011).

Three-year averaged maximum, average and minimum temperatures for Moeijelyk are given in the table below. Annual average temperatures for the area are given as 18.3°C. The average daily maximum temperatures range from 22.9°C in December to 8.1°C in July, with daily minima ranging from 21.5°C in December to 7.1°C in July. Annual average temperature for the region is given as 16.8°C.

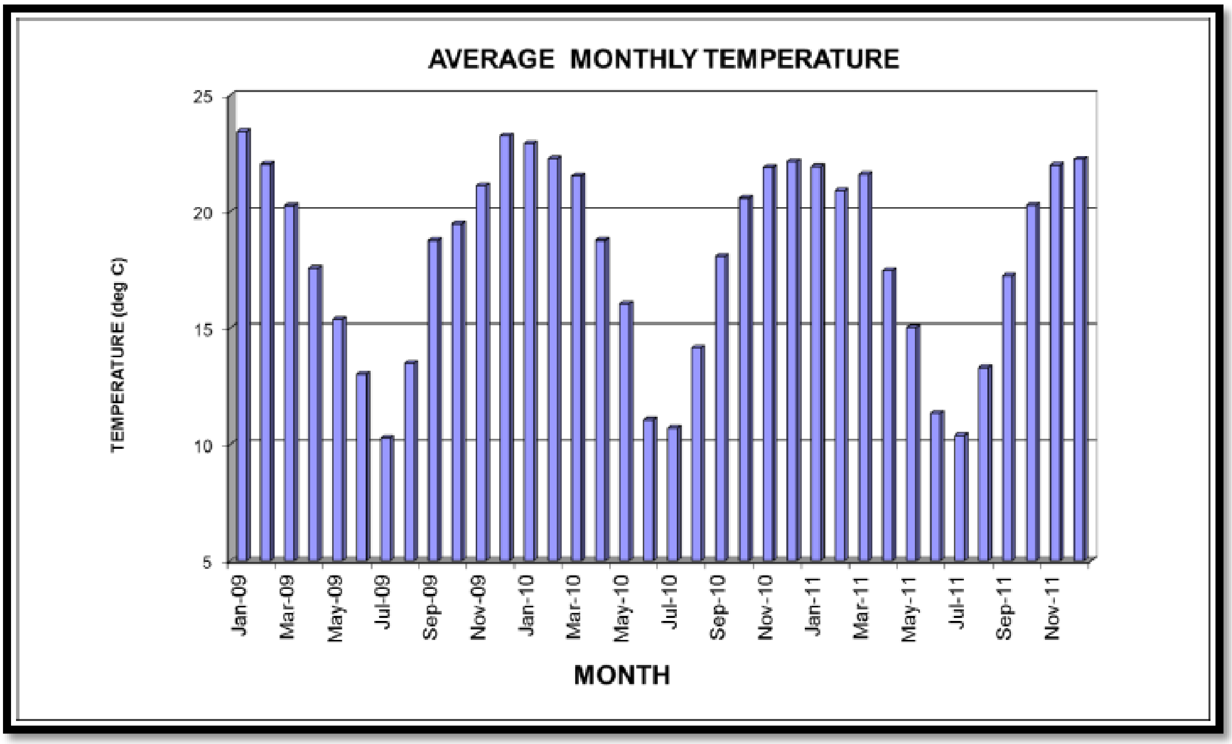

Figure 11: Average monthly temperature for the Moeijelyk project area (2009-2011)

Table 3: Averaged monthly minimum, maximum and average temperature values for the Moeijelyk project area (2009-2011)

Temperature (deg °C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	23.5	22.3	21.6	18.8	16.0	13.0	10.7	14.1	18.8	20.6	22.0	23.3	18.7
Monthly Min.	21.9	20.9	20.3	17.5	15.0	11.1	10.3	13.3	17.2	19.5	21.1	22.2	17.5
Monthly Ave.	22.8	21.7	15.5	17.9	15.5	11.8	10.5	13.6	18.0	20.1	21.7	22.6	17.6

4.2.5 RELATIVE HUMIDITY

The data in the table below is representative of the relative humidity for the Moeijelyk project area. The annual maximum, minimum and average relative humidity is given as 66.9 %, 61.1 % and 63.9 %, respectively. The daily maximum relative humidity remains above 60 % for most of the year (with exception of November and December), and range from 78.5 % in winter (July) to 55.8 % in November. The daily minimum relative humidity on the other hand is less than 70 % throughout the year, with the highest minimum (69.4 %) occurring in June and the lowest (49.4 %) occurring in November.

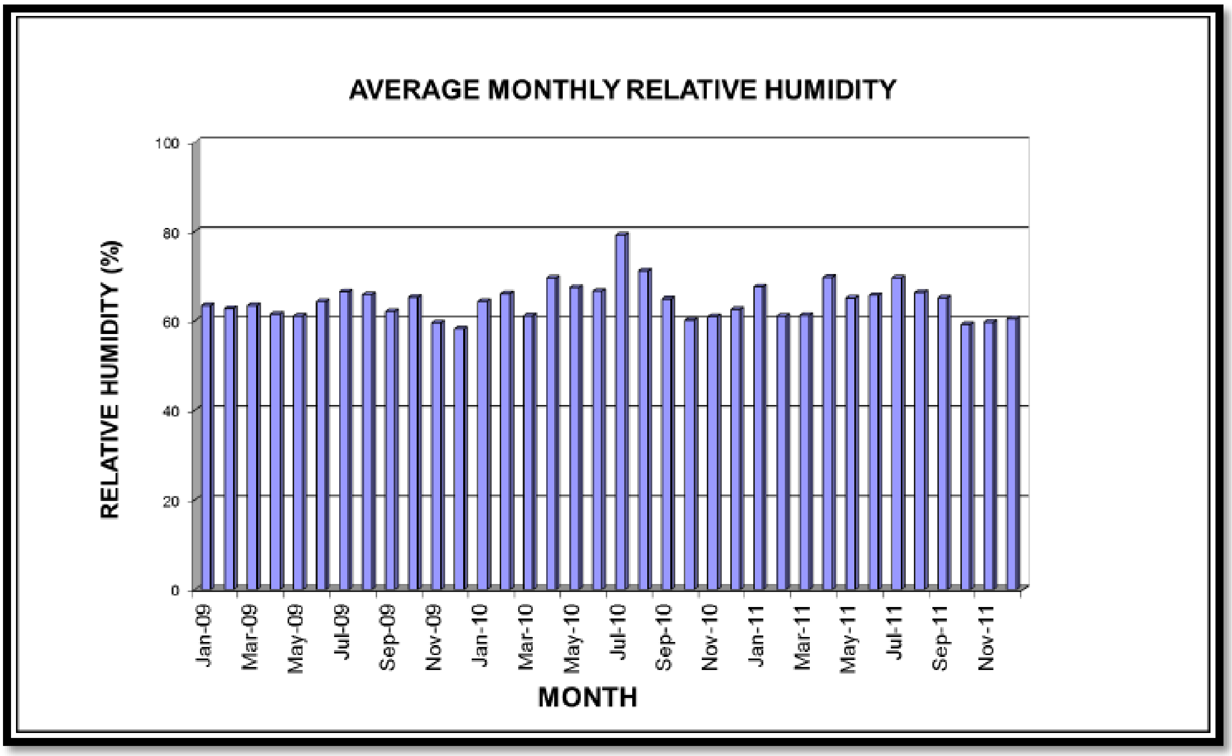

Figure 12: Average Monthly Relative Humidity for the Moeijelyk project area (2009-2011)

Table 4: Average Monthly Relative Humidity for the Moeijelyk project area (2009-2011)

Relative Humidity (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	68	66	63	70	67	67	79	71	65	65	61	63	67
Monthly Min.	63	61	61	62	61	64	67	66	62	59	60	58	62
Monthly Ave.	65	63	65	67	65	66	72	68	64	62	60	60	65

4.2.6 RAINFALL

As shown in the table below, the three year annual maximum, minimum and average monthly precipitation rates for the Meoijelyk site are 106.9 mm, 47.9 mm and 76.4 mm, respectively. The highest monthly maximum precipitation (266.4 mm) occurs for June. The rate decreases down to 8.1 mm in July. The monthly minimum precipitation ranges between 191.3 mm in January and 0 mm in July and August.

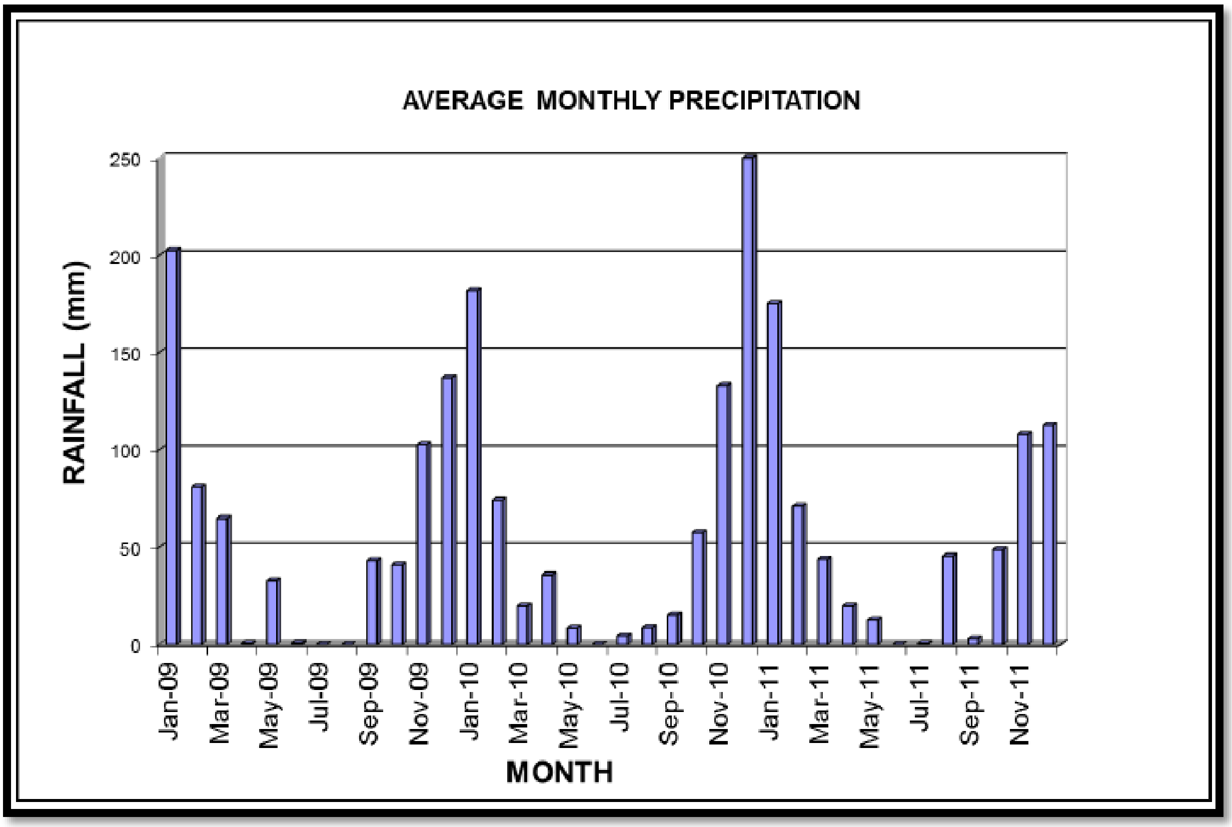

Figure 13: Average Monthly Precipitation for the Moeijelyk project area (2009-2011)

Table 5: Average Monthly Precipitation for the Moeijelyk project area (2009-2011)

Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	202	81	65	36	33	1	5	45	43	57	133	304	84
Monthly Min.	175	71	20	1	8	0	0	0	3	41	103	113	45
Monthly Ave.	186	75	18	19	18	0	2	18	20	49	115	185	59

4.2.7 EVAPORATION

As shown in the table below, the annual maximum, minimum and average monthly evaporation rates for the Potgietersrus (Mokopane) area for the period 1957-1987 are 244 mm, 130 mm and 178 mm, respectively. The highest monthly maximum evaporation (332.2 mm) occurs for November. The rate decreases significantly down to 121.6 mm in June. The monthly minimum evaporation ranges between 200.7 mm in December and 69.9 mm in June.

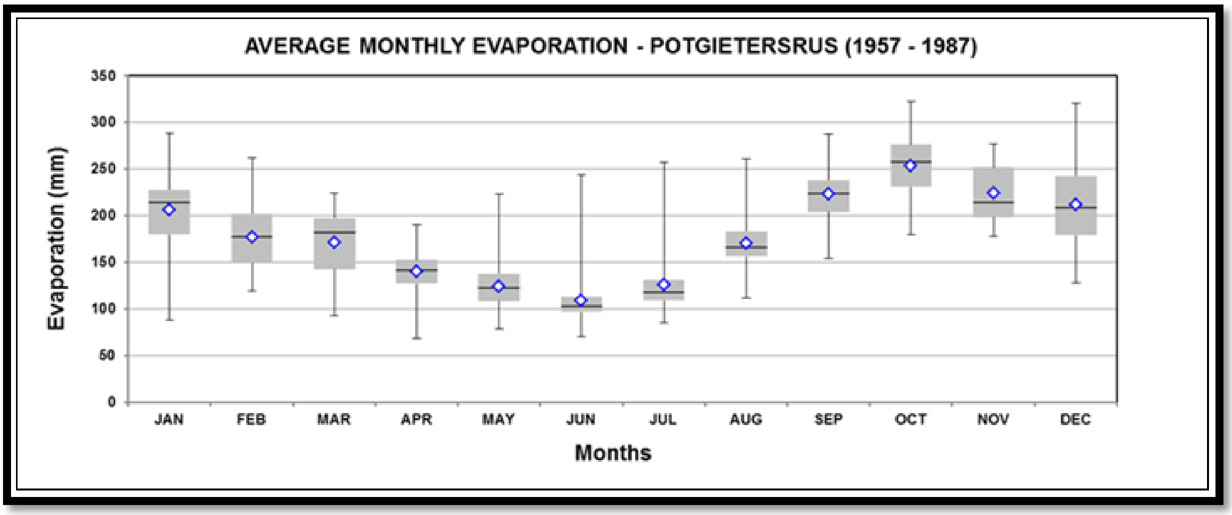

Figure 14: Average Monthly Evaporation for Mokopane (Potgietersrus) S-Pan Evaporation Station (1957 – 1987) (Source: South African Weather Service)

Table 6: Maximum, minimum and average monthly evaporation rates for the Mokopane (Potgietersrus) (Symon's Pan) S-Pan evaporation station for 1957-1987 period (South African Weather Service)

Evaporation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	289	262	224	190	223	244	257	261	288	322	277	320	289
Monthly Min.	88	120	93	68	79	70	85	111	155	180	178	128	88
Monthly Ave.	206	177	171	141	124	109	126	170	224	253	224	212	206

4.3 SURFACE INFRASTRUCTURE

As the the Bauba a Hlabirwa Moeijelyk Chrome project is an existing small scale operation very little additional infrastructure and facilities will be required to support the expansion of the mining operations. The infrastructure at the Moeijelyk operations will be the minimum required to service the opencast mining and underground mining operations plus a load out facility where road trucks would be loaded to transport ore. The proposed development on a portion of the remaining extent of the farm Moeijelyk 412 KS is demarcated for the expansion of current chrome mining activities in a north-western direction. Current mining activities border the proposed area to be developed to the southeast. The demarcated portion is located on the southern side of the R37 and is partially located on a mountain range. The mountain range stretch in a northwest and southeast direction and the area demarcated for development stretches from the 885 contour line to the 830 contour line and follows the curvature of the mountain. Tsibeng village borders the proposed development on the north north-western side.

The proposed mining activity will be roughly 30 hectare in size and will include the following: construction of access roads, bush clearing, top soil storage areas, stripping of overburden, stockpiles, load and hauling of ore to the stockpile, construction of a guard house, toilet and water reservoir, and a crushing / screening plant.

Material will be extracted via an opencast bench mining method. Bulldozers will first remove surface vegetation and topsoil layers, followed by excavators that will extract material from the pit. Loader and tipper trucks will then deliver the excavated material to the designated stockpile area.

The proposed mining activities will consist of three phases: Construction, operational and decommissioning. During the construction phase the existing access road will be upgraded using on-site material and the minimum required area will be cleared. The operational phase will see the topsoil removed from the proposed mining area. The removed topsoil will be stored in a bund wall which will be located on the high ground side of the mining area outside of the 1:50 flood level. Overburden removed will be also be stored in a bund wall and will be utilised during the decommissioning phase. During the operational phase the ore will be excavated and transported to the stockpile area from where it will be moved to various plants and smelters for testing.

The decommissioning phase will see all stockpiled chrome and ore removed from the site. All infrastructure will be demolished and removed from the site, but the access road will remain for the use of possible future mining activities. The topsoil removed during the operation phase will be backfilled onto the overburden layer and the surface of the stockpile and crusher areas will be ripped and seeded with a seed mix of the surrounding area. Drainage channels will also be provided to avoid storm water accumulating within the mining area.

SURFCAE INFRASTRUCTURE PLANS

There is a plant on site that will be used for the crushing, screening of the raw materials located within the ROM areas.

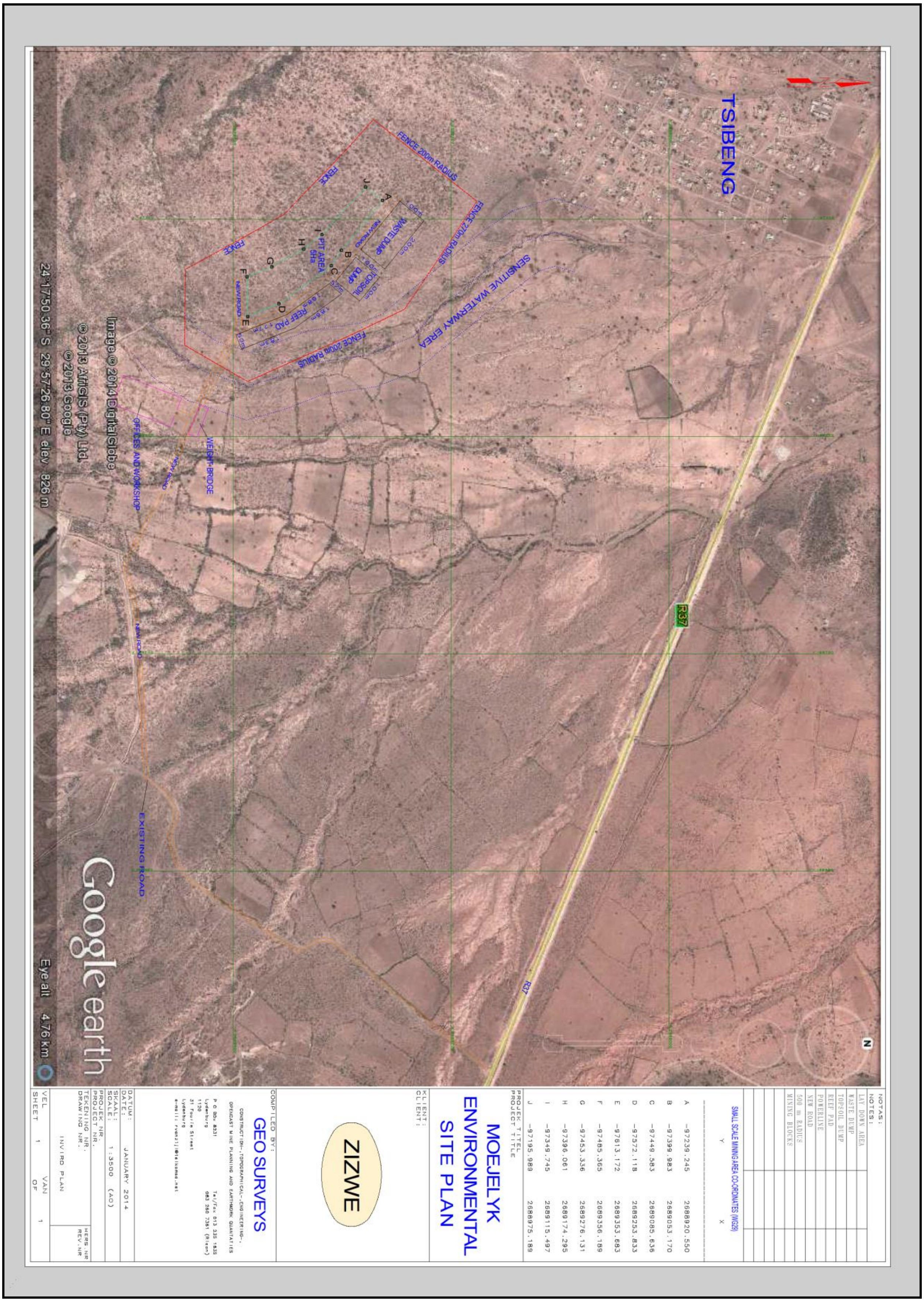

Figure 15: Proposed Moejelyk project layout aerial imagery overlay

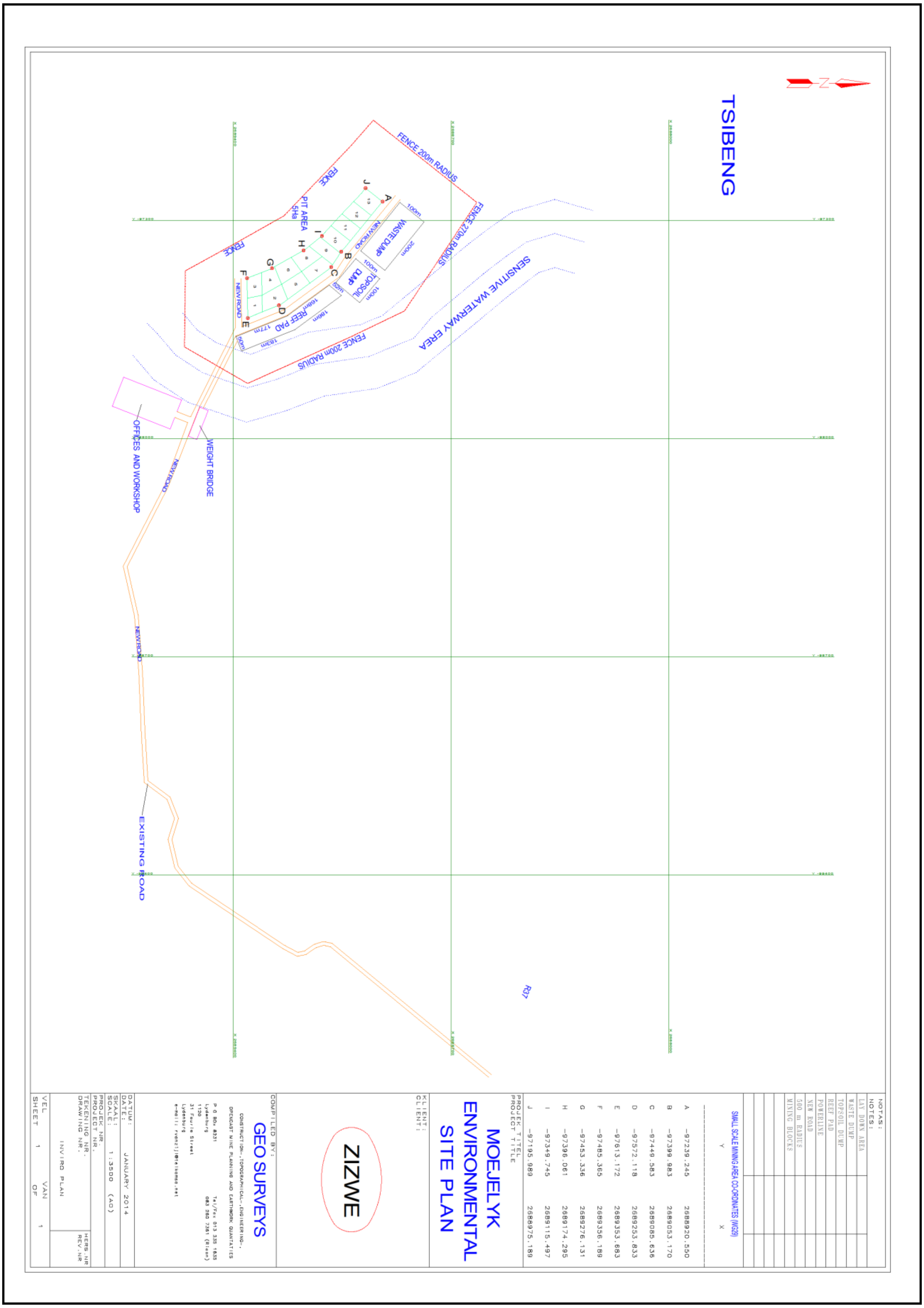

Figure 16: Proposed Moejelyk project layout surveyor drawing

CHAPTER 5: OVEVIEW

The National Environmental Management: Air Quality Act, Act No. 39 of 2004 is in the process of replacing, and has to a large extent already replaced, the Atmospheric Pollution Prevention Act (APPA), Act 45 of 1965. The Air Quality Act requires a shift from source-based air pollution control to a receiving environment, air quality management approach. Key features of the new approach to air quality governance include:

- Decentralisation of air quality management responsibilities.
- A requirement that all significant sources be identified, quantified and addressed.
- Setting of ambient air quality targets as goals to achieve emission reductions.
- Recognition of source-based, command-and-control measures (i.e. authorities set source requirements and emission limits requiring adherence by responsible parties), in addition to alternative measures, including market incentives and disincentives, voluntary programmes, and education and awareness.
- Promotion of cost-optimised mitigation and management measures.
- Required air quality management planning by authorities and emission reduction and management planning by sources.
- Access to information and public consultation.
- The new approach has significant implications for government, business and civil society.

This report and investigation aims to identify potential air quality impacts which may result due to the proposed operations. This assessment forms part of the environmental impact assessment phase of this investigation and will focus on the impacts from the proposed mine in order to provide a better understanding of the magnitude of these impacts.

As a summary the following proposed activities will be established and executed and are associated with the proposed Moeijelyk Chrome Mine activities;

- Site preparation;
- Opencast mining with a roll over rehabilitation sequence;
- Crushing, screening and washing of the ROM;
- Access road, haul road construction;
- Site offices and security office;
- Sanitation and change house;
- Stores and store yard;
- Workshop and maintenance area;
- Bulk fuel storage;
- Surface water infrastructure (evaporation, dust suppression and washing use);
- Clean and dirty water separation system;
- Trenching;
- Fencing;
- Mine fleet hard park;
- Staff and visitors parking;

- Drilling, blasting and explosives handling;
- Topsoil, subsoil, overburden, discard, tailings and ROM stockpiles/storage facilities;
- Waste management; and
- Mine closure and rehabilitation.

PARTICULATE MATTER

Particulate matter (PM) is the collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. PM includes dust, smoke, pollen and soil particles (Kemp, 1998). PM has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function, and an increased risk of myocardial infarction (USEPA, 1996).

PM can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions (USEPA, 1996):

- PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung);
- PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less);
- PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and
- Ultra fine particles generally defined as those less than 0.1 microns.

Particles can be classified by their aerodynamic properties into coarse particles, PM10 (particulate matter with an aerodynamic diameter of less than 10 µm) and fine particles, PM2.5 (particulate matter with an aerodynamic diameter of less than 2.5 µm) (Harrison and van Grieken, 1998). The fine particles contain the secondarily formed aerosols such as sulphates and nitrates, combustion particles and re-condensed organic and metal vapours. The coarse particles contain earth crust materials and fugitive dust from roads and industries (Fenger, 2002).

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters. Fine particles are directly emitted from combustion sources and are also formed secondarily from gaseous precursors such as sulphur dioxide, nitrogen oxides, or organic compounds. Fine particles are generally composed of sulphate, nitrate, chloride and ammonium compounds, organic and elemental carbon, and metals. Combustion of coal, oil, diesel, gasoline, and wood, as well as high temperature process sources such as smelters and steel mills, produce emissions that contribute to fine particle formation. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere hundreds to thousands of kilometres, while most coarse particles typically deposit to the earth within minutes to hours and within tens of kilometres from the emission source. Some scientists have postulated that ultra-fine particles, by virtue of their small size and large surface area to mass ratio may be especially toxic. There are studies which suggest that these particles may leave the lung and travel through the blood to other organs, including the heart. Coarse particles are typically mechanically generated by crushing or grinding and are often dominated by resuspended dusts and crustal material from paved or unpaved roads or from construction, farming, and mining activities (USEPA, 1996).

In terms of health impacts, particulate air pollution effects are broad, but are predominately associated with effects of the respiratory and cardiovascular systems (WHO, 2005). Particle size is important for health because it controls where in the respiratory system a given particle deposits. Fine particles have been found to be more damaging to human health than coarse particles as larger particles are less respirable in that they do not penetrate deep into the lungs compared to smaller particles (Manahan, 1991). Larger particles are deposited into the extra thoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000). A study by Pope and Burnett (2002) indicated that PM2.5 leads to high plaque deposits in arteries, causing vascular inflammation and atherosclerosis (Kaonga and Kgabi, 2009). As yet, no evidence of a threshold in the relationship between particulate concentrations and adverse human health effects has been determined (Burger and Scorgie, 2000a; Burger and Scorgie 2000b; WHO 2005).

Short-term exposure

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 µg/m3). 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

Long-term exposure to low concentrations (~10 µg/m3) 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; with an increased risk associated with an increase in exposure (WHO 2005).

NUISANCE DUST

Nuisance dust may be defined as coarse fraction of airborne particulates. Nuisance dust is known to result in the soiling of materials and has the potential to reduce visibility. Nuisance dust has a long history of having little adverse effect on the lungs. Any reaction that may occur from nuisance dust is potentially reversible. However, excessive concentrations of nuisance dust in the workplace may reduce visibility, may cause unpleasant deposits in eyes, nasal passages and may cause injury to the skin or mucous membranes by the chemical or mechanical action. The light is scattered and visibility is diminished by the atmospheric particulate.

Various costs are associated with the loss of visibility, including: the need for artificial illumination and heating; delays, disruption and accidents involving traffic; vegetation growth reduction associated with reduced photosynthesis; and commercial losses associated with aesthetics. The soiling of building and materials due to dust frequently gives rise to damages and costs related to the increased need for washing, cleaning and repainting. Dustfall may also impact negatively on sensitive industries, e.g. bakeries or textile industries. Certain elements in dust may damage materials. For instance it was found that sulphur and chlorine if present in dust may cause damage to copper (Maeda *et al.*, 2001).

Nuisance dust can also cause serious aesthetic deterioration in the surrounding environment and communities. Fortunately due to relatively large particulate matter sizes associated with the mining emissions and the relatively short release height of the pollutants, such negative impacts are usually confined in relatively small areas. Within these areas of impact, fugitive dust may result in damage to the vegetation and agriculture. The deposited particulate matter may block the plant leaf stomata hence inhibit gas exchange, or smother the plant leaf surfaces reducing photosynthesis levels. Besides the impacts on vegetation, health effects of particulates on mine personnel and public may also be significant.

Air pollution is a recognized health hazard for man and domestic animals (Newman *et al.*, 1979). Air pollutants have had a worldwide effect on both wild birds and wild mammals, often causing decreases in local animal populations (Newman *et al.*, 1979). The major effects of industrial air pollution on wildlife include direct mortality, debilitating industrial-related injury and disease, physiological stress, anaemia, and bioaccumulation. Some air pollutants have caused a change in the distribution of certain wildlife species.

THE IMPORTANCE OF MANAGING DUST

Managing dust from mines is important as it can impact local and regional air quality, adversely affect local amenity and pose a risk to public health.

- **Protecting local and regional air quality**

An important aspect of the protection of air quality from mining operations is to minimise dust generated from sources such as wind erosion, crushing & screening, vehicles using unsealed roads and blasting. Mines are required by the National Environmental Management Air Quality Act to meet certain criteria for ambient air quality. In order to meet these criteria, mines must manage the emissions of dust from their activities in a competent manner.

- **Community health**

Health impacts of mine dust vary depending on the nature of the particles, their origin and their size, which is measured as particulate matter (PM). Exposure to fine particles can have potential health impacts on the respiratory system. Infants and children, elderly people, people with existing respiratory conditions, heart disease or diabetes may be more susceptible to the health effects from fine and coarse particles. Mines should be operated with proper dust controls to ensure that people are not affected by the dust they generate and their related health effects.

- **Community amenity**

If not properly managed, dust from mines can be a nuisance to local communities. Nuisance dust usually has a particle size larger than 10 microns (gravimetric dust fallout). High levels of nuisance dust may reduce visibility and amenity. The presence of nuisance dust can also cause a perceived increase in health risk. The impact of dust from mines on local amenity depends on the distance from the mine site and climatic conditions including wind speed and direction. Concerns about amenity from mine site dust often relate to the 'visibility' of dust plumes and dust sources. Visible dust is usually due to short-term episodes of high emissions, such as blasting. Other amenity impacts include dust depositing on fabrics (such as washing) or on house roofs, and dust transported from roofs to water tanks during rain.

CHAPTER 6: RELEVANT LEGISLATION, GUIDELINES AND STANDARDS

6.1 NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY, 2004 (ACT 39 OF 2004)

The National Environmental Management: Air Quality Act 39 of 2004 has shifted the approach of air quality management from source-based control to receptor-based control. The Act made provision for National ambient air quality standards, however it is generally accepted that more stringent standards can be established at the Provincial and Local levels. Emissions are controlled through the listing of activities that are sources of emission and the issuing of emission licences for these listed activities. Atmospheric emission standards have been established for each of these activities and an atmospheric licence is now required to operate. The issuing of emission licences for Listed Activities will be the responsibility of the Metropolitan and District Municipalities. 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 will be responsible for the issuing of atmospheric emission licences or the Air Quality Officer could delegate the responsibility to the Director of community environmental services.

NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT, 2004 (ACT NO. 39 OF 2004) - NATIONAL DUST CONTROL REGULATIONS (GOVERNMENT GAZETTE NO. 36794 - NO. R 827)

Water and Environmental Affairs Minister Edna Molewa has published the National Dust Control Regulations on 1 November 2013, in terms of the National Environmental Management Air Quality Act, which prescribes general measures for the control of dust.

Restriction Areas	Dustfall rate (D) (mg/m²/day, 30-days average)	Permitted frequency of exceeding dust fall rate
Residential area	D < 600	Two within a year, not sequential months.
Non-residential area	600 < D < 1200	Two within a year, not sequential months.

According to the regulations, any person conducting any activity in such a way as to give rise to dust in quantities and concentrations that exceeded the dustfall standard set out in the regulation was impelled to, upon receipt of a notice from an air quality officer, implement a dustfall monitoring programme. The method to be used for measuring the dustfall rate and the guideline for locating sampling points would be the American Standards for Testing and Materials method, or an equivalent method approved by any internally recognised body.

The regulation further stated that an air quality officer could require any person, through a written notice, to undertake a dustfall monitoring programme if the officer reasonably suspected that the person was contravening the regulations or that the activity being conducted required a fugitive dust emission management plan.

A person required to implement the programme must then, within a specified period, submit a dustfall monitoring report to the air quality officer. A dustfall monitoring report must provide information on the location of sampling sites, classification of the area where samplers were located, as well as reference to the standard methods used for site selection, sampling and analysis. The report would also be required to provide meteorological data for the sampling area, the dustfall monitoring results, including a comparison of current year and historical results for each site, as well as a tabular summary of compliance with the dustfall standard.

Any person that had exceeded the dustfall standard must, within three months after submission of the dustfall monitoring report, develop and submit a dustfall management plan to the air quality officer for approval. This management plan must identify all possible sources of dust within the affected site, detail the best practicable measures to be undertaken to mitigate dust emissions, identify the line management responsible for implementation and incorporate the dust fallout monitoring plan. Such a plan would need to be implemented within a month of the date of approval and an implementation progress report must be submitted to the air quality officer at agreed time intervals.

LEGISLATION FOR LOCAL GOVERNMENT

The Local Government: Municipal Systems Act 32 of 2000, together with the Municipal Structures Act 117 of 1998, establishes local government as an autonomous sphere of government with specific powers and functions as defined by the Constitution. Section 155 of the Constitution provides for the establishment of Category A, B and C municipalities each having different levels of municipal executive and legislative authorities. According to Section 156(1) of the Constitution, a municipality has the executive authority in respect of, and has the right to, administer the local government matters (listed in Part B of Schedule 4 and Part B of Schedule 5) that deal with air pollution.

AMBIENT AIR QUALITY GUIDELINES AND STANDARDS

Guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and well-being (WHO, 2000). Once the guidelines are adopted as standards, they become legally enforceable. The South African Bureau of Standards (SABS), in collaboration with DEA, established ambient air quality standards for gravimetric dust fallout and is listed in the table below.

Ambient air quality – Limits for common pollutants

Table 7: Limits for PM10 in ug/m3

1	2	3
Average period	**Concentration** µg/m^3	**Frequency of exceedances**
Interim		
24 h	120	4
1 year	50	0
Target		
24 h	75	4
1 year	40	0

Table 8: Four-band scale evaluation criteria for dust deposition in mg/m2/day

1	2	3	4
Band number	**Band description label**	**Dustfall rate, *D* (mg/m^{-2}·day^{-1}, 30-day average)**	**Comment**
1	Residential	$D < 600$	Permissible for residential and light commercial
2	Industrial	$D \leq 1\,200$	Permissible for heavy commercial and industrial.
3	Action	$1\,200 < D \leq 2\,400$	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year
4	Alert	D >2 400	Immediate action and remediation required following the first incidence of the dustfall rate being exceeded. Incident report to be submitted to the relevant authority

Table 9: Target, action and alert thresholds for dust deposition in mg/m2/day

1	2	3	4
Level	**Dustfall rate, *D* (mg/m^{-2}·day^{-1}, 30-d average)**	**Average period**	**Permitted frequency of exceeding dustfall rate**
Target	300	Annual	
Action residential	600	30 days	Three within any year, no two sequential months
Action industrial	1 200	30 days	Three within any year, not sequential months
Alert threshold	2 400	30 days	None. First incidence of dustfall rate being exceeded requires remediation and compulsory report to the relevant authorities

CHAPTER 7: METHODOLOGY

For the purpose of the baseline investigation samples has been taken on site for gravimetric dust fallout in $mg/m^2/day$ and particulate matter PM 10 in mg/m^3 converted to ug/m^3 in line with the standard. The samples has been compared to the guidelines and standards while attention has also been given to relevant referencing sites of a similar nature in the vicinity of the proposed project area to determine the impacts that have been experienced before. Passive and active sampling techniques were used for the baseline determination as explained below.

7.1 PASSIVE SAMPLING

Site layout for the sampling points has been carried out according to the eight main compass directions; the site layout and equipment placement is done in accordance with the ASTM standard, D 1739 – 2010, thereafter relevant sampling reference numbers were allocated to the receptors accordingly. At each gravimetric dust fallout gauge/receptor point there is a stand built according to specification containing the dust sample collection bucket. Samples are collected after a 1 month running period (+-30days exposure). After sample collection the samples are taken to the relevant SANAS accredited laboratory as required. A visual site investigation is done where after correlations and drawn and findings are identified and reported on.

Dust buckets of a standard size and shape are prepared and set up at locations related to the eight main compass points on the borders of the property so that dust can settle in them for periods of 30+/-2 days. The dust buckets is then sealed and replaced with new empty ones and send away to the SANAS accredited laboratory for analysis. The masses of the water-soluble and –insoluble components of the material collected are then determined and results are reported as $mg/m^2/day$. This methodology is described according to South African National Standards 1929:2004 and the American Society for Testing and Materials (ASTM) Designation: D 1739-98 (2010). The results for this method of testing are obtained by gravimetrical weighing. The apparatus required include open top buckets/containers not less than 150mm in diameter with a height not less than twice its diameter. The buckets must be placed on a stand at a height of 2+/-0.2m above the ground.

7.2 ACTIVE SAMPLING

For the Active Sampling the new DUSTTRAK II Dust Monitor that has been used is a battery-operated, data-logging, light-scattering laser photometer that gives you real-time aerosol mass readings. This active sampling machine uses a sheath air system that isolates the aerosol in the optics chamber to keep the optics clean for improved reliability and low maintenance. Samples were taken at the same locations as for the passive sampling as per the sampling layout map.

Features & Benefits

- New high concentration Model 8531 measures 0.5 to 400 mg/m^3
- Easy to program, easy to operate
- Integrated pump allows use of size-selective aerosol inlet conditioners
- New graphical user interface with large colour touch screen

- Performs in-line gravimetric analysis for custom reference calibrations
- Automatic zeroing (with optional zero module) minimizes the effect of zero drift
- Displays real-time concentration (mg/m^3) during sampling
- Alarm setpoint from 0.002 to 100 mg/m^3
- Particle size range 0.1 to 10 µm
- Display statistics: max, min. and average readings and elapsed time
- Analog output allows remote access to real-time particle concentration data
- Sheath air system keeps optics chamber clean for improve reliability and low maintenance
- Preprogram, analyze data, print graphs and create report with TRAKPRO™ Data Analysis Software

Applications

- Ambient/work area monitoring
- Industrial/occupational hygiene surveys
- Indoor air quality investigations
- Fugitive emissions monitoring
- Site perimeter monitoring
- Fenceline monitoring
- Dust control operations
- Environmental research studies
- Baseline trending and screening
- Point source monitoring
- Engineering studies
- Engineering control evaluations
- Corrective action validation
- Remote and process monitoring
- Emissions monitoring
- Aerosol research studies
- Outdoor unattended environmental monitoring

Figure 17: Dusttrak Particulate Sampler Image

Table 10: Dusttrak Particle Sampler Specifications

Product Specification	Description
Sensor Type	90° light scattering
Particle Size Range	to 10 µm
Aerosol Concentration Range	8530 Desktop 0.001 to 150 mg/m3 8531 Desktop High Conc. 0.001 to 400 mg/m3 8532 Handheld 0.001 to 150 mg/m3
Resolution	±0.1% of reading or 0.001 mg/m3, whichever is greater
Zero Stability	±0.002 mg/m3 per 24 hours at 10 sec time constant
Flow Rate	3.0 L/min set at factory, 1.40 to 3.0 L/min, user adjustable
Flow Accuracy	±5% of factory set point, internal flow controlled
Temperature Coefficient	+0.001 mg/m3 per °C
Operational Temp	32 to 120°F (0 to 50°C)
Storage Temp	-4 to 140°F (-20 to 60°C)
Operational Humidity	0 to 95% RH, non-condensing
Time Constant	User adjustable, 1 to 60 seconds
Data Logging	5 MB of on-board memory (>60,000 data points) 45 days at 1 minute logging interval
Log Interval	User adjustable, 1 second to 1 hour
Physical Size (HWD)	Handheld 12.5 x 12.1 x 31.6 cm Desktop 13.5 x 21.6 x 22.4 cm
Weight	Handheld 2.9 lb (1.3 kg), 3.3 lb (1.5 kg) with battery Desktop 3.5 lb (1.6 kg), 4.5 lb (2.0 kg)–1 battery, 5.5 lb (2.5 kg)–2 batteries

7.3 SAMPLING LOCALITIES AND LAYOUT

Table 11: Air quality measurements locality descriptions

Site Reference	Location Description	GPS Sampling Localities
BM01	In proximity to office area and parking zone	24°18'12.02"S 29°57'55.21"E
BM02	Close to topsoil dumps and current operational area	24°18'0.37"S 29°57'39.07"E
BM03	Future mining development area	24°17'49.06"S 29°57'22.18"E
BM04	In close proximity to local community	24°17'43.68"S 29°57'7.08"E
BM05	Mountain area directly south of community	24°17'51.58"S 29°57'9.47"E
BM06	High up in mountain above current disturbance area	24°17'57.71"S 29°57'20.80"E
BM07	Close proximity to water tanks	24°18'20.87"S 29°57'40.22"E
BM08	On the border of the adjacent Swartkoppies mining area	24°18'21.52"S 29°57'50.14"E

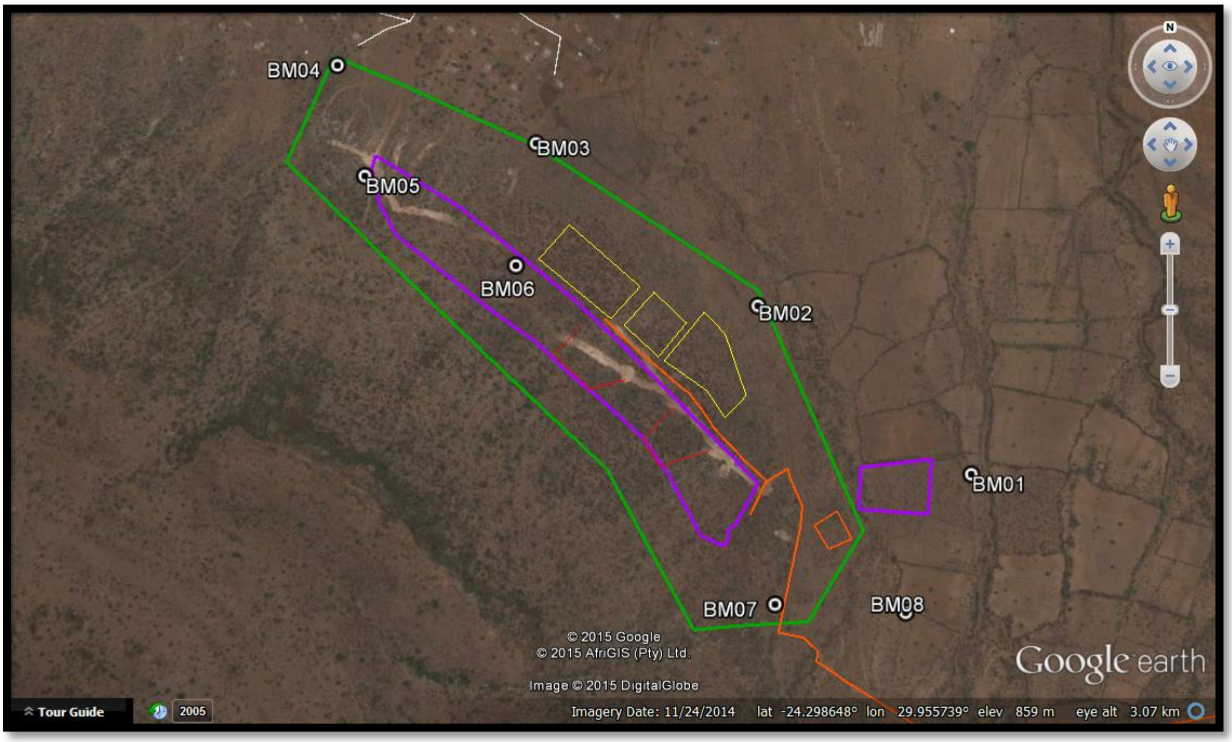

Figure 18: Air quality sampling layout

CHAPTER 8: BASELINE AIR QUALITY MEASUREMENT RESULTS

The results from the air quality recordings which has been taken during the month of May 2015 for active sampling and April 2015 to May 2015 for passive sampling, for all the sampled points that has been listed in the tables below.

GRAVIMETRIC DUST FALLOUT

Table 12: Gravimetric Dust Fallout in mg/m2/day

Reference	Description	GPS Localities	Gravimetric Dust Fallout mg/m2/day
BM01	In proximity to office area and parking zone	24°18'12.02"S 29°57'55.21"E	174
BM02	Close to topsoil dumps and current operational area	24°18'0.37"S 29°57'39.07"E	3695
BM03	Future mining development area	24°17'49.06"S 29°57'22.18"E	Not retrievable
BM04	In close proximity to local community	24°17'43.68"S 29°57'7.08"E	124
BM05	Mountain area directly south of community	24°17'51.58"S 29°57'9.47"E	98
BM06	High up in mountain above current disturbance area	24°17'57.71"S 29°57'20.80"E	113
BM07	Close proximity to water tanks	24°18'20.87"S 29°57'40.22"E	149
BM08	On the border of the adjacent Swartkoppies mining area	24°18'21.52"S 29°57'50.14"E	103

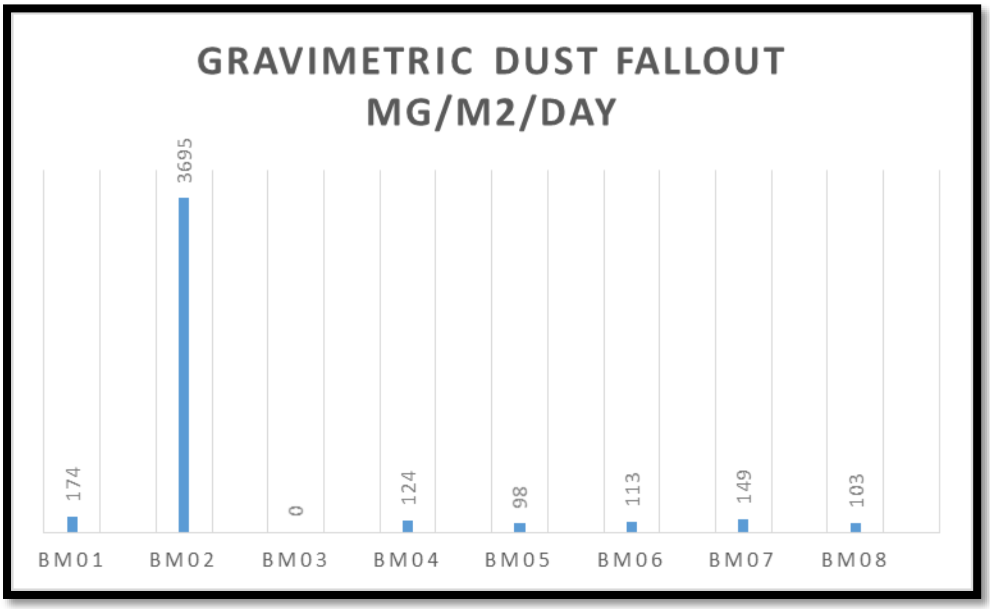

Figure 19: Gravimetric Dust Fallout in mg/m2/day

The results obtained for the gravimetric dust fallout sampling period during the month of April - May 2015 for a 30 day exposure period on the proposed site indicated very low existing dust levels currently although the operation is already active. Only one sample was not retrievable BM03 which was situated on the Northern border between the operation and the community. The sampling stand was clearly driven over by mine vehicles during the moving of the fence line and construction of a new road. The seven remaining samples that has been obtain is however sufficient to make relevant findings regarding the baseline gravimetric dust fallout situation on site. The overall average for the samples obtained resulted in a value of 636mg/m^2/day which is almost within the lower residential threshold of 600mg/m2/day. The dust levels currently on site is within the upper industrial limit of 1200mg/m^2/day but would most probably increase as mining activities increase.

Sampling locality BM04 and BM05 which is in close proximity to the community was very low at 124mg/m^2/day and 98mg/m^2/day which is a very good indication of no negative impacts as a result of the current mining during the sampling period. Sampling locality BM02 was extremely high and three times higher than the industrial limit of 1200mg/m^2/day at a level recorded 3695mg/m^2/day. This is a concern as it is within the current operational area and could be representative of future dust levels expected should no mitigation be implemented. Through implementing the management and mitigation measures contained further on in this report has it been observed previously on numerous sites that the dust fallout levels can quite easily be controlled to a level within the acceptable and/or tolerable level. The mine should investigate this further and ensure that the high dust fallout levels in this area be managed accordingly. During the sampling period active stripping and stockpiling of topsoil was taking place in very close vicinity to BM02 and has definitively contributed to the results obtained.

The remainder of the sampling points were well within the lower residential limit which. When excluding BM02 as an outlier in the data since it was placed as a control in the middle of the operational area to determine the dust generated on site, the remaining six sampling localities had an average of 126mg/m^2/day which is extremely good. It should be noted that neighbouring mining activities and the various gravel roads being used in proximity to the site also contribute to the gravimetric dust fallout. There is currently no reason for concern related to gravimetric dust fallout on site except for the dust being generated in the direct vicinity of the active operation. The fugitive dust emanating from sampling locality BM02 at the operational area has dispersed to acceptable levels being sampled on the borders of the property where the dust is being blown out to the receiving environment. Increased levels of dust would therefore be expected during the windy months. The main wind directions according to the Wind Rose diagrams are in the South Western direction which is blowing away from the community and into the mountainous environment.

PARTICULATE MATTER PM10

Table 13: Particulate Matter PM10 in ug/m3

Reference	Description	GPS Localities	PM 10 ug/m3
BM01	In proximity to office area and parking zone	24°18'12.02"S 29°57'55.21"E	40
BM02	Close to topsoil dumps and current operational area	24°18'0.37"S 29°57'39.07"E	42
BM03	Future mining development area	24°17'49.06"S 29°57'22.18"E	55
BM04	In close proximity to local community	24°17'43.68"S 29°57'7.08"E	44
BM05	Mountain area directly south of community	24°17'51.58"S 29°57'9.47"E	35
BM06	High up in mountain above current disturbance area	24°17'57.71"S 29°57'20.80"E	40
BM07	Close proximity to water tanks	24°18'20.87"S 29°57'40.22"E	70
BM08	On the border of the adjacent Swartkoppies mining area	24°18'21.52"S 29°57'50.14"E	163

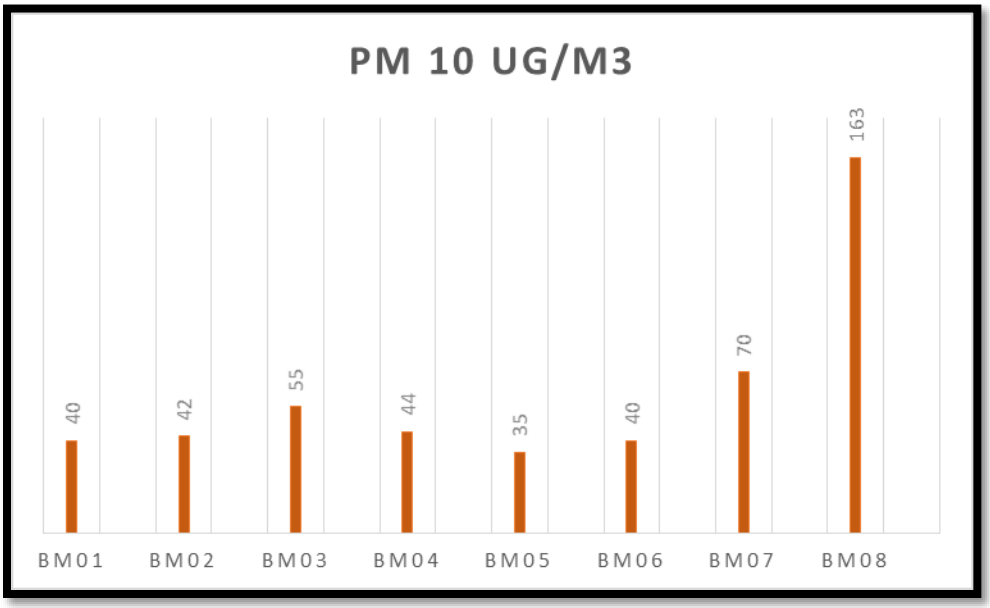

Figure 20: Particulate Matter PM10 in ug/m3

The particulate matter PM10 sampling that was undertaken on site during May 2015 resulted in very good and low values below the 120ug/m^3 threshold overall except for one sampling locality BM08 which resulted in a value of 163ug/m^3. Overall the site performance during the sampling period in May 2015 was very good. It should be noted that grab samples were taken for 1 minute intervals at each point and results would vary during different atmospheric conditions. The site average for the eight samples taken is at 61ug/m^3 which is 50% of the allowable limit and therefore within the compliance level.

The vast majority of dust from mining activities consists of coarse particles (around 40 per cent) and particles larger than PM 10, generated from activities such as the mechanical disturbance of rock and soil materials by dragline or shovel, bulldozing, blasting, and vehicles on dirt roads. Particles are also generated when wind blows over bare ground and stockpiles. These larger particles can have amenity impacts as well as health impacts. Fine particles can have health impacts and are also produced at mine sites, though they only account for about 5 per cent of the particles emitted during the mining process. Fine particles produced at mine sites are mainly from vehicle and mobile equipment exhausts. The results at BM08 was definitely influenced by vehicular movement on site as the sample was taken right next to the road on the border of the adjacent Swartkoppies mining site which was fully operational during the sampling time.

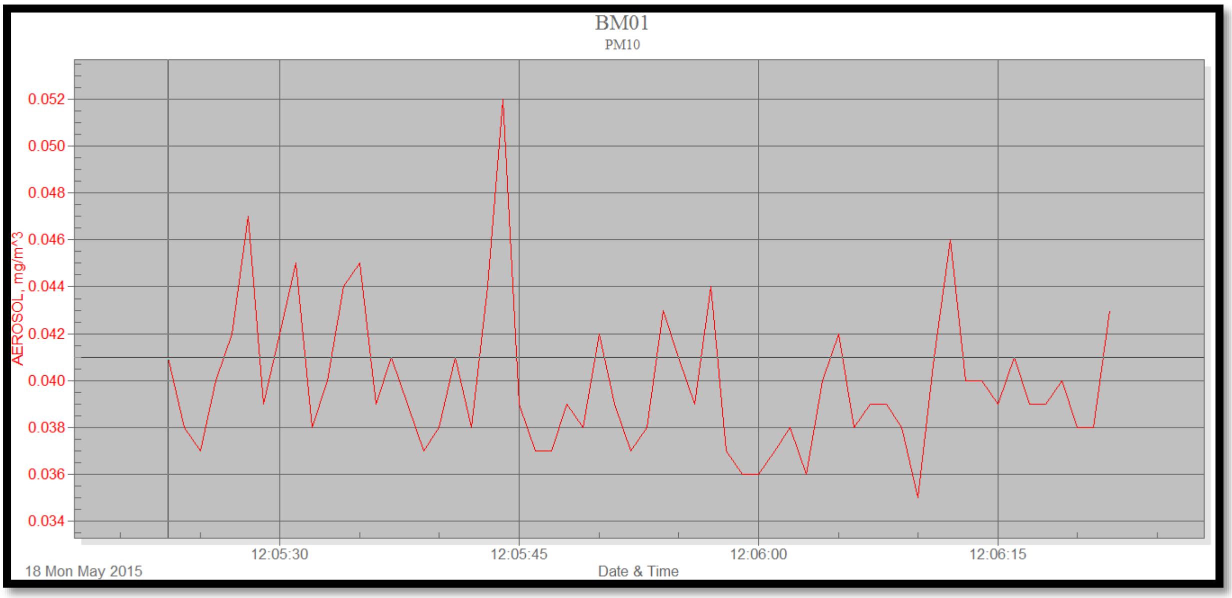

Figure 21: BM01 PM10 Measurements (mg/m3)

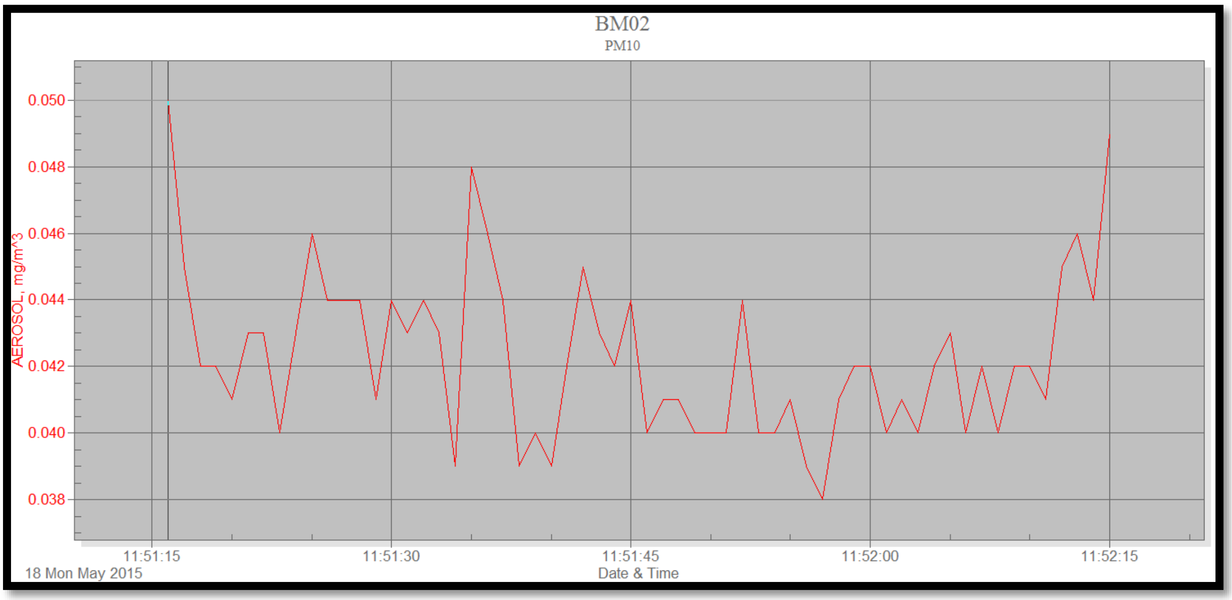

Figure 22: BM02 PM10 Measurements (mg/m3)

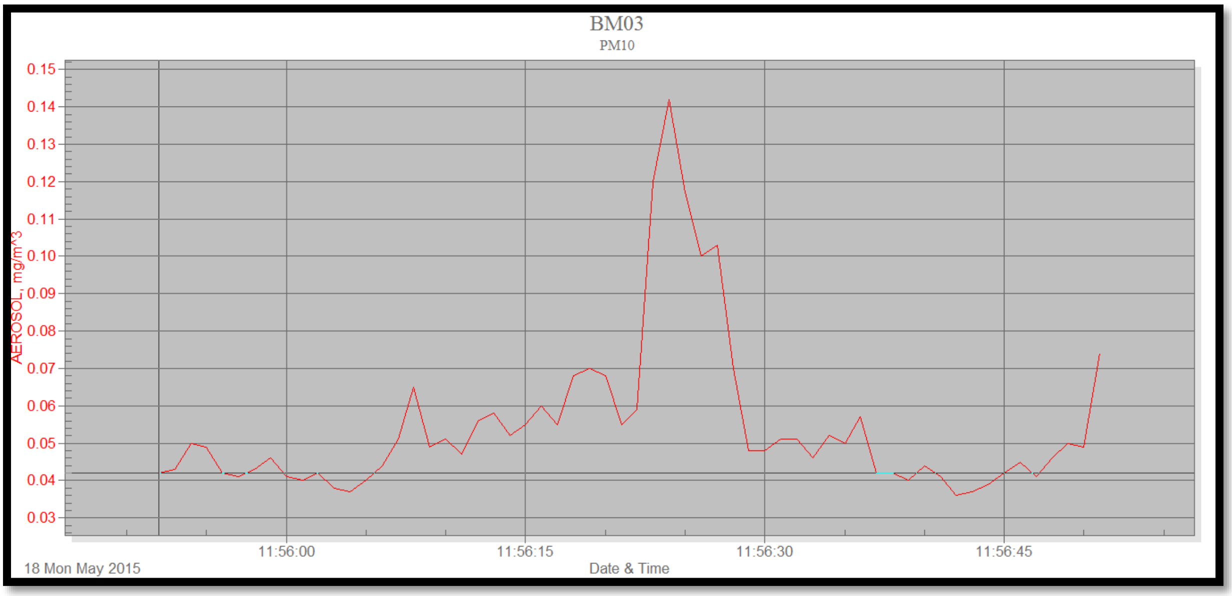

Figure 23: BM03 PM10 Measurements (mg/m3)

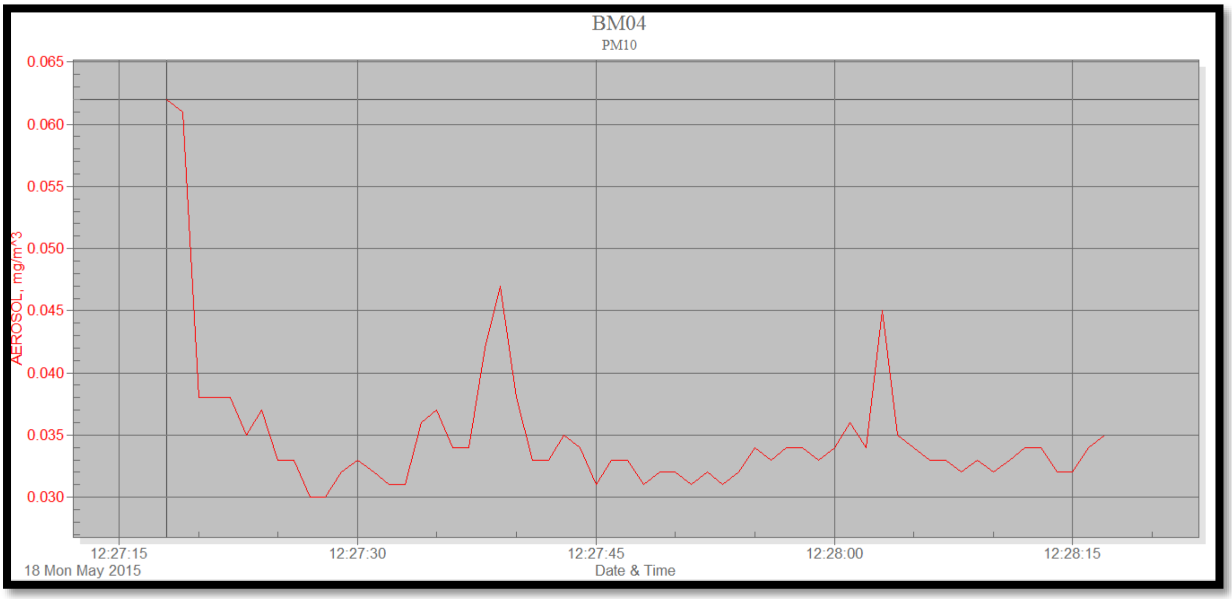

Figure 24: BM04 PM10 Measurements (mg/m3)

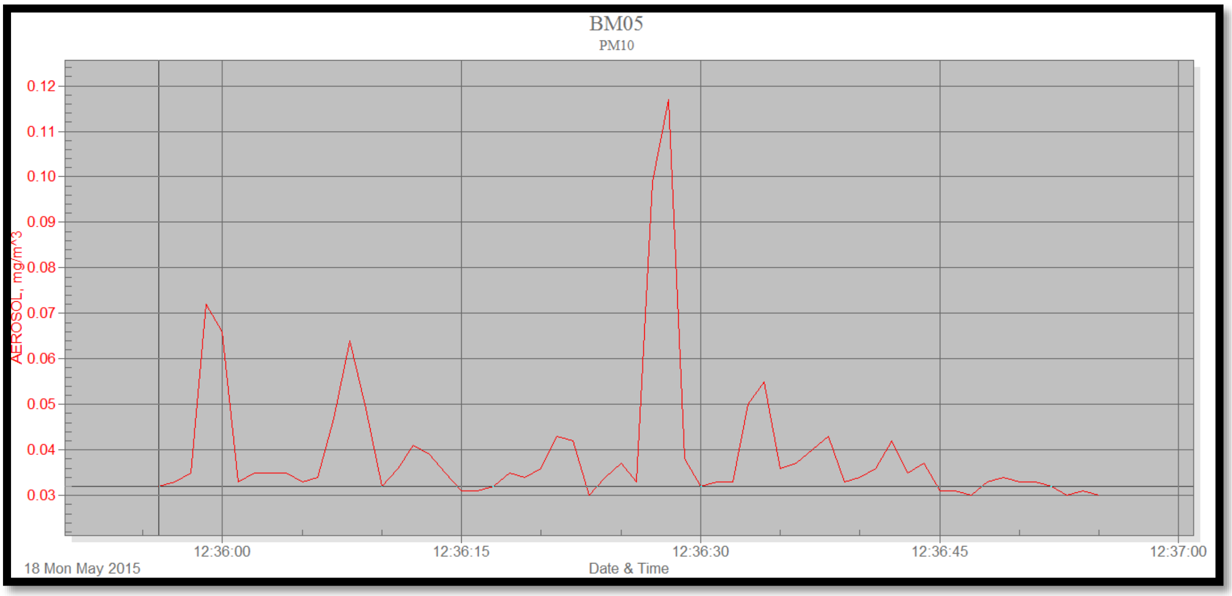

Figure 25: BM05 PM10 Measurements (mg/m3)

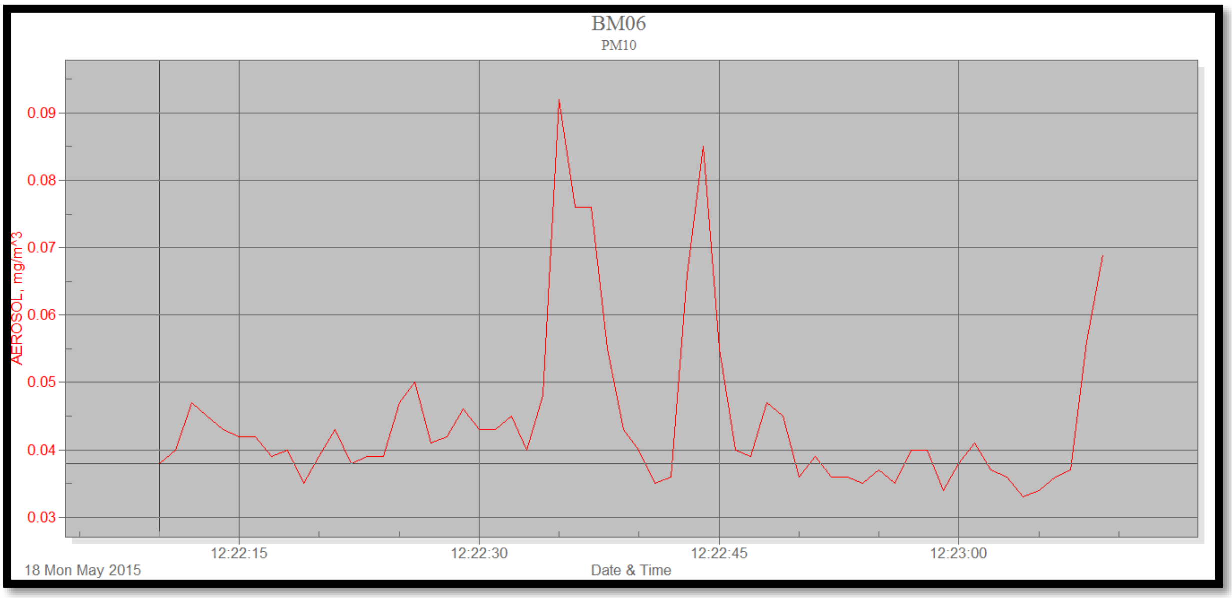

Figure 26: BM06 PM10 Measurements (mg/m3)

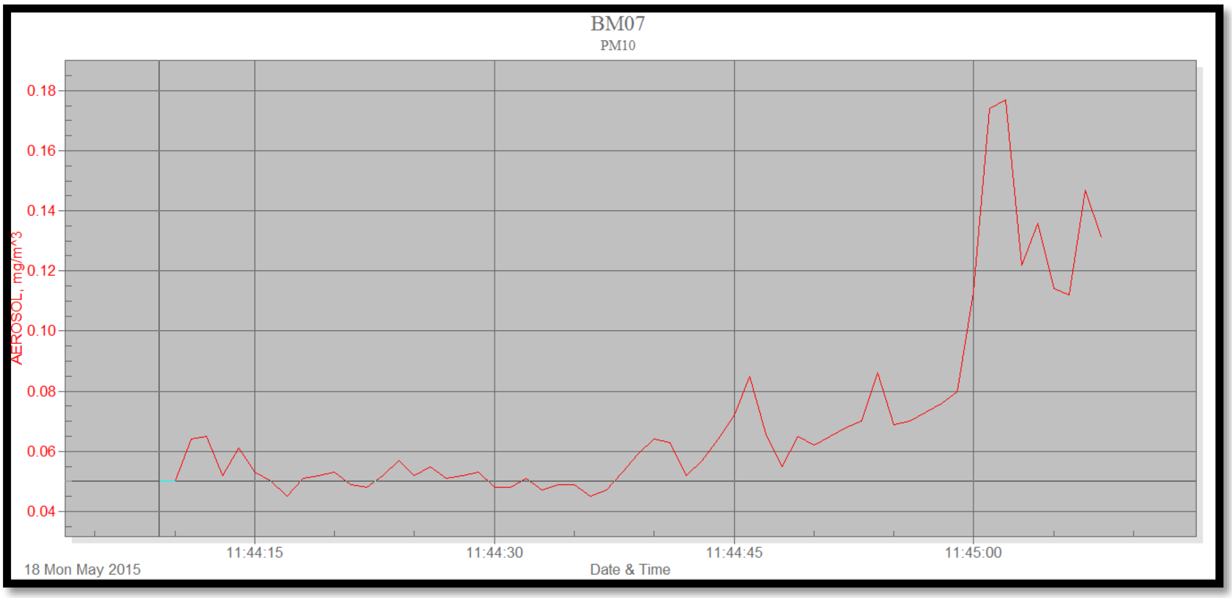

Figure 27: BM07 PM10 Measurements (mg/m3)

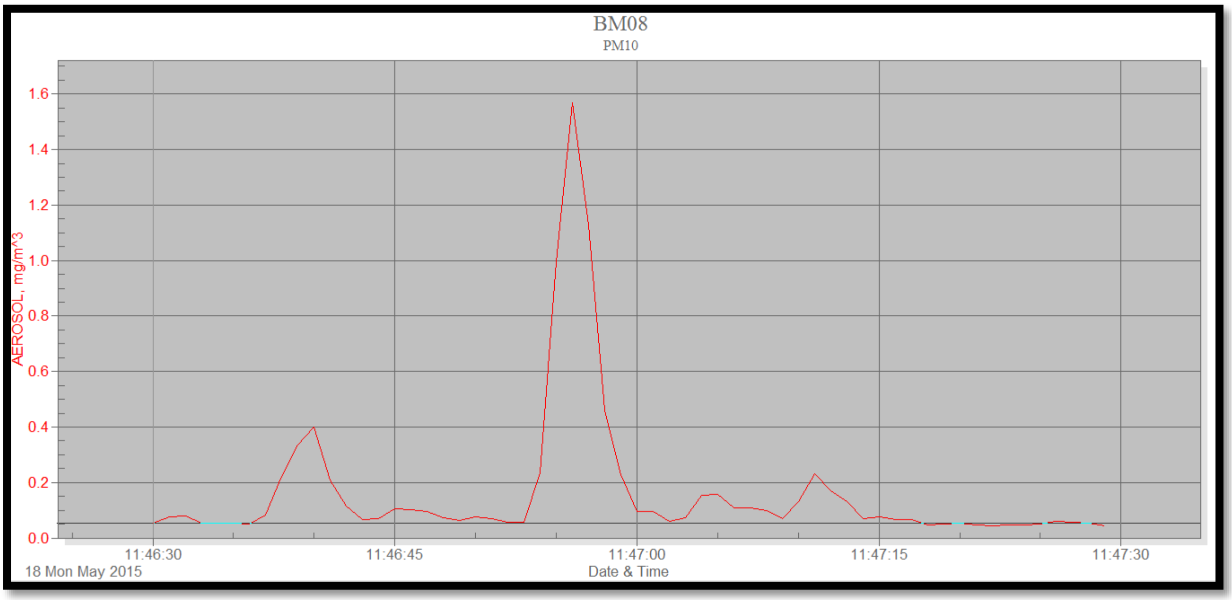

Figure 28: BM08 PM10 Measurements (mg/m3)

8.1 DISCUSSION OF THE BASELINE AIR QUALITY MONITORING RESULTS

SENSITIVE RECEPTORS

Sensitive receptors which have been identified in the immediate vicinity of the study area is the rural community situated to the North in close proximity of the site. Other sensitive receptors in the area might be ecologically related to species existing in the mountainous terrain which are sensitive to dust. Small agricultural plots also exist in the vicinity of the operation. During the baseline monitoring no signs of negative impacts were detected as a result of the mining operation towards these sensitive receptors.

BAELINE AIR QUALITY IMPACTS

Proposed baseline air quality samples for gravimetric dust fallout will be taken for 30day exposure periods which would serve as emission inventory and reference whilst mining commence. It should however be noted that the onsite measurements during the field visit is only applicable to the time period when sampling took place during March 2015 and does not take into account seasonal and other local various that might occur during other months. However, it is still a good general overview of the existing air quality climate.

From the site visits and the desktop study, the following sources been identified as potential pollution causes;

- **Vehicle exhaust gases**

Vehicle exhausts contain a number of pollutants including carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons, oxides of nitrogen (NOx), sulphur and PM10. Tiny amounts of poisonous trace elements such as lead, cadmium and nickel are also present. The quantity of each pollutant emitted depends upon the type and quantity of fuel used, engine size, speed of the vehicle and abatement equipment fitted. Once emitted, the pollutants are diluted and dispersed in the ambient air. Pollutant concentrations in the air can be measured or modelled and then compared with ambient air quality criteria.

- **Veldt fires**

Veld fires are widespread across the world, occurring in autumn, winter and early spring. In addition to controlled burning for fire-breaks and veld management, many fires are set deliberately for mischievous reasons. Some are accidental, notably those started by motorists throwing cigarettes out of car windows. Emissions from veld fires are similar to those generated by coal and wood combustion. Whilst veld fire smoke primarily impacts visibility and landscape aesthetic quality, it also contributes to the degradation of regional scale air quality. Dry combustible material is consumed first when a fire starts. Surrounding live, green material is dried by the large amount of heat that is released when there are veld fires, sometimes this material can also burn. The major pollutants from veld burning are particulate matter, carbon monoxide, and volatile organics. Nitrogen oxides are emitted at rates from 1 to 4 g/kg burned, depending on combustion temperatures. Emissions of sulphur oxides are negligible (USEPA, 1996).

- **Agricultural activities**

Little information is available with respect to the emissions generated due to the growing of crops. The activities responsible for the release of particulates and gasses to atmosphere would however include:

  - Particulate emissions generated due to wind erosion from exposed areas;
  - Particulate emissions generated due to the mechanical action of equipment used for tilling and harvesting operations;
  - Vehicle entrained dust on paved and unpaved road surfaces;
  - Gaseous and particulate emissions due to fertilizer treatment; and
  - Gaseous emissions due to the application of herbicides and pesticides.

- **Current mining activities in the region of the project area**

Mining operations like drilling, blasting, hauling, collection, and transportation are the major sources of emissions and air pollution. The use of explosives releases carbon monoxide (CO). Dust and coal particles stirred up during the mining process, as well as soot released during aggregate transport, contributes to emissions and respiratory problems.

- **Trucks passing on the gravel road, loading and offloading raw materials**

Dust emissions occur when soil is being crushed by a vehicle, as a result of the soil moisture level being low. Vehicles used on the roads will generate PM-10 emissions throughout the area and they carry soils onto the paved roads which would increase entrainment PM-10 emissions. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic.

- **Wind erosion as a result of ROM material, topsoil stockpiles and Tailings Storage Facilities**

The topsoil and waste rock stockpiles generated during the construction phase will be minimal and probably used for construction purposes on site (berm and foundations for buildings), reason being that this will be limited to the adit areas – since the project is mainly an underground operation with limited opencast operations.

At the ROM stockpile, there will be constant transfer of ore from underground to the stockpile and then to the crushing/screening. During milling the ore is ground into wet pulp, and pumped through the flotation circuit. During flotation the ore is split into two streams: Concentrate and Tails. The Tails stream is pumped to the TSF, the Concentrate is filtered and dried, and ready for transport to smelter. The following are the specifications of the different stockpiles which are identified as sources of wind erosion;

- ROM stockpiles
- Waste material stockpiles
- Topsoil stockpiles
- Tailings Storage Facility stockpiles

- **Material handling (loading, hauling and tipping)**

Material handling during loading, hauling and tipping as mining processes has been known to have influence on dust generation in terms of increasing the fugitive dust emissions being generated. With the different kind of materials – topsoil, soft, and hard, tipping will be negligible. The tipping is mostly associated with the ROM at the processing plant vicinity. During these activities factors such as the surrounding wind regime, the material tipping rate, and the moisture content of the material all have an influence on the dust generation at the tipping transfer points.

- **Plant - crushing, screening and washing**

There are two basic methods of crushing, either compressive or impact. The main types within these categories are: Compressive; jaw crushers, single and double toggles, gyratory crushers, cone crushers, roll crushers, ball mills and rod mills. Impact; rotary or vertical shaft impactors (e.g. Barmac), hammer mills (fixed or swing hammers).

Compressive crushing produces dust but does not in itself produce a great deal of air movement, but rather the material passing through the crusher causes the dust from the process and the processed material to become airborne. Excessive clearance under the crusher can cause a lot of dust generation in the same way as a high discharge point. Impact-type crushers, for example hammer mills, act as powerful fans and not only produce dust from the impact of hammer on rock, but also blow the dust out.

Screening provides the most difficult dust control problem in mining operations, particularly if dry screening is taking place. Very careful planning of screen layout has to be undertaken to take out the fine cut as early as possible to lessen the dust carried through the screening process, and allow the use of water to both clean chip and allay dust, as water is the cheapest form of dust suppression there is.

In most cases, the crushing and screening process represents a significant source of fugitive dust with high quantities of respirable fractions released to the atmosphere. Dust sources around the plant, apart from crushing and screening, include discharge into hoppers, long open chutes, and from conveyors and transfer points. High discharge heights produce an air pressure blast effect and create turbulence, which carries dust into the air. This also causes particle fracture, and free fall allows the wind to pick up and carry the dust for a long distance from the discharge point.

CHAPTER 9: FINDINGS

9.1 GENERALISED SITE IMPACTS

The two main impacting sources are wind-blown dust from exposed surfaces and vehicle entrained dust from unpaved roads.

Specific mitigation measured could be included in the design of the mine. For instance, primary crushing and screening chemical dust suppression systems are proposed, and for secondary and tertiary crushing and screening dust extraction systems comprising of wet scrubbers.

A water truck will be operational on the unpaved haul roads. Control techniques for fugitive dust sources generally involve watering, chemical stabilization, and the reduction of surface wind speed though the use of windbreaks and source enclosures. Watering represents a commonly used, relatively inexpensive option, but provides only temporary dust control. Although the chemical treatment of exposed surfaces is more expensive, it provides for longer dust suppression. The use of chemicals may, however, have adverse effects on the receiving biophysical environment if not carefully selected. The construction of windbreaks and source enclosures are not always practical due to the size of many fugitive dust sources (Cowherd *et al.*, 1988; EPA, 1996).

Preventative measures aimed at the reduction of the source extent, or process modifications and adjusted work practices, may also reduce fugitive emissions. Measures aimed at reducing the extent of the source of fugitive dust include: the reduction in the mass of material being handled, the elimination of track-on on paved roads, and the paving of unpaved roads. (Track-on refers to the material carried onto the paved road by vehicles from the unpaved shoulders of paved roads and from adjoining unpaved roads.)

Mitigative measures which entail the periodic removal of deposited material may also be adopted to reduce dust generation. Examples of mitigative control measures include the clean-up of spillage on paved roads (broom and vacuum sweeping) and at conveyor transfer points (Cowherd *et al.*, 1988; EPA, 1996). *Ideally a higher priority should be given to measures aimed at preventing the deposition of materials onto the surface, rather than cleaning up deposited material.*

Exposed surface wind erosion dust generating capacity

Most research on wind eroded dust from exposed surfaces has been done on tailings dams. Since the discard dump is operated in a similar way as tailings impoundments (i.e. fine slimes on the surface and coarser material on the sides), it is believed that the principles in mitigating tailings dam surfaces are the same for discard dumps. Prior to the review of specific dust control measures and their efficiency it is important to note developments in understanding regarding areas of tailings impoundments from which most dust emissions emanate. It was initially believed that wind entrains dust from the top surface of tailings dams with very little being entrained from the side surfaces. Subsequent research, conducted both local and international, has shown that the majority of the dust in entrained from the top one-third of the side slopes facing the prevailing wind direction(s). Such dust may, however, be deposited on the top surfaces of tailings and re-entrained under higher wind speeds (i.e. greater wind velocities are required for deflation at the tailings surface since the approach to surface wind speed ratio is lower). The conclusion reached is that the upper wind-ward slopes of tailings dams are subject to the highest wind erosion losses and therefore need careful attention within dust control plans. The implementation of dust controls on the surface of the tailings reduce the potential for re-entrainment if material is deposited on the surface (Scorgie and Randell, 2002).

Vegetal cover retards erosion by binding the residue with a root network, by sheltering the residue surface and by trapping material already eroded. Vegetation is also considered the most effective control measure in terms of its ability to also control water erosion. In investigating the feasibility of vegetation types the following properties are normally taken into account: indigenous plants; ability to establish and regenerate quickly; proven effective for reclamation elsewhere; tolerant to the climatic conditions of the area; high rate of root production; easily propagated by seed or cuttings; and nitrogen-fixing ability.

The long-term effectiveness of suitable vegetation selected for the site will be dependent on (a) the nature of the cover, and (b) the availability of aftercare. The Department of Minerals and Energy in Western Australia in its Guidelines on the Safe Design and Operating Standards for Tailings Storages (1996), for example, stipulates a covering of a minimum of 500 mm of suitable waste rock, followed by a layer of topsoil (or growth medium) and subsequent seeding. According to these guidelines all external surfaces should have a self-generating cover compatible with the surrounding environment.

Rock cladding or armouring of the sides of tailings dams has been shown in various international studies to be effective in various instances in reducing wind erosion of slopes. Cases in which rock cladding has been found to be effective in this regard generally involve rock covers of greater than 0.5 m in depth (Ritcey, 1989; Jewell and Newson, 1997). Rock cladding on tailings dams has been found to be unlikely to protect the impoundment from water erosion in the event of an overtopping event, or even the long term effects of rainfall.

Unpaved/gravel roads dust control

The haul roads on-site were identified as the second most significant source of dust emissions. Three types of measures may be taken to reduce emissions from unpaved roads: (a) measures aimed at reducing the extent of unpaved roads, e.g. paving, (b) traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds, and (c) measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (EPA, 1987; Cowhert *et al.*, 1988; APCD, 1995). Given the indication that unsurfaced roads would be watered, control efficiencies which may be achieved through wet suppression were investigated. In addition the reduction in vehicle entrainment due to reduced vehicle kilometers travelled are also included.

Permanent improvements in travel surfaces, such as the paving of a road, results in continuous control efficiencies. The control efficiencies obtained by wet suppression and the use of chemical stabilizers are, however, cyclic rather than continuous by nature as indicated previously. The efficiency afforded by the application of water or chemicals decays over time, requiring periodic reapplication to maintain the desired average efficiency (Cowherd *et al.*, 1988). The following empirical model for the estimation of the average control efficiency of watering, developed by the US-EPA (EPA, 1996), can be applied in the estimation of control efficiencies achievable by unpaved road watering programmes:

$$C = 100 - (\frac{0.8pdt}{i})$$

where,

c = average control efficiency (%)

d = average hourly daytime traffic rate (hr-1)

i = application intensity (litres per m2)

t = time between applications (hr)

p = potential average hourly daytime evaporation rate (mm/hr)

9.2 IMPACT ASSESSMENT METHODOLOGY

The level of detail as depicted in the EIA regulations were fine-tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project.

The impact assessment criteria used to determine the impact of the proposed development are as follows:

- ***Nature*** of the impact;
- The ***Source*** of the Impact;
- ***Extent*** - The physical and spatial scale of the impact;
- ***Duration*** - The lifetime of the impact, that is measured in relation to the lifetime of the proposed development;
- ***Intensity*** - The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself;
- ***Probability*** - This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time;
- ***Mitigation***: The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.
- ***Determination of Significance – Without Mitigation****:* Significance is determined through a synthesis of impact characteristics as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required.
- ***Determination of Significance – With Mitigation***: Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the identified mitigation measures.

Previous experience has shown that it is often not feasible or practical to only identify and address possible impacts. The rating and ranking of impacts is often a controversial aspect because of the subjectivity involved in attaching values to impacts. Therefore, the assessment will concentrate on addressing key issues.

The methodology employed will involve a circular route, which will allow for the evaluation of the efficiency of the process itself. The project will be divided into three phases in order to assess impacts related to the Constructional, Operational and Decommissioning & Closure Phases. The assessment of actions in each phase will be conducted in the following order:

a) Identification of key issues;

b) Analysis of the activities relating to the proposed development;

c) Assessment of the potential impacts arising from the activities, without mitigation; and

d) Investigation of the relevant mitigation measures, as well as an assessment of their effectiveness in alleviating impacts.

Table 14: Assessment criteria

EXTENT: GEOGRAPHICAL	
Footprint	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
Site	The impact could affect the whole, or a significant portion of the site.
Regional	The impact could affect the area including the neighbouring properties, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	Where the impact has international ramifications that extent beyond the boundaries of South Africa.
DURATION	
Short term	The impact would either disappear with mitigation or will be mitigated through natural processes in a period shorter than that of the construction phase.
Short – Medium term	The impact will be relevant through to the end of the construction phase.
Medium term	The impact will last up to the end of the development phases, where after it will be entirely negated.
Long term	The impact will continue or last for the entire operational lifetime of the development, but will be mitigated by direct human action or by natural processes thereafter.
Permanent	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.
INTENSITY	
Low	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
Medium	The affected environment is altered, but functions and processes continue, albeit in a modified way.
High	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.
PROBABILITY	
Impossible	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0%).

Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25%.
Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50%.
Highly likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75%.
Definite	The impacts will take place regardless of any provisional plans, and or mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100%.

The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.

Determination of Significance – Without Mitigation

Significance is determined through a synthesis of impacts as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required. Where the impact is positive, significance is noted as "positive". Significance is rated on the following scale:

a) **No significance**: The impact is not substantial and does not require any mitigation action.
b) **Low:** The impact is of little importance, but may require limited mitigation.
c) **Medium:** The impact is of importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impacts to acceptable levels.
d) **High:** The impact is of major importance. Failure to mitigate, with the objective of reducing the impact to acceptable levels, could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.

Determination of Significance – With Mitigation

Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. Significance with mitigation is rated on the following scale:

a) **No significance:** The impact will be mitigated to the point where it is regarded as insubstantial.
b) **Low:** The impact will be mitigated to the point where it is of limited importance.
c) **Low to Medium**: The impact is of importance however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels.

d) **Medium:** Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.

e) **Medium to High:** The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels.

f) **High:** The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

Assessment Weighting

Each aspect within the impact description was assigned a series of quantitative criteria. Such criteria are likely to differ during the different stages of the project's life cycle. In order to establish a defined base upon which it becomes feasible to make an informed decision, it is necessary to weigh and rank all criteria.

Ranking, Weighting and Scaling

For each impact under scrutiny, a scale weighting factor is attached to each respective impact (refer to the figure below). The purposes of assigning such weights serve to highlight those aspects considered most critical to the various stakeholders and ensure that each specialist's element of bias is taken into account. The weighting factor also provides a means whereby the impact assessor can successfully deal with the complexities that exist between the different impacts and associated aspects criteria.

Simply, such a weighting factor is indicative of the importance of the impact in terms of the potential effect that it could have on the surrounding environment. Therefore, the aspects considered to have a relatively high value will score a relatively higher weighting than that which is of lower importance.

Table 15: Assessment parameters and associated weightings

Extent	Duration	Intensity	Probability	Weighting Factor (WF)	Significance Rating (SR)	Mitigation Efficiency (ME)	Significance Following Mitigation (SFM)
Footprint 1	Short term 1	Low 1	Probable 1	Low 1	Low 0-19	High 0,2	Low 0-19
Site 2	Short to medium 2	2	Possible 2	Low to medium 2	Low to medium 20-39	Medium to high 0,4	Low to medium 20-39
Regional 3	Medium term 3	Medium 3	Likely 3	Medium 3	Medium 40-59	Medium 0,6	Medium 40-59
National 4	Long term 4	4	Highly Likely 4	Medium to high 4	Medium to high 60-79	Low to medium 0,8	Medium to high 60-79
International 5	Permanent 5	High 5	Definite 5	High 5	High 80-100	Low 1,0	High 80-100

9.3 PREDICTED IMPACTS

SUMMARSIED IMPACTS ACCORDING TO DEVELOPMENT PHASES

PHASE	ACTIVITIES
Construction Phase	**Activity 1** - Site clearing, removal of topsoil and vegetation
	Activity 2 - Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of adits for mining, etc)
	Activity 3 - General transportation, hauling and vehicle movement on site
Operational Phase	**Activity 4** - Removal of overburden, mineral extraction and backfilling when possible (including drilling/blasting hard overburden & stockpiling)
	Activity 5 - Use and maintenance of haul roads (incl. transportation of minerals to plant);
	Activity 6 – Generation of stockpiles and associated mining waste; and
	Activity 7 - Beneficiation by means of crushing, screening and washing.
Closure and Decommissioning	**Activity 8 -** Demolition & Removal of all infrastructure (incl. transportation off site); and
	Activity 9 - Rehabilitation (spreading of soil, revegetation & profiling/contouring).

CONSTRUCTION PHASE

The following activities during the Construction Phase are identified as possible fugitive emission sources and may impact on the ambient air quality at the relevant environmental sensitive receivers;

- **Activity 1** - Site clearing, removal of topsoil and vegetation.
- **Activity 2** - Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of adits for mining, etc).
- **Activity 3** - General transportation, hauling and vehicle movement on site.

Activity 1	**Site clearing, removal of topsoil and vegetation**
Mining Phase	**Construction Phase**

<table>
<tr><td rowspan="1">Impact description</td><td colspan="3">During this activity, a number of operations take place such as land clearing, topsoil removal, loading of material, hauling, grading, stockpiling, bulldozing and compaction. Initially, topsoil and subsoil will be removed with large scrapers. The topsoil will be stockpiled for rehabilitation in the berm that will surround mining area. It is anticipated that each of the above mentioned operations will have its own duration and potential for dust generation. Fugitive dust (containing TSP (total suspended particulate, will give rise to nuisance impacts as fallout dust), as well as PM10 and PM2.5 (dust with a size less than 10 microns, and dust with a size less than 2.5 microns giving rise to health impacts)) It is anticipated that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This activity will be short-term and localised, seizing after construction activities. Material will be removed by using a bulldozer and then storing this material separately for use during rehabilitation at end of life of mine when the operation cease. These construction sites are ideal for dust suppression measures as land disturbance from clearing and excavation generates a large amount of soil disturbance and open space for wind to pick up dust particles and deposit it elsewhere (wind erosion). Issues with dust can also arise during the transportation of the extracted material, usually by truck and shovel methods, to the stock piles. The dust can further be created by the entrainment from the vehicle itself or due to dust blown from the back of the bin of the trucks during transportation of material to and from stockpiles.</td></tr>
<tr><td rowspan="4">Magnitude</td><td colspan="2">Extent [footprint(1); site(2); regional(3); national(4); international(5)]</td><td>FOOTPRINT</td></tr>
<tr><td colspan="2">Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]</td><td>SHORT</td></tr>
<tr><td colspan="2">Intensity [low(1); medium(3); high(5)]</td><td>LOW</td></tr>
<tr><td colspan="2">Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]</td><td>HIGHLY LIKELY</td></tr>
<tr><td>Weighting factor (WF)</td><td colspan="2">WF [low(1); low-medium(2); medium(3); medium-high(4); high(5)]</td><td>LOW-MEDIUM</td></tr>
<tr><td>Mitigation Efficiency (ME)</td><td colspan="2">ME [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]</td><td>MEDIUM-HIGH</td></tr>
<tr><td rowspan="2">Significance</td><td>Without mitigation (WOM)</td><td colspan="2">(Extent + Duration + Intensity + Probability) x WF = WOM
(1 + 1+ 1 + 4) x 2 = 14
LOW</td></tr>
<tr><td>With mitigation (WM)</td><td colspan="2">WOM x ME = WM
14 x 0.4 =5.6
LOW</td></tr>
<tr><td>Significance With Mitigation (WM)</td><td colspan="3">LOW</td></tr>
</table>

Mitigation Measures	There are various measures that can be implemented to mitigate the impacts of construction activities on atmospheric environment. • Topsoil should not be removed during windy months (August, September and October) due to associated wind erosion heightening dust levels in the atmosphere. • The area of disturbance must be kept to a minimum and no unnecessary clearing of vegetation must occur. • Topsoil should be re-vegetated to reduce the exposure areas. • During the loading of topsoil onto trucks or stockpiles, the dropping heights should be minimised. • Water or other binding agents such as (petroleum emulsions, polymers and adhesives) can be used for dust suppression on earth roads. • When using bulldozers and graders, there is need to minimise travel speed and distance and volume of traffic on the roads. • Stockpiles should not be left for prolonged periods as wind energy generates erosion and causes more dust to form. • It should be noted that emissions generated by wind are also dependent on the frequency of disturbance of the erodible surface and therefore covering the stockpiles with vegetation would reduce the negative erosion effect. • Any crusting of the surface binds the erodable material. • All stockpiles should be damped down, especially during dry weather or re-vegetated (hydroseeding is a good option for slope revegetation). • Successful trialling of broadacre temporary rehabilitation of unshaped overburden emplacement areas by aerial sowing of a cover crop, providing an established vegetative stabilisation to minimise the potential for windblown dust generation • Constricting the areas and time of exposure of pre-strip clearing in advance of mining development

Activity 2	**Construction of surface infrastructure (e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of adits for mining, etc)**	
Mining Phase	**Construction Phase**	
Impact description	During this phase, it is anticipated there will be construction of infrastructure. This will include ventilation shafts, incline shaft portal, access roads, pipes, storm water diversion berms, change houses, admin blocks, drilling, blasting and development of adits for mining, etc. Activities of vehicles on access roads, levelling and compacting of surfaces, as well localised drilling and blasting will have implications on ambient air quality. The above mentioned activities will result in fugitive dust emissions containing TSP (total suspended particulate, giving rise to nuisance impacts as fallout dust). Opencast mining will commence with the clearing of the site and stripping of the vegetation for the initial boxcut. Topsoil and overburden need to be removed and stockpiled separately by means of truck and shovel methods (front end loaders, excavators and haul trucks). Once the rock has been reached will blasting be required to further remove material to the point where the mineral can be extracted. Bulldozing, excavation, drilling and blasting operations will result in the emission of dust to atmosphere. The construction of haul roads take place through removing the topsoil and then grading the exposed surface in order to achieve a smooth finish for vehicles to move on. Temporary stockpiles will be created close to the edge of the road in order to be backfilled easily once the road has expired or need to be rehabilitated.	
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**SHORT-MED**
	Intensity [low(1); medium(3); high(5)]	**MEDIUM**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**HIGHLY LIKELY**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]	**HIGH**
Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** (2 + 2+ 3 + 4) x 3 = 33 **LOW-MEDIUM**

	With mitigation (WM)	**WOM x ME = WM** 33 x 0.2 = 6.6 **LOW**
Significance With Mitigation (WM)	**LOW**	
Mitigation Measures	• Dust emitted during bulldozing activity can be reduced by increasing soil dampness by watering the material being removed thus increasing the moisture content. • Another option would be to time the blasting with wind to ensure the dust will not be blown to the sensitive receptors or especially the community. • Blasting should also not take place when poor atmospheric dispersion are expected i.e. early morning and late evening. • Material need to be removed to dedicated stockpiles to be used during rehabilitation. • This hauling of materials should take place on roads which is being watered and/or sprayed with dust suppressant. • To reduce the amount of dust being blown from the load bin in the haul roads, the material being transported can be watered or the back of the vehicles can be covered with plastic tarpaulin covers. • Constricting the areas and time of exposure of pre-strip clearing in advance of construction to limit exposed soil surfaces	

Activity 3	**General transportation, hauling and vehicle movement on site**	
Mining Phase	**Construction Phase**	
Impact description	Transportation of the workers and materials in and out of mine site will be a constant feature during the construction phase. This will however results in the production of fugitive dust (containing TSP, as well as PM10 and PM2.5) due to suspension of friable materials from earth roads. It is anticipated this activity will be short-term and localised and will seize once the construction activities are finalised. Haul trucks generate the majority of dust emissions from surface mining sites. Observations of dust emissions from haul trucks show that if the dust emissions are uncontrolled, they can be a safety hazard by impairing the operator's visibility. Substantial secondary emissions may be emitted from material moved out from the site during grading and deposited adjacent to roads. Passing traffic can thus loosen and re-suspend the deposited material again into the air. In order to minimize these impacts the stockpiles should be vegetated for the duration that it is exposed	
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**SHORT-MED**
	Intensity [low(1); medium(3); high(5)]	**MEDIUM**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**DEFINITIVE**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]	**MEDIUM-HIGH**
Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** (2 + 2 + 3 + 5) x 3 = 36 **LOW - MEDIUM**
	With mitigation (WM)	**WOM x ME = WM** 36 x 0.4 = 14.1 **LOW**
Significance With Mitigation (WM)	**LOW**	

Mitigation Measures	• Hauling of materials and transportation of people should take place on roads which is being watered and/or sprayed with dust suppressant. • To reduce the amount of dust being blown from the load bin in the haul roads, the material being transported can be watered or the back of the vehicles can be covered with plastic tarpaulin covers. • In order to mitigate the impacts of the activity, the speed limit should be kept to the low as more dust will be generated at higher wind speeds. • Speed limits need to be observed and adhered to. • Management should fit roads with speed humps to ensure adherence. • Application of wetting agents or application of dust suppressant to bind soil surfaces to avoid soil erosion. • The drop heights should be minimised when depositing materials to the ground. • Encourage car-pool and bulk delivery of materials in order to reduce the number of trips generated daily.

OPERATIONAL PHASE

The following activities during the Operational Phase are identified as possible fugitive emission sources and may impact on the ambient air quality at the relevant environmental sensitive receivers:

- **Activity 4** -Removal of overburden, mineral extraction and backfilling when possible (including drilling/blasting hard overburden & stockpiling).
- **Activity 5** - Use and maintenance of haul roads (incl. transportation of minerals to plant).
- **Activity 6** – Generation of stockpiles and associated mining waste.
- **Activity 7** - Beneficiation by means of crushing, screening and washing.

Mining methods vary widely and depend on the location, type and size of mineral resources. Surface mining methods are most economical in situations where mineral deposits occur close to the surface (e.g. coal, salts and other evaporite deposits or road quarry material) or form part of surface deposits (e.g. alluvial gold and diamonds, and heavy mineral sands). For this specific project the mining of chrome by means of surface mining methods are viable due to the fact that the resource is situated close enough to the surface to make it economically mineable, although underground mining techniques will also be employed for the resources located at deeper levels. Typical surface mining methods include: strip mining and open pit mining, as well as dredge, placer and hydraulic mining in riverbeds, terraces and beaches. The Moeijelyk reserve will be mined by means of open pit or also known as opencast mining methods following a roll over rehabilitation sequence and a section of underground mining will also be developed for the remainder of the life of mine. These activities always disrupt the surface and this, in turn, affect soils, surface water and near-surface ground water, fauna, flora and all alternative types of land-use (Fuggle & Rabie, 1996; Ashton, 1999).

Besides the rate and method of mining, the location, variety and scale of mine infrastructure also influences the nature and extent of impacts. The Moeijelyk opencast reserve will be mined relatively quickly in a period of approximately 5 years while the underground section will remain in operation for an anticipated 20 years. The fast opencast mining sequence will ensure impact duration during this phase of the mining is short. Typical mine infrastructure includes: haul roads and spoil dumps; surface facilities (e.g. offices, workshops, car parks and warehouses); tailings and waste rock disposal areas; transport and service corridors (e.g. railway lines, roads, pipelines, conveyers, power and water corridors); product stockpiles; chemicals and fuel storage and housing facilities (Australian Environmental Protection Agency, 1995-1996; Fuggle & Rabie, 1996; Ashton, 1999; Weaver & Caldwell, 1999).

The most economical method of mineral extraction from chrome seams depends on the depth and quality of the seams, and also the geology and environmental factors of the area being mined. The impact of chrome mining processes is generally differentiated by whether they operate on the surface or underground. In this instance the mineral will be won by means of opencast surface mining and underground methods as indicated in the mining plans. Chrome is mined only where technically feasible and economically justifiable. Evaluation of technical and economic feasibility of a potential mine requires consideration of many factors: regional geologic conditions, overburden characteristics, chrome seam continuity, thickness, structure, quality, and depth; strength of materials above and below the seam for roof and floor conditions; topography (especially altitude and slope); climate; land ownership as it affects the availability of land for mining and access; surface drainage patterns; ground water conditions; availability of labour and materials; coal purchaser requirements in terms of tonnage, quality, and destination; and capital investment requirements.

The Moeijelyk operation proposes to use the rollover mining and rehabilitation method during opencast operations. Roll-over opencast mining is typical of small scale opencast mining operations. The proposed mining entails both opencast and underground methods for this stage of the project. The opencastable reserves will be mined in conventional truck and shovel mining methods using the lateral roll-over technique in a single direction. This would mean mining from the one side of the development footprint in a linear fashion towards the opposite side while backfilling and rehabilitating the area that has already been mined, thus creating the effect that the mining cuts are rolling over in a single direction. Sustainable development applied to mining works necessarily includes rehabilitation with the aim of either restoring the land to its original use, or eliminating or reducing adverse environmental impacts to a long-term acceptable condition. The process is driven primarily by legislation which ensures that the mine owner must comply with the intention of achieving those end conditions, which are defined in broad terms by guidelines.

Activity 4	**Removal of overburden, mineral extraction and backfilling when possible (including drilling/blasting hard overburden & stockpiling)**		
Mining Phase	**Operational Phase**		
Impact description	In order to transport mined PGM material to surface a number of activities are conducted simultaneously, including the transportation of machinery to opencast and underground, as well as materials and workforce. This will be followed by followed by subsequent drilling and blasting activities underground and above surface, crushing and hauling of materials to the surface. Drilling is an intermittent exercise that emits fugitive dust. There will be fumes from diesel trucks transporting ore to the conveyor belt. The conveyor belts deposit the minerals into the crusher, the crushing process releases fugitive dust. Activities by machinery underground will lead to exhaust fumes from vehicles and dust from drilling and blasting processes. Fugitive dust (containing TSP, as well as PM10 and PM2.5) occurs as a result of the aforementioned processes.		
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]		**FOOTPRINT**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]		**LONG**
	Intensity [low(1); medium(3); high(5)]		**MEDIUM**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]		**DEFINITIVE**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]		**MEDIUM-HIGH**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]		**MEDIUM**
Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** (1 + 4 + 3 + 5) x 4 = 52 **MEDIUM**	

	With mitigation (WM)	**WOM x ME = WM** 52 x 0.6 = 31.2 **LOW - MEDIUM**
Significance With Mitigation (WM)	**LOW - MEDIUM**	
Mitigation Measures	• Drilling by the nature of the action required to drill holes can produce a lot of dust. Drilling rigs for hole diameters over 50 mm generally have their own dust collectors which suck the drill cuttings to a large cyclone separator on board, which dumps the larger cuttings (over 2-3 mm); the finer dust is collected on filter elements and dumped by intermittent reverse air pulses through the elements. Cyclones can be use in many other applications and present a very good method of capturing dust. • Use of pre-blast environmental checklists, real-time weather monitoring data and stringent controls on blasts carried out in sensitive areas • A no-blast arc is automatically calculated for the nearest private residence based on the latest relevant weather conditions, including wind speed and direction, temperature inversions and amount of atmospheric turbulence (i.e. stability category) before the blast can be fired • Respiratory protection should only be used to control the dust exposures where other dust collection or suppression systems have not been able to reduce the dust to acceptable levels. • When using hand held rock drills efforts should be made to control dust at source e.g. water injection or extraction. If control of dust at source is not practicable then respiratory protection should be used. • Low or in-pit dumping of overburden during high wind conditions • There is need to have water sprays. • Filtration systems can be utilised to remove the pollutants from the underground air prior to their release to the surface via the vent. • Use of efficient diesel fuel for heavy underground machinery. • Successful trialling of broadacre temporary rehabilitation of unshaped overburden emplacement areas by aerial sowing of a cover crop, providing an established vegetative stabilisation to minimise the potential for windblown dust generation • Constricting the areas and time of exposure of pre-strip clearing in advance of mining development	

Activity 5	**Use and maintenance of haul roads (incl. transportation of minerals to plant)**	
Mining Phase	**Operational Phase**	
Impact description	Transportation of the workers and materials in and out of mine site will be a constant feature during the operational phase. This will however results in the production of fugitive dust (containing TSP, as well as PM10 and PM2.5) due to suspension of friable materials from earth roads. It is anticipated this activity will be long-term and regional and will seize once the life of mine has been reached. Haul trucks generate the majority of dust emissions from surface mining sites. Observations of dust emissions from haul trucks show that if the dust emissions are uncontrolled, they can be a safety hazard by impairing the operator's visibility. Substantial secondary emissions may be emitted from material moved out from the site during grading and deposited adjacent to roads. Passing traffic can thus loosen and re-suspend the deposited material again into the air. In order to minimize these impacts the stockpiles should be vegetated for the duration that it is exposed.	
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]	**REGIONAL**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**LONG**
	Intensity [low(1); medium(3); high(5)]	**MEDIUM**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**HIGHLY LIKELY**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]	**MEDIUM-HIGH**

Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** (3 + 4 + 3 + 4) x 3 = 42 **MEDIUM**
	With mitigation (WM)	**WOM x ME = WM** 42 x 0.4 = 16.8 **LOW**
Significance With Mitigation (WM)	**LOW**	
Mitigation Measures	• Formulation and implementation of sound management plans for all operations likely to create dust • Planting plenty of trees or hedges as shelterbelts to eliminate or minimise wind disturbance • Planning operations to maximise the benefit of wind breaks • Disturbed areas such as those caused by stripping off grass and topsoil should be kept to a minimum • Haul roads and standing areas should be sealed or concreted where possible • Use water sprays or water carts to settle dust. Care must be taken to ensure that the water used is free from pollution by noxious matter. There are additives available that reduce the volume of water used, and increase its effectiveness, but approval to use them should be obtained from the local territorial authority. • Use of a global positioning system as a tool to track the locations of mining and dust suppression equipment (e.g. water carts) and cross-referencing this information with real-time weather monitoring to assist with dust control • Use of water sprays at each contact or transfer point along the conveyance system which have adjustable rates of application (low, medium and high) depending on dust levels • Automatic water sprays installed at the ROM hopper bin that produce a fine mist to suppress dust generated with the triggering of sensors when a truck enters the dump zone and automatic sprays activated until a set time following the departure of the truck • Use of a reclaim tunnel at the product stockpile and an enclosed conveyor to transfer minerals to the loader, both of which minimise dust generation • Use of a retractable telescopic chute with curtains to load minerals into transport trucks • Speed restrictions should be imposed and enforced • Cabs of machines should be swept or vacuumed regularly to remove accumulated dust • Exhaust pipes of vehicles should be directed so that they do not raise dust • Engine cooling fans of vehicles should be shrouded so that they do not raise dust • Hard surfaced haul roads or standing areas should be washed down and swept to remove accumulated dust	

Activity 6	**Generation of stockpiles and associated mining waste**	
Mining Phase	**Operational Phase**	
Impact description	Most significant waste is produced from the operational phase as there is a significant amount of waste rock removed and tailings generated during beneficiation. Since this is going to be an underground and opencast operation, the topsoil generated will be minimal. However, there will be waste rock stockpiles generated from the underground process. Hazardous products include fuel, explosives and waste or sewage. Hazardous materials and waste impacts are related to the types, amount of equipment and machinery used for the phase. It includes evaporation of diesel fuel and heavy fuel from temporary tanks and possible spills during loading of fuel from tanks on site that are used for re-fuelling of heavy machinery and trucks. Some of the waste produced includes waste oils, chemicals and hazardous chemicals. After beneficiation at the plant the remainder of the tailings will also need to be stored on tailings storage facilities which are prone to dust generation as a result of the erosion forces related to wind velocity.	
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**LONG**
	Intensity [low(1); medium(3); high(5)]	**MEDIUM**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**HIGHLY LIKELY**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM-HIGH**

<table>
<tr><td>Mitigation Efficiency (ME)</td><td colspan="2">ME [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]</td><td>MEDIUM</td></tr>
<tr><td rowspan="2">Significance</td><td>Without mitigation (WOM)</td><td colspan="2">(Extent + Duration + Intensity + Probability) x WF = WOM
(2 + 4 + 3 + 4) x 4 = 52
MEDIUM</td></tr>
<tr><td>With mitigation (WM)</td><td colspan="2">WOM x ME = WM
52 x 0.6 = 31.2
LOW-MEDIUM</td></tr>
<tr><td>Significance With Mitigation (WM)</td><td colspan="3">LOW-MEDIUM</td></tr>
<tr><td>Mitigation Measures</td><td colspan="3">
Automatic sprays installed around the perimeter of the ROM stockpile activated when the wind speed is >6 m/sec (averaged over 15 minutes)
Finished product stockpiles formed on an as-needs basis with stockpiled minerals loaded out by truck as soon as possible
A tree windbreak located downwind of the prevailing wind direction to minimise dust from the finished product stockpiles
Topsoil handling and storage procedures including stockpile inventory, vegetative cover and signage to optimise rehabilitation and minimise wind erosion
Successful trialling of a chemical dust suppressant on haul roads resulting in a considerable reduction in the amount of water used for dust suppression on haul roads
Dust from stockpile sources can be contained in an enclosure, the use of plastic or other material cover, compaction of the surface and the use of water or sprays, trees and careful citing of stockpiles
In summary, care and planning of sites for plant, haul roads and stockpiles will help in reducing problems with nuisance dust. For existing plants, care must be taken to ensure the dust suppression system used fits in with the products produced and is easily used and maintained
There is a need to develop a waste management plan.
This will identify anticipated liquid and solid waste streams and will ensure thorough inspection and waste minimisation procedures, storage locations, and waste-specific management and disposal requirements.
Optimum material handling and recycling strategy should be enforce by management and strict adherence on the part of workers during the operation phase.
There is need to understand the process that generates waste and monitoring constantly to observe if there are changes in the waste or the waste characteristics in order to minimize stockpiles.
Successful trialling of broadacre temporary rehabilitation of unshaped overburden emplacement areas by aerial sowing of a cover crop, providing an established vegetative stabilisation to minimise the potential for windblown dust generation.
Constricting the areas and time of exposure of pre-strip clearing in advance of mining development in turn limiting stockpile requirements.
</td></tr>
</table>

Activity 7	Beneficiation by means of crushing, screening and washing		
Mining Phase	**Operational Phase**		
Impact description	In this activity, the use of the primary and secondary crusher and TSF are the most likely to have implications on ambient air quality. The crushing process releases fugitive dust, especially if there are no enclosure and water sprays. Dust contained within the RoM ore can be released into the atmosphere during this process i.e. fugitive dust (containing TSP, as well as PM10 and PM2.5). Wind erosion from TSF can be a perennial source of dust if not properly managed during and post mining operations. The plant, crushing and screening areas all have the potential to generate dust and therefore specific mitigation measures can be assigned to each of these activities.		
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]		**FOOTPRINT**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]		**LONG**
	Intensity [low(1); medium(3); high(5)]		**HIGH**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]		**DEFINITIVE**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]		**HIGH**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]		**MEDIUM-HIGH**
Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** (1 + 4 + 5 + 5) x 5 = 75 **MEDIUM-HIGH**	
	With mitigation (WM)	**WOM x ME = WM** 75 x 0.4 = 30 **LOW-MEDIUM**	
Significance With Mitigation (WM)	**LOW-MEDIUM**		

<table>
<tr>
<td>Mitigation Measures</td>
<td>
Plant

Fog Suppression System
Dust extraction hoods and cyclones and/or bag filters
Conventional water sprays, whose performance can be enhanced with the addition of wetting agents that assist in water to dust particle contact, lessening the amount of water required
Locating plant so that it is sheltered from the prevailing wind and the introduction of plant shelterbelts

Crushing

Dust can be reduced by providing a controlled fine water spray system that directs water onto the input material before it enters the crusher (be careful not to over water as this can cause further problems down the production process)
Dust extractor hoods and cyclone collectors and/or bag filters. This is particularly suitable for use on the output chute or stone box under the crusher
Where practicable, stone boxes on process plants can direct and slow the fall of material onto conveyor belts, and thus the amount of dust generated at transfer points
Crushing often requires constant supervision; therefore some extra operator protection at this typically dusty process is almost always required
In order to reduce dust contamination in crusher control rooms and operator's positions, these areas should be completely enclosed and ventilated with uncontaminated air to create a positive air pressure
Thus it may be necessary to provide air conditioning so the operator has no need to open doors or windows
Protection of the control room will, in addition to creating a healthier environment, protect the electrical equipment from dust contamination that may lead to malfunctioning.
Fog Suppression System is another method

Screening

In order to control dust in dry screening, the conventional method is to place a hood over the total screen area with rubber curtains sealing to the screen sides
To be effective the screens and discharge chutes should be sealed to the bins to prevent currents of air carrying fine dust away into the surrounding area, and the screen house building must be well sealed or dust will escape
Desirable elements for effective control are enclosed screens; enclosed transfer points, covered conveyors and chutes, and sealed bins. In theory it is then only necessary to deal with dust-laden air in the controlled area. As an aid to creating these conditions, extensive use can be made of specially developed rubber sheet covering that can be removed for maintenance and the inevitable blockage
A careful summary of what permanent sealing and what removable sealing can be done should be carried out before determining the degree of further dust control, which may need to be applied
Ducting from each plant item and transfer point may be connected to a filter system. Each item can either have its own filter or be ducted through to a central collector, usually a cyclone or bag filter system, or an electrostatic precipitator. The electrostatic precipitator is very efficient, but is an expensive item to buy. They are usually used where there is a large amount of dust produced
Metal sheeting or rubber panels normally achieve the enclosure of equipment, plus rubber seals at the joints. The use of rubber sheeting panels has grown recently, as it is easily removed and replaced for maintenance purposes
An important factor in the enclosure of a screen or the enclosing of any machinery is that adequate clearance must be allowed for moving parts, and account should be taken of potential temperature build-up in bearings and gearboxes. Further limitation on the discharge of dust can be achieved by the complete housing of the plant

</td>
</tr>
</table>

DECOMISSIONING AND CLOSURE PHASE

It is assumed that the decommissioning activities will only take place during daylight hours. The following activities during the Decommissioning & Closure phase are identified as possible air impacting sources and may impact on the ambient air quality at the relevant sensitive receivers:

- **Activity 8 -** Demolition & Removal of all infrastructure (incl. transportation off site).
- **Activity 9 -** Rehabilitation (spreading of soil, revegetation & profiling/contouring).

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The following activities are associated with the decommissioning phase (US-EPA, 1996):

- Existing buildings and structures demolished, rubble removed and the area levelled;
- Remaining exposed excavated areas filled and levelled using overburden recovered from stockpiles;
- Stockpiles to be smoothed and contoured;
- Topsoil replaced using topsoil recovered from stockpiles; and
- Disturbed land prepared for revegetation.

Possible sources of fugitive dust emission during the closure and post-closure phase include:

- Smoothing of stockpiles by bulldozer;
- Grading of sites;
- Transport and dumping of overburden for filling;
- Infrastructure demolition;
- Infrastructure rubble piles;
- Transport and dumping of building rubble;
- Transport and dumping of topsoil; and
- Preparation of soil for revegetation – ploughing and addition of fertiliser, compost etc.

Exposed soil is often prone to erosion by water. The erodability of soil depends on the amount of rainfall and its intensity, soil type and structure, slope of the terrain and the amount of vegetation cover (Brady, 1974). Revegetation of exposed areas for longterm dust and water erosion control is commonly used and is the most cost-effective option. Plant roots bind the soil, and vegetation cover breaks the impact of falling raindrops, thus preventing wind and water erosion. Plants used for revegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings.

Activity 8	Demolition & Removal of all infrastructure (incl. transportation off site)	
Mining Phase	**Closure and Decommissioning Phase**	
Impact description	During this activity, there is demolition of buildings and foundation and subsequent removal of rubbles generated. There is cleaning-up of workshops, fuels and reagents, removal of power and water supply, removal of haul and access roads. Potential for impacts during this phase will depend on the extent of demolition and rehabilitation efforts during closure as well as features which will remain. The impacts on the atmospheric environment during the decommissioning phase will be similar to the impacts during the construction phase. The process includes dismantling and demolition of existing infrastructure, transporting and handling of topsoil on unpaved roads in order to bring the site to its initial/rehabilitated state. Demolition and removal of all infrastructures will cause fugitive dust emissions. The impacts will be short-term and localised. Any implication or implications this phase will have on ambient air quality will seize once the activities are finalised.	
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**SHORT-MEDIUM**
	Intensity [low(1); medium(3); high(5)]	**HIGH**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**HIGHLY LIKELY**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**MEDIUM**
Mitigation Efficiency (ME)	**ME** [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]	**MEDIUM**
Significance	**Without mitigation (WOM)**	**(Extent + Duration + Intensity + Probability) x WF = WOM** (2 + 2 + 5 + 4) x 3 = 39 **LOW-MEDIUM**
	With mitigation (WM)	**WOM x ME = WM** 39 x 0.6 = 23.4 **LOW-MEDIUM**
Significance With Mitigation (WM)	**LOW-MEDIUM**	
Mitigation Measures	• Demolition should not be performed during windy periods (August, September and October), as dust levels and the area affected by dust fallout will increase. • The area of disturbance must be kept to a minimum, as demolition should be done judiciously avoid the exposure of larger areas to wind erosion. • Speed restrictions should be imposed and enforced. • Cabs of machines should be swept or vacuumed regularly to remove accumulated dust. • Exhaust pipes of vehicles should be directed so that they do not raise dust. • Engine cooling fans of vehicles should be shrouded so that they do not raise dust. • Hard surfaced haul roads or standing areas should be washed down and swept to remove accumulated dust. • Dust suppression of roads being used during rehabilitation should be enforced.	

Activity 9	Rehabilitation (spreading of soil, revegetation & profiling/contouring)	
Mining Phase	**Closure and Decommissioning Phase**	
Impact description	During this activity, there is the reshaping and restructuring of the landscape. Since this is an underground operation, the area to be reconstructed will be limited to the adit area(s). Topsoil can be imported to reconstruct the soil structure. There is less transfer of soil from one area to other therefore negligible chances of dust through wind erosion. Profiling of TSF ans waste rock dump to enhance vegetation cover and reduce wind erosion from such surfaces post mining. Adits and vent shafts will be sealed to avoid the release of gases from underground from several reactions that might take place once mining stops, as this would have implications on ambient air quality.	
Magnitude	**Extent** [footprint(1); site(2); regional(3); national(4); international(5)]	**SITE**
	Duration [short(1); short-med(2); medium(3); long(4); permanent(5)]	**SHORT-MEDIUM**
	Intensity [low(1); medium(3); high(5)]	**LOW**
	Probability [probable(1); possible(2); likely(3); highly likely(4); definite(5)]	**HIGHLY LIKELY**
Weighting factor (WF)	**WF** [low(1); low-medium(2); medium(3); medium-high(4); high(5)]	**LOW-MEDIUM**

<table>
<tr><td>Mitigation Efficiency (ME)</td><td colspan="2">ME [high(0.2); medium-high(0.4); medium(0.6); low-medium(0.8); low(1.0)]</td><td>MEDIUM-HIGH</td></tr>
<tr><td rowspan="2">Significance</td><td>Without mitigation (WOM)</td><td colspan="2">(Extent + Duration + Intensity + Probability) x WF = WOM
(2 + 2 + 1 + 4) x 2 = 18
LOW</td></tr>
<tr><td>With mitigation (WM)</td><td colspan="2">WOM x ME = WM
18 x 0.4 = 7.2
LOW</td></tr>
<tr><td>Significance With Mitigation (WM)</td><td colspan="3">LOW</td></tr>
<tr><td>Mitigation Measures</td><td colspan="3">• Revegetation of exposed areas for longterm dust and water erosion control is commonly used and is the most cost-effective option.
• Plants with roots that bind the soil, and vegetation cover should be used that breaks the impact of falling raindrops, thus preventing wind and water erosion.
• Plants used for revegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings.
• The area of disturbance must be kept to a minimum, as demolition should be done judiciously avoid the exposure of larger areas to wind erosion.
• Spreading of soil must be performed on less windy days.
• The bare soil will be prone to erosion and therefore there is need to reduce the velocity near the surface of the soil by re-vegetation.
• Leaving the surface of the soil in a coarse condition reduces wind erosion and ultimately reduces the dust levels.
• Additional mitigation measures include keeping the soil moist using sprays or water tanks, using wind breaks.
• The best time to re-vegetate the area must be linked to the distribution and reliability of the rainfall.
• Speed restrictions should be imposed and enforced.
• Cabs of machines should be swept or vacuumed regularly to remove accumulated dust.
• Exhaust pipes of vehicles should be directed so that they do not raise dust.
• Engine cooling fans of vehicles should be shrouded so that they do not raise dust.
• Hard surfaced haul roads or standing areas should be washed down and swept to remove accumulated dust.
• Dust suppression of roads being used during rehabilitation should be enforced.
• It is recommended that the rehabilitation by vegetating should begin during the operational phase already as the objective is to minimise the erosion.
• These measures should be aimed to reduce the potential for fugitive dust generation and render the impacts on ambient air quality negligible.</td></tr>
</table>

CHAPTER 10: MONITORING PROGRAMME

Moeijelyk mine conducted dust monitoring campaign for one month during April-May 2015 and results are presented in this report. It is advised that Moeijelyk should commission a dust monitoring network even before the operation is implemented again in order to gather sufficient baseline information of the existing conditions on site and take into account possible seasonal variations. It is advised that such monitoring be continue after the current monitoring period expires, for the project life in order to establish historical repository of data needed to fully understand/address fugitive and airborne dust emissions from the construction, operation and closure activities. Managing dust fallout effectively will result in the reduction of respiratory diseases that are as a result of air pollution, reduced risk of damage to property, improved visibility, and fewer disturbances to existing flora and fauna habitats.

Gravimetrical Dust Fallout – (milligram/square meter/day) or (mg/m^2/day) (monthly 8 samples)

Site layout for the sampling points must be carried out according to the eight main compass directions; the site layout and equipment placement must be done in accordance with the ASTM standard, D 1739 – 2010, thereafter relevant sampling reference numbers will be allocated to the receptors accordingly. At each gravimetric dust fallout gauge/receptor point there is a stand built according to specification containing the dust sample collection bucket. Samples will be collected after a 1 month running period (+-30days exposure). After sample collection the samples are taken to the relevant SANAS accredited laboratory as required. A visual site investigation is done where after correlations and drawn and findings are identified and reported on.

Dust buckets of a standard size and shape are prepared and set up at locations related to the eight main compass points (currently limited to six sampling points due to sampling site in process of obtaining two more monitoring gauges) on the borders of the property so that dust can settle in them for periods of 30+/-2 days. The dust buckets is then sealed and replaced with new empty ones and send away to the SANAS accredited laboratory for analysis. The masses of the water-soluble and –insoluble components of the material collected are then determined and results are reported as mg/m^2/day. This methodology is described according to South African National Standards 1929:2004 and the American Society for Testing and Materials (ASTM) Designation: D 1739-98 (2010). The results for this method of testing are obtained by gravimetrical weighing. The apparatus required include open top buckets/containers not less than 150mm in diameter with a height not less than twice its diameter. The buckets must be placed on a stand at a height of 2+/-0.2m above the ground.

Particulate matter PM10 (monthly 8 samples)

As reported previously, Moeijelyk conducted PM10 monitoring during the period of May 2015. The client should re-establish a fine particulate monitoring programme, which should include one particulate instrument to monitor PM10 and preferably PM2.5 from the mine operation. PM10 instrument that could be used can be similar to the one used during this investigation. The handheld sampling instrument not only allows for sampling in the 8 main wind directions, but also on-site sampling down-wind of potential dust sources to quantify and determine impacts that need to be managed. It is advised to conduct this sampling on a monthly basis but also when the need arise during periods of elevated dust concentrations being emanated from the site.

CHAPTER 11: CONCLUSION

The findings reported here are a mixture of historical, observed and previously modelled data and provided the background and predicted scenario of various pollutants in the Moeijelyk mining area. The samples taken during the baseline assessment indicated that the existing air quality on site is very good and within the legal limits.

The gravimetric dust fallout results taken during Aptil-May 2015 over an exposure period of 30 days indicated values as little as 98mg/m^2/day to 174mg/m^2/day in general (excluding BM02 outlier) which is within the lower threshold of the residential limit of 600mg/m2/day. The highest concentration of dust was observed next to areas of exposed soil and gravel roads which is currently being used by occupants of the land on the proposed development area.

The PM10 results taken during the May 2015 sampling period were also very low and ranged between 35ug/m^3 and 163ug/m$^{3.}$ It should be noted that PM10 concentrations vary significantly as a result of not only fugitive dust emissions but also the atmospheric conditions on site. Currently all the sampling points were within the legal limit of 120ug/m3 except BM08 at 163ug/m^3.

Based on the results presented the following recommendations are outlined:

- It is recommended that ambient air quality monitoring be undertaken to establish the baseline condition prior to the onset of operations on-site and in order to establish the level at which the proposed operations are noted to impact on the ambient air quality.
- Fallout monitoring should be included to assess the level of nuisance dust associated with both mining and process related operations. Sampling of fallout should be undertaken within the neighbouring areas as well as on-site. Dust fallout monitoring should ideally be located on-site, around the pit and shafts, at the crusher and in the vicinity of major storage stockpiles.
- Indicative PM10 and PM2.5 dust monitoring must also be undertaken at the same sites as mentioned under the previous bullet but also in and around potential fugitive emission sources to determine mitigation measures and focus management efforts

The most significant impacts for the proposed mine includes the storage of ROM stockpile, TSF, waste rock stockpiles, use of the crushing and screening facility, general transportation and hauling and the release of gaseous pollutants from the ventilation shafts. The mitigation and management measures discussed in section 9 of this report should be sufficient to ensure the mining operation can be conducted with minimal impact on the receiving environment and therefore not have a detrimental effect.

The study area is situated in a region which already experience affected air quality as a result of current mining activities, agricultural activities and the use of gravel roads in relative close proximity to the proposed site. Through the implementation of the management and mitigation measures and continuous compliance monitoring should the potential impact of the proposed Moeijelyk Chrome Mine be minimal on the receiving environment and can it be mitigated to an extent where the significance will be low and acceptable within the tolerable level. It can therefore be concluded that the proposed project could go forward without a detrimental impact on the environment given the sound implementation of the management, mitigation and monitoring measures as presented throughout this report.

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ANNEXURE 1 – LABORATORY CERTIFICATE OF ANALYSIS

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CERTIFICATE OF ANALYSES
WATER QUALITY PARAMETERS

Date received: 2015 - 05 - 25 Date completed: 2015 - 06 - 12

Project number: 1000 Report number: 52349 Order number: -

Client name: Eco Elementum Contact person: Mr. H. Engelbrecht

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Analyses	Method Identification	Sample Identification: Bauba Moeijelik			
		BM01		BM02	
Sample Number		7224		7225	
Units		mg	mg/m²/day	mg	mg/m²/day
Dust Fallout	WLAB057	119	174	2 516	3 695

Analyses	Method Identification	Sample Identification: Bauba Moeijelik			
		BM03		BM04	
Sample Number		No Sample		7226	
Units		mg	mg/m²/day	mg	mg/m²/day
Dust Fallout	WLAB057	---	---	85	124

Analyses	Method Identification	Sample Identification: Bauba Moeijelik			
		BM05		BM06	
Sample Number		7227		7228	
Units		mg	mg/m²/day	mg	mg/m²/day
Dust Fallout	WLAB057	67	98	77	113

Analyses	Method Identification	Sample Identification: Bauba Moeijelik			
		BM07		BM08	
Sample Number		7229		7230	
Units		mg	mg/m²/day	mg	mg/m²/day
Dust Fallout	WLAB057	102	149	70	103