A Final Air Quality Impact Assessment Report for Coal of Africa Limited (Pty) Ltd: Chapudi Project

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Glossary

Air quality A measure of exposure to air which is not harmful to your health. Air quality is measured against health risk thresholds (levels) which are designed to protect ambient air quality. Various countries including South Africa have Air Quality Standards (legally binding health risk thresholds) which aim to protect human health due to exposure to pollutants within the living space.

Ambient air The air of the surrounding environment.

Baseline The current and existing condition before any development or action.

Boundary layer In terms of the earth's planetary boundary layer is the air layer near the ground affected by diurnal heat, moisture or momentum to or from the surface.

Concentration When a pollutant is measured in ambient air it is referred to as the concentration of that pollutant in air. Pollutant concentrations are measured in ambient air for various reasons, i.e. to determine whether concentrations are exceeding available health risk thresholds (air quality standards); to determine how different sources of pollution contribute to ambient air concentrations in an area; to validate dispersion modelling conducted for an area; to determine how pollutant concentrations fluctuate over time in an area; and to determine the areas with the highest pollution concentrations.

Condensation The change in the physical state of matter from a gaseous into liquid phase.

Dispersion potential The potential a pollutant has of being transported from the source of emission by wind or upward diffusion. Dispersion potential is determined by wind velocity, wind direction, height of the mixing layer, atmospheric stability, presence of inversion layers and various other meteorological conditions.

Emission The rate at which a pollutant is emitted from a source of pollution.

Emission Factor A representative value, relating the quantity of a pollutant to a specific activity resulting in the release of the pollutant to atmosphere.

Evaporation The opposite of condensation

Inversion An increase of atmospheric temperature with an increase in height.

Mixing layer The layer of air within which pollutants are mixed by turbulence. Mixing depth is the height of this layer from the earth's surface

Oxides of Nitrogen Refers to NO and NO_2. The gas is produced during combustion especially at high temperatures.

Particulate matter (PM) The collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface and includes dust, smoke, soot, pollen and soil particles. Particulate matter is classified as a criteria pollutant, thus national air quality standards have been developed in order to protect the public from exposure to the inhalable fractions. 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:

* 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.

Precipitation Ice particles or water droplets large enough to fall at least 100 m below the cloud base before evaporating.

Relative Humidity The vapour content of the air as a percentage of the vapour content needed to saturate air at the same temperature

Sulphur dioxide A toxic gas with the chemical formula of SO_2. It has a pungent, irritating smell that is released by various industrial processes.

1 INTRODUCTION

Royal HaskoningDHV was requested by Jacana Environmentals CC to carry out an Air quality Impact assessment as part of the mining rights application for the establishment of the Chapudi Project area for Coal of Africa Limited, in the Soutpansberg area of Limpopo. The Chapudi Project area consists namely of Chapudi and Chapudi West which covers an area of 4321 ha and Wildebeesthoek which covers an area of approximately 3254 ha (Figure 1.1). The type of mining methodology planned for the Chapudi project is open pit mining, which involves stripping, blasting, loading and hauling of overburden and ROM coal. The current mining plan is that construction and mining will commence at Wildebeesthoek section where the coking coal yields are highest.

The Chapudi Section is situated within the extension of the Tshipe Coalfields a subdivision of the Soutpansberg Coalfields (Figure 1.2). This extension is also referred to as the Waterpoort Coalfields. Mining is expected to commence in year 2034 at the Chapudi section and year 2041 at Chapudi West. The estimated Run of mine (RoM) coal production is 12.5 Mtpa, with 100 Mtpa of waste mining and a combined product of 7 Mtpa. The expected life of mine (LoM) is 43 years with year 1 starting in 2034. The Chapudi project has the potential to produce good quality hard coking coal and a domestic thermal coal product.

Wildebeesthoek represents an isolated and un-faulted block of Karoo Sediments, which lies adjacent to the Chapudi section (Figure 1.2). The project area comprises of typical local Karoo strata. The mine is scheduled to run over a period of approximately 31 years at a RoM production rate of 12.5 Mtpa including the ramp down phase in the 31st year. The waste volumes that will be mined are approximately 130 Mtpa for the first five years, 112.5 Mtpa for years 6-18, 120 Mtpa for years 19-25 and then ramps down from year 26 to LoM.

The air quality impact assessment will aim to assess the potential air quality impacts arising from the construction, operation and eventual decommissioning of the proposed mine, as well as provide guidance on possible mitigation measures to reduce environmental impacts.

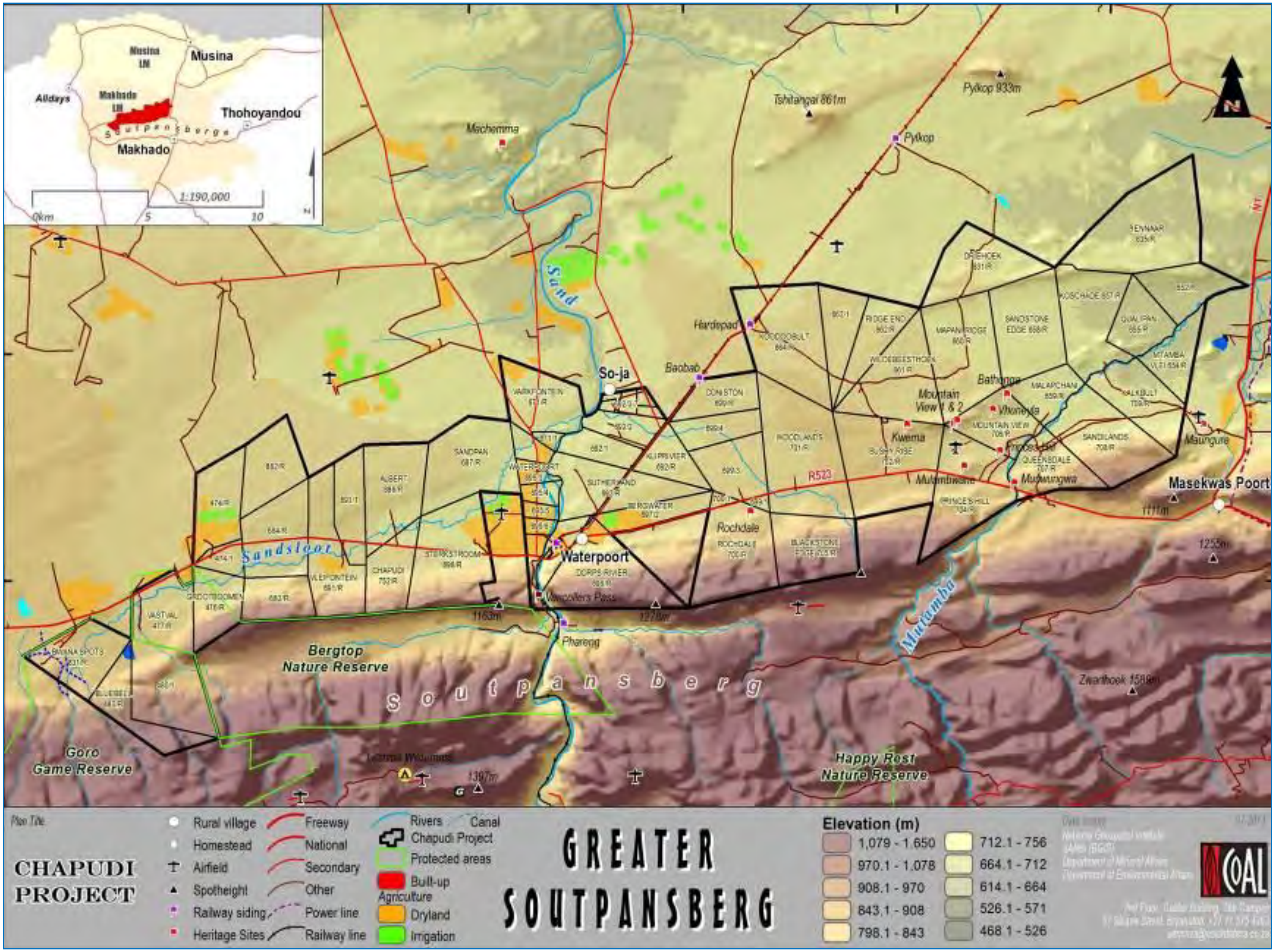

Figure 1.1: Chapudi Project location

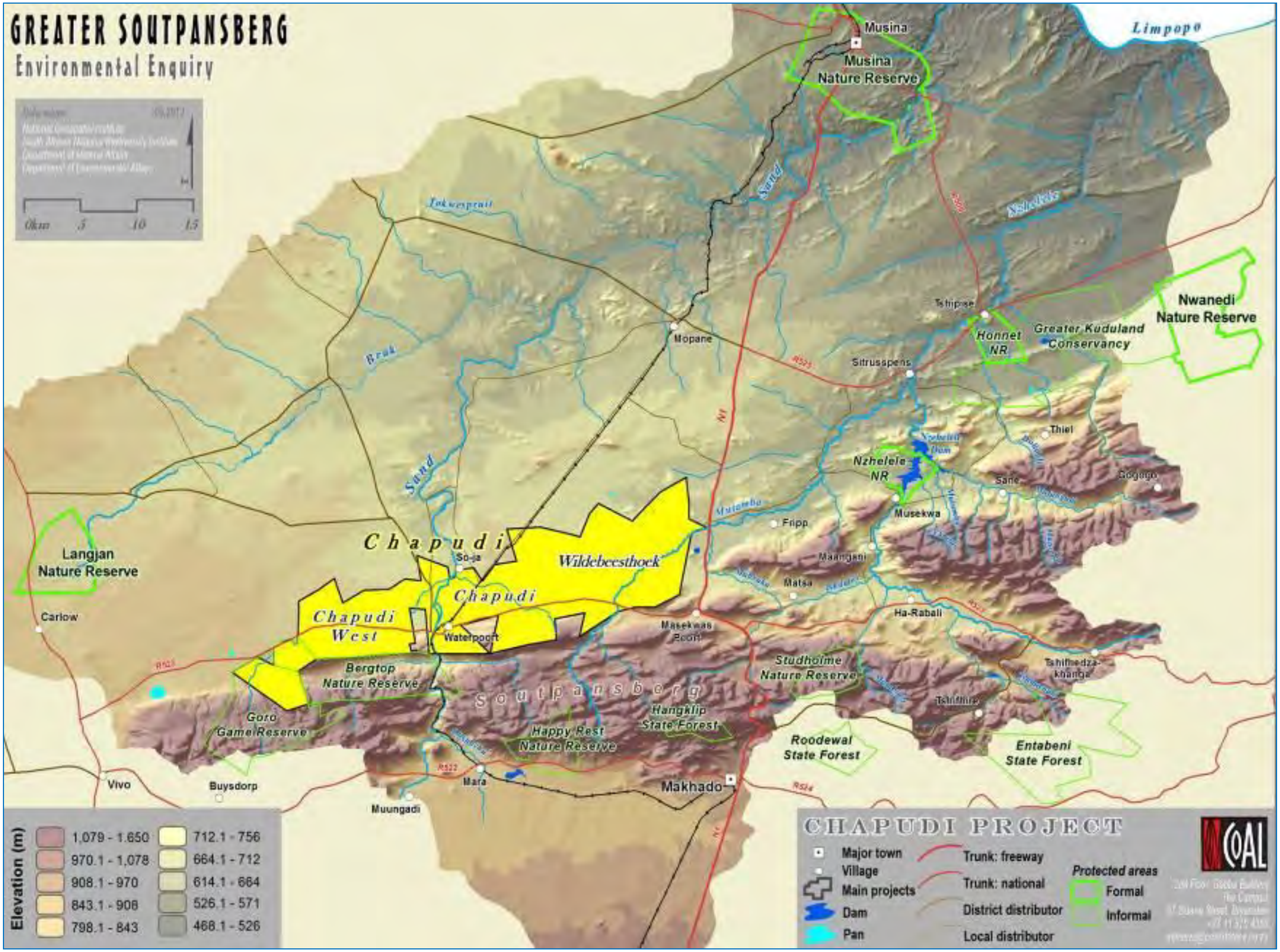

Figure 1.2: Chapudi West, Chapudi and Wildebeesthoek section.

1.1 Process Description

The type of mining methodology employed for the Chapudi Project is the conventional Open pit Truck and shovel method. The processes involved with this type of mining includes; blasting, drilling, stripping, loading and hauling of overburden to the waste dump, RoM stockpiles or processing plant.

Commercial emulsion type explosives will be used for blasting. Drilling of the blast holes will be conducted by pneumatic or hydraulic mounted drills. The loading and hauling will be carried out by means of shovel and/or front end loaders into haul trucks. A fleet of 220 tonne payload will be allocated for waste movement while a fleet of 150 tonne payload will be allocated for Coal mining and reject haulage.

Figure 1.3 below illustrates the mining process of the Chapudi section.

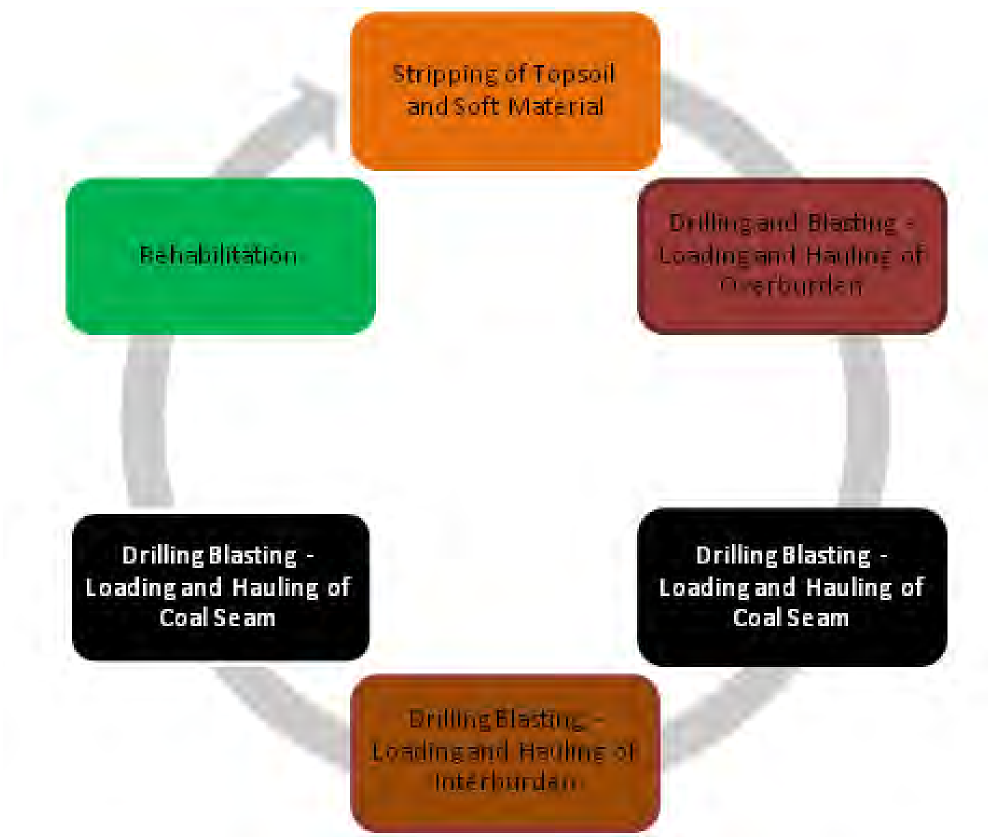

Figure 1.3: Schematic presentation of the mining process

Source: Coal of Africa, Chapudi mining inputs.

The Wildebeesthoek section will be developed first and hence mine designs are more detailed than the Chapudi section. Further feasibility studies will be conducted on Chapudi and Chapudi West during the LoM (Life of Mine) of Wildebeesthoek.

Each of the Wildebeesthoek, Chapudi and Chapudi West sections will require a dedicated coal beneficiation plant, situated on the farms Mountain view 706 MS, Woodlands 701 MS and Albert 686 MS respectively. A conveyor will be installed in order to transport the ROM from the open pits to the respective beneficiation plants.

The total ROM capacity for the Wildebeesthoek beneficiation plant is 12.5 Mtpa. Two mining areas will be exploited for Chapudi coal with the Chapudi section supplying 8 Mtpa to a large beneficiation plant and the Chapudi West section supplying 4.5 Mtpa to a smaller beneficiation plant.

1.2 Terms of Reference

The terms of reference for the Air Quality Impact Assessment for the proposed project can briefly be summarised as follows:

- **Baseline Assessment**

- Provide an overview of the prevailing meteorological conditions in the area;
- Review applicable legislation and policies related to air quality management which are applicable to the proposed operations;
- Review potential health effects associated with emissions released from the proposed operations;
- Identification of existing sources of emission and surrounding sensitive receptors, such as local communities, surrounding the plant;
- Assess the baseline air quality using available ambient air quality monitored data;

- **Impact Assessment**

- Compilation of an emissions inventory for the proposed air quality related sources identified on site;
- Dispersion modelling simulations undertaken using AERMOD to determine the potential air quality impacts of the proposed activities on the surrounding area;
- Comparison of the modelled results to the National ambient air quality standards to determine compliance;
- Provide recommendations for the implementation of appropriate mitigation measures and a monitoring programme (if required);
- Compilation of an Air Quality Impact Assessment Report.

1.3 Methodology

An overview of the methodological approach to be followed during this Air Quality Baseline and Impact Assessment is outlined in the section which follows.

1.3.1 Baseline Assessment

During the baseline assessment, a qualitative approach was used to assess the baseline conditions in the project area. Local meteorological data was obtained from the South African Weather Services located in Chapudi for the period of Jan 2008 – Dec 2012. Applicable air quality legislation such as the National Environmental Management: Air Quality Act 39 of 2004 (GN163: 2005) and the Listed Activities and Associated Minimum Emission Standards (GN248: 2010) were reviewed. Criteria pollutants relevant to the project and their potential human health effects are also discussed. Existing sources of air pollution surrounding Sasol were qualitatively assessed. Sensitive receptors, such as local communities, in close proximity to Sasol were identified using satellite imagery.

1.3.2 Impact Assessment

During this phase, an emissions inventory was compiled to estimate emissions from the identified emission sources associated with the proposed activities. Where information is not available, use was made of available United States Environmental Protection Agency (USEPA) emission factors or emission models to estimate emission releases. Dispersion modelling simulations were undertaken using the AERMOD dispersion model and presented graphically as isopleths plots. Comparison with the National ambient air quality standards (GN263; 2009) was made to determine compliance. Based on the predicted results, recommendations for appropriate mitigation measures and/or ambient air quality management are provided.

1.4 Report Structure

Section 1 of the report provides the background to the project. **Section 2** includes a meteorological overview of the region. **Section 3** provides a review of applicable air quality legislation, pollutants and their potential health effects. The emissions inventory, impact assessment and general conclusions are presented in **Section 4**. The references are provided **in Section 5** and the Appendices with CV's of specialist are found at the end of this report.

2 BASELINE DESCRIPTION OF THE AREA

2.1 Meso-Scale Meteorology

The nature of the local climate will determine what will happen to particulates when released into the atmosphere (Tyson & Preston-Whyte, 2000). Concentration levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson & Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air lies directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth's surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson & Preston-Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth's surface. These surface inversions are however, usually destroyed as soon as the sun rises and warm the earth's surface. With the absence of surface inversions, the pollutants are able to diffuse freely upward; this upward motion may however be prevented by the presence of an elevated inversion (Tyson & Preston-Whyte, 2000).

Elevated inversions occur commonly in high pressure areas. Sinking air warms adiabatically to temperatures in excess of those in the mixed boundary layer. The interface between the upper, gently subsiding air is marked by an absolutely stable layer or an elevated subsidence inversion. This type of elevated inversions is most common over Southern Africa (Tyson & Preston-Whyte, 2000).

The climate and atmospheric dispersion potential of the interior of South Africa is determined by atmospheric conditions associated with the continental high pressure cell located over the interior. The continental high pressure present over the region in the winter months results in fine conditions with little rainfall and light winds with a northerly flow. Elevated inversions are common in such high pressure areas due to the subsidence of air. This reduces the mixing depth and suppresses the vertical dispersion of pollutants, causing increased pollutant concentrations (Tyson and Preston-Whyte, 2000).

Seasonal variations in the positions of the high pressure cells have an effect on atmospheric conditions over the region. For most of the year the tropical easterlies cause an air flow with a north-easterly to north-westerly component. In the winter months the high pressure cells move northward, displacing the tropical easterlies northward resulting in disruptions to the westerly circulation. The disruptions result in a succession of cold fronts over the area in winter with pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure. Airflow ahead of a cold front passing over the area has a strong north-north-westerly to north-easterly component, with stable and generally cloud-free conditions. Once the front has passed, the airflow is reflected as having a dominant southerly component (Tyson and Preston-Whyte, 2000).

Easterly and westerly wave disturbances cause a southerly wind flow and tend to hinder the persistence of inversions by destroying them or increasing their altitude, thereby facilitating the dilution and dispersion of pollutants. Pre-frontal conditions tend to reduce the mixing depth. The potential for the accumulation of pollutants during pre-frontal conditions is therefore enhanced over the plateau (Tyson and Preston-Whyte, 2000).

2.1.1 Wind

The wind field for the proposed Chapudi Project is presented in Figure 2.1 below. Wind roses comprise of 16 spokes which represents the direction 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. Based on an evaluation of the meteorological data obtained from the South African Weather Services, the following deductions regarding the prevailing wind direction and wind frequency can be assessed.

Looking at Figure 2.1 below, the predominant wind direction within the Chapudi project area is mainly from the south eastern region. Secondary winds originate from the eastern region. At the site, 0.1% of the total wind field accounted for calm conditions over the area.

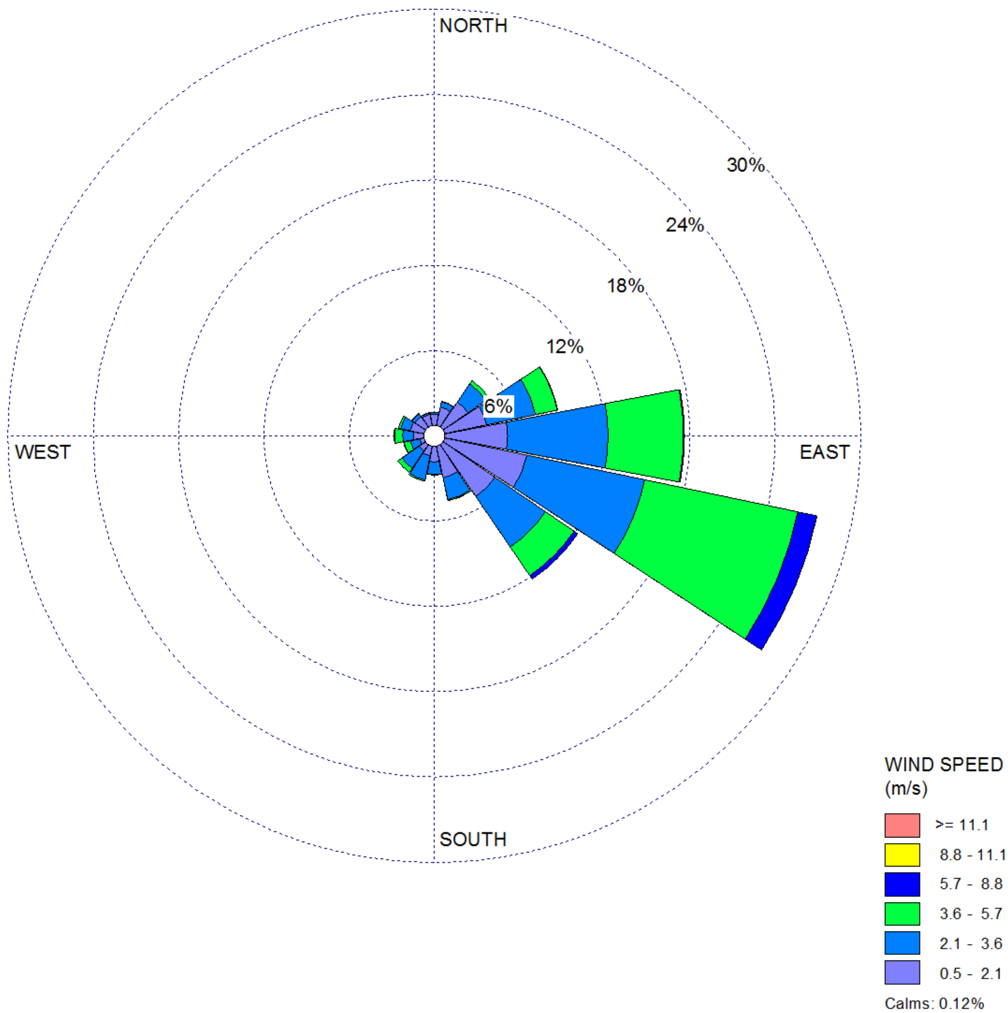

Figure 2.1: Period wind rose for the Chapudi Project for the period Jan 2009 – Dec 2012.

Figure 2.2 below illustrates the wind frequency distribution for the Jan 2009- Dec 2012 monitoring period. 42.2 % of the time accounted for wind speeds within the range of 0.5 – 2.1 m/s. The second highest wind class 2.1- 3.6 m/s occurred for 33.5% of the time.

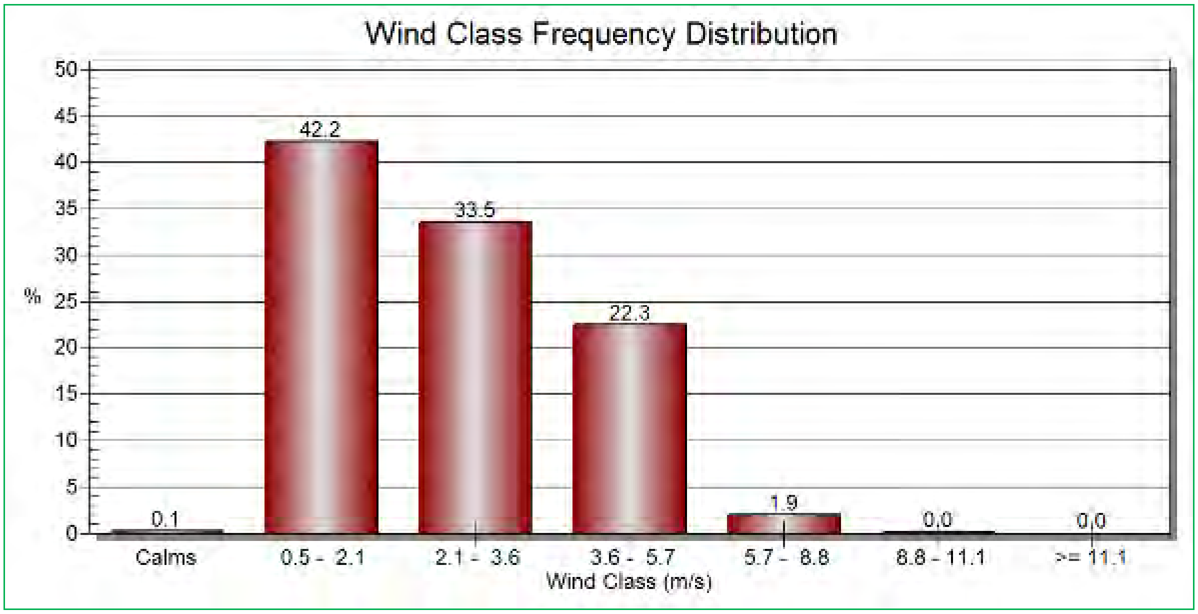

Figure 2.2: Wind class frequency distribution

Diurnal wind roses for the Chapudi Project area are shown in Figure 2.3 below. During the morning hours (00:00 - 06:00) the predominant wind direction is seen from the south eastern region. A slight shift is seen during the daylight (06:00 – 18:00) and nigh time hours (18:00 – 24: 00) with a primary wind direction originating from the south eastern region and secondary winds from the north eastern region.

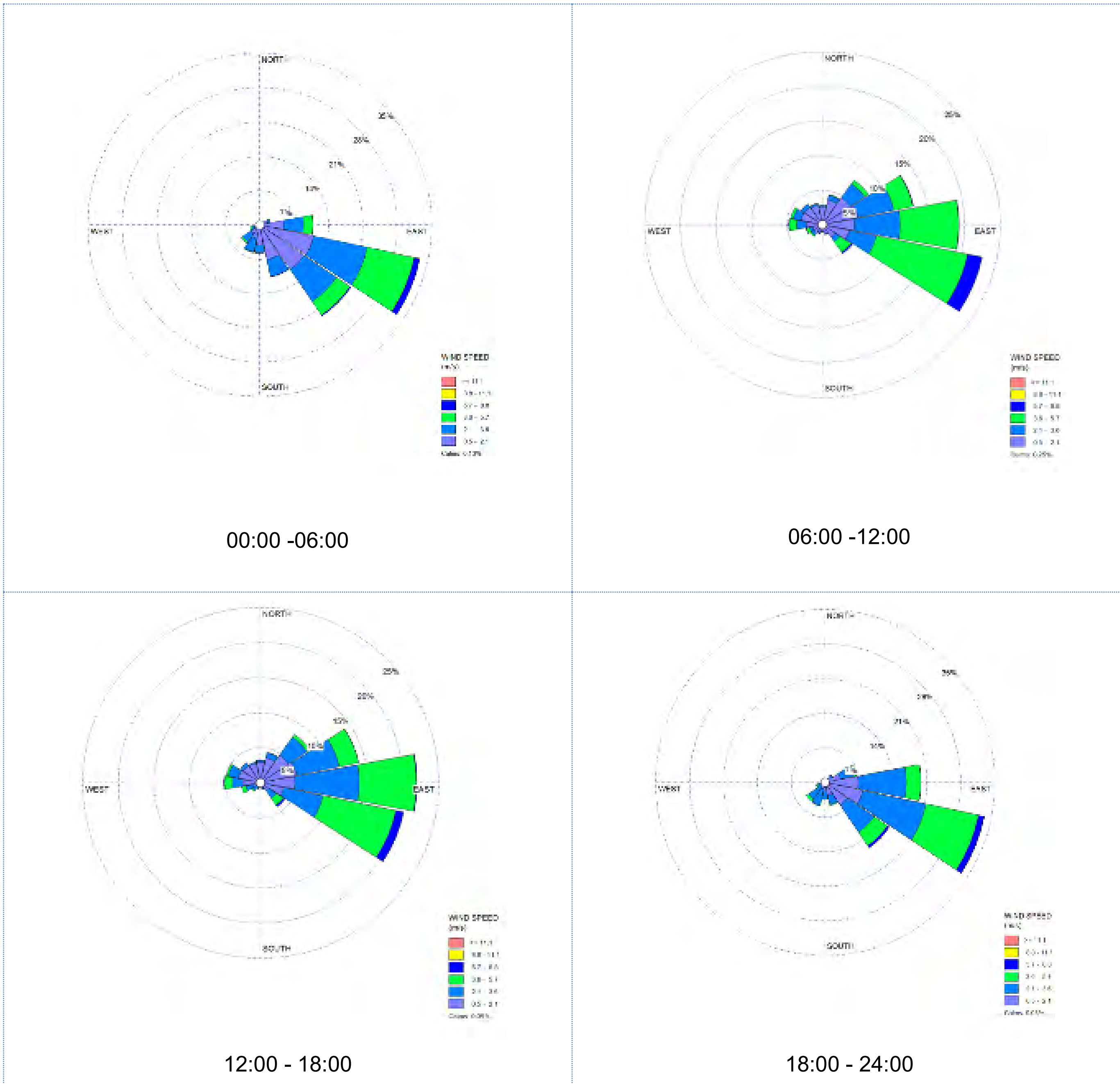

Figure 2.3: Diurnal wind roses for the Chapudi project area (Jan 2008-Dec 2012)

Seasonal variability in the wind field for the Chapudi project area is shown in Figure 2.4 below. During the spring (Sep, Oct and Nov), autumn (Mar, Apr and May) and summer months (Dec, Jan and Feb) illustrates a predominant wind direction from south eastern region. A sight shift in the wind field in seen during the winter months (Jun, Jul and Aug) with a winds originating from the south eastern and south western region.

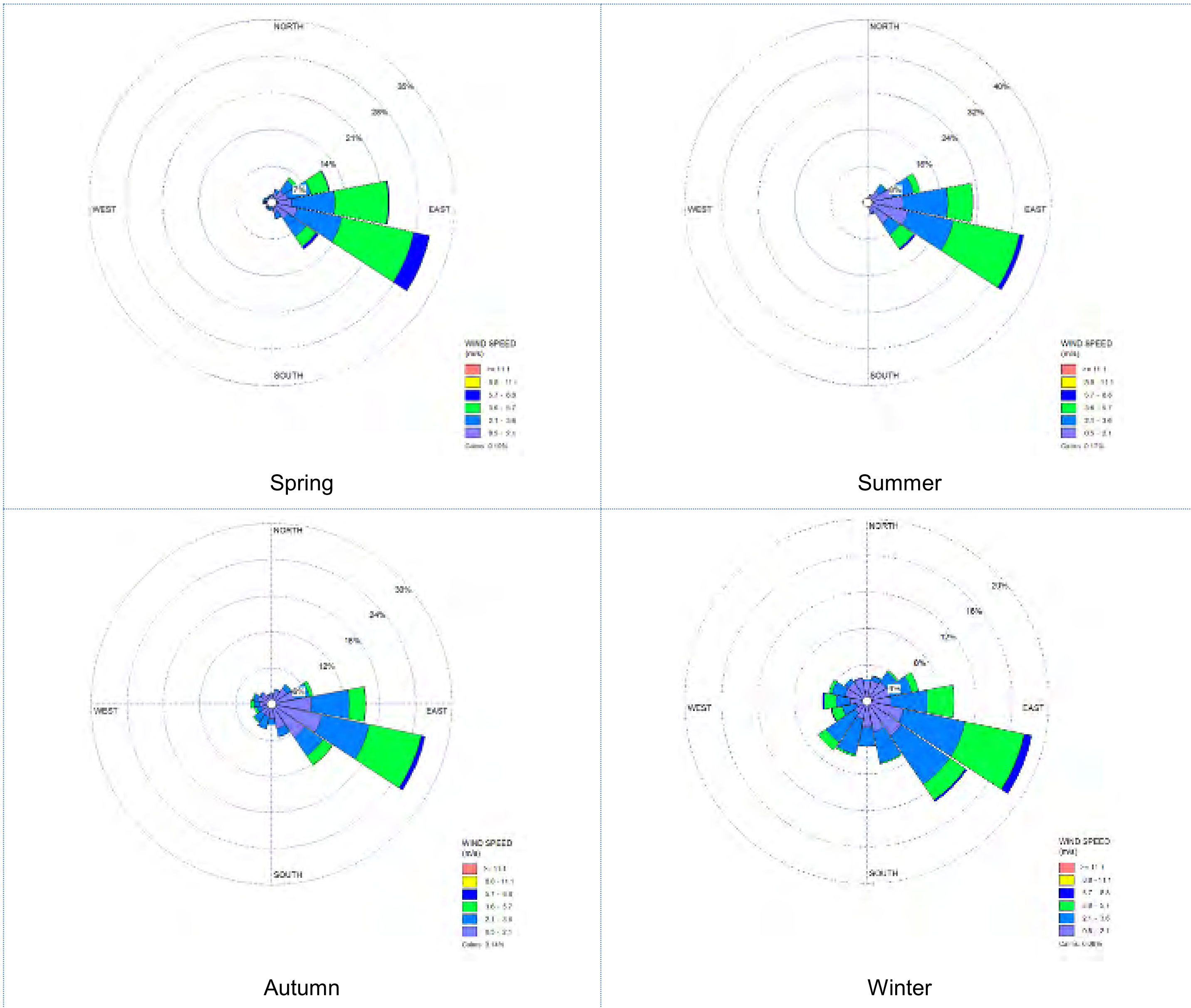

Figure 2.4: Seasonal variation for the Chapudi Project area for the Jan 2008 – Dec 2012 monitoring period

2.1.2 Atmospheric Stability

Atmospheric stability is commonly categorized into six stability classes. These are briefly described in Table 2.1 below. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night-time a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

A neutral atmospheric potential neither enhances nor inhibits mechanical turbulences. An unstable atmospheric condition enhances turbulence, whereas a Stable atmospheric condition inhibits mechanical turbulence. Majority of the wind class fell within Class F (very stable conditions) which occurred for 34.4% of the time.

Table 2.1: Atmospheric Stability class

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

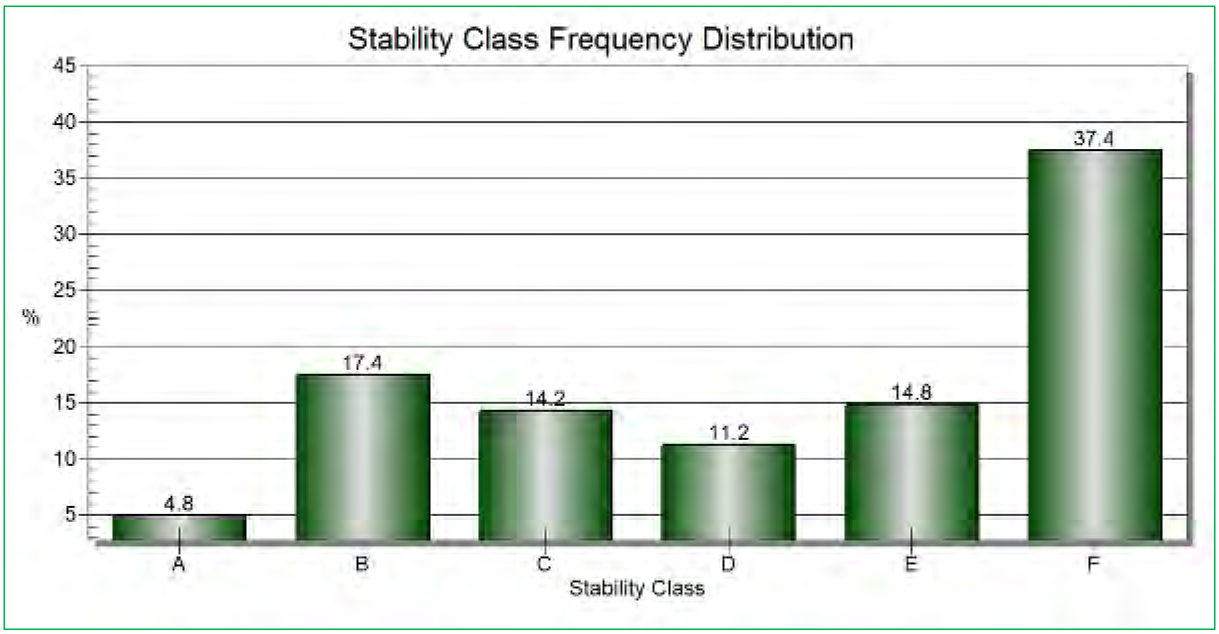

Figure 2.5: Atmospheric Stability Class Frequency Distribution

Due to the high stability levels indicated above, it is likely that an inversion layer will develop, particularly in the early hours of winter mornings. This phenomenon has the possibility of increasing ground level pollution concentrations.

2.1.3 Temperature and Humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella & Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. Temperature also provides an indication of the rate of development and dissipation of the mixing layer as well as determining the effect of plume buoyancy; the larger the temperature difference between the plume and ambient air, the higher the plume is able to rise. Higher plume buoyancy will result in an increased lag time between the pollutant leaving the source, and reaching the ground. This additional time will allow for greater dilution and ultimately a decrease in the pollutant concentrations when reaching ground level. The average monthly temperatures for the Jan 2009 – Dec 2012 period is depicted in Figure 2.6 below.

The average summer temperatures range between 23 ºC – 24 ºC, while the average winter temperatures range between 13 ºC -15 ºC. Autumn temperatures range between 17 ºC - 23 ºC, while spring temperatures range between 19 ºC – 22 ºC. The maximum temperature recorded at the site was 24 ºC, while the average lowest temperatures recorded was 13 ºC.

Humidity is the mass of water vapour per unit volume of natural air. When temperatures are at their highest the humidity is also high, the moisture is trapped inside the droplets of the water vapour. This makes the moisture content of the air high. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids, as well as secondary pollutants within the atmosphere. Figure 2.6 below illustrates the relationship between temperature and relative humidity. Humidity increases with increasing temperature. The humidity levels are highest during the summer months with an average of 75% and lowest during the winter months.

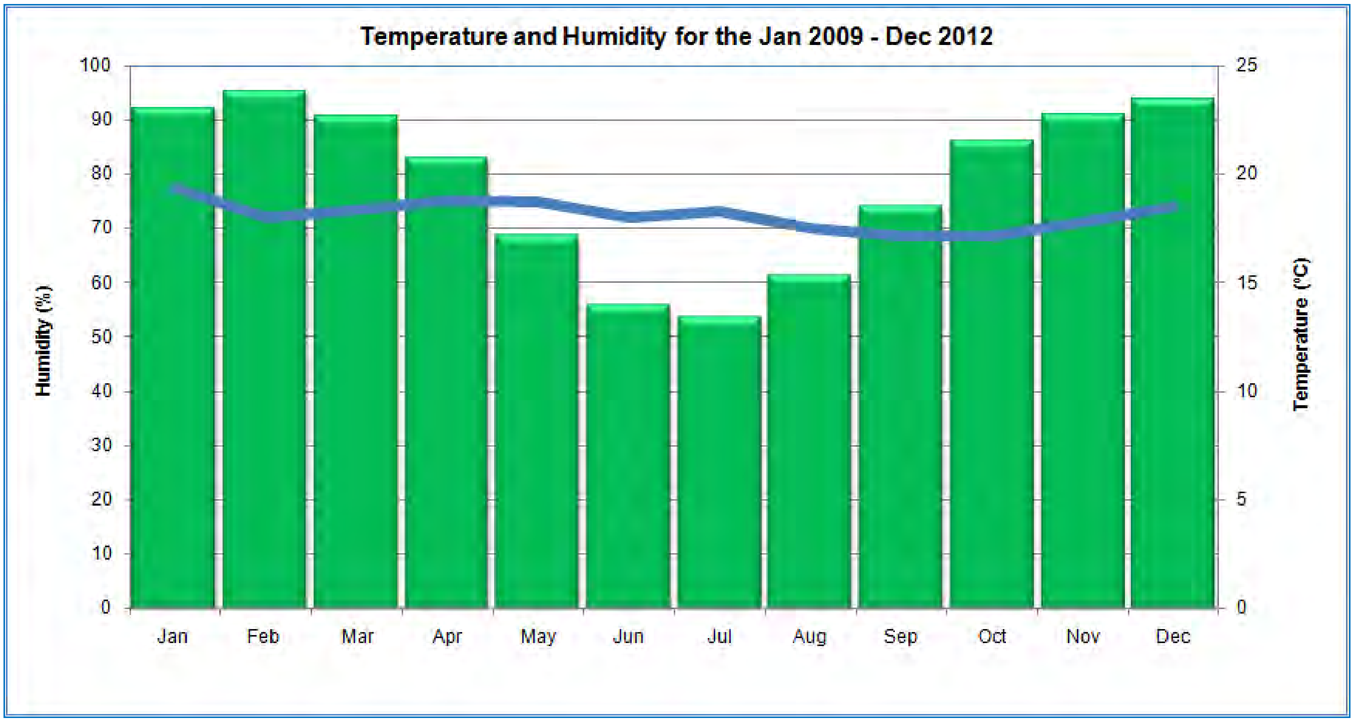

Figure 2.6: Monthly Temperature and Relative Humidity for the Chapudi Project area.

2.1.4 Precipitation

Precipitation cleanses the air by capturing airborne pollutants and depositing them on the ground (Kupchella & Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999. Figure 2.7 below illustrates the average rainfall experienced at the site. The total rainfall recorded at the site was 982 mm. The highest period of rainfall was recorded during the month of April with 405mm, while no rainfall was recorded during the winter month of August.

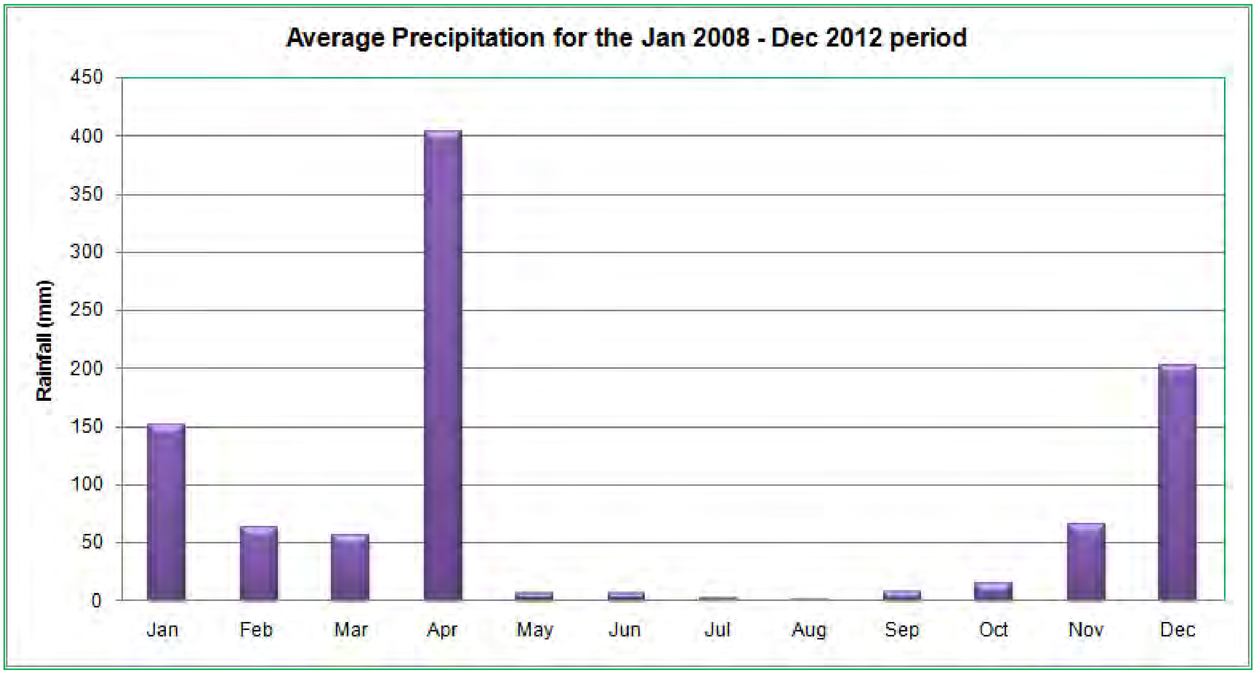

Figure 2.7: Average Precipitation for the Chapudi Project for the Jan 2009 – Dec 2012 monitoring period.

3 APPLICABLE LEGISLATION

The information presented in the section which follows, details the local legislation within South Africa, as well as a list of international laws and conventions to which South Africa is a signatory.

3.1 South African legislative and standards frameworks

3.1.1 National Environmental Management: Air Quality 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 main objectives of the Act are to:

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

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

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

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

3.1.2 National Ambient Air Quality Standards

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging periods. These averaging periods refer to the time-span over which the air concentration of the pollutant was monitored at a location. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average.

The Department of Environmental Affairs and Tourism (DEAT) have issued ambient air quality guidelines to support receiving environment management practices. Ambient air quality guidelines are only available for such criteria pollutants which are commonly emitted, such as SO_2, Pb, NO_x, benzene, particulates and CO. The pollutant of importance during this assessment is Benzene, the guidelines specific to this pollutant are listed in the subsection which follows.

3.1.2.1 Particulate Matter

Particulate matter is the collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. Particulate matter includes dust, smoke, soot, pollen and soil particles (Kemp, 1998). Particulate matter 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).

Particulate matter represents a broad class of chemically and physically diverse substances. Particles can be described by size, formation mechanism, origin, chemical composition, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (USEPA, 1996).

Particulate Matter 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):

- PM_{10} (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)
- PM_{10}-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.

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.

Table 3.1: Ambient Air Quality Guidelines for Particulate Matter

Pollutant	Averaging period (µg/m^3)	Guideline (µg/m^3)	Number of Exceedance Allowed Per Year
PM_{10}	Daily average	120 (1) 75 (2)	4 4
	Annual average	50 (1) 40 (2)	0 0
PM2.5	Daily average	65 (3) 40 (4) 25 (5)	4 4 4
	Annual average	25 (3) 20 (4) 15 (5)	0 0 0

Notes: (1) Come into effect immediately until 31 December 2014

(2) Come into effect 1st January 2015

(3) Come into effect immediately until 31 December 2015

(4) Come into effect 1 January 2016 – 31 December 2029

(5) Come into effect 1 January 2030

3.1.2.2 Dust Fallout

On the 7th of December 2012 the minister of Water and Environmental affairs published the new National Dust Control Regulations. This document now enforces the monitoring of dust fallout from activities that is suspected of contributing significantly to dust fallout in its region. The regulation provides a set standard for dust fallout to comply to, enforces that a baseline should be established to projects that would give rise to increased dust fallout, specifications for dust fallout monitoring and the format of reports if the activity should exceed the thresholds.

If an activity exceeds the standard the entity must submit a dust monitoring report to the air quality officer (local authority), before December 2013 (Section 4, GN1007 of 2012). The entity must develop a dust management plan, within three months after the submission of a dust monitoring report (Section 5, GN1007 of 2012). If the dust fallout is continued to be exceeded, the authority may request that continuous PM_{10} monitoring be conducted at the site.

Table 3.2: Dust fallout rates as measured (using ASTM d1739:1970 or equivalent) at and beyond the boundary of the premises where dust originates.

Restriction area	Dustfall rate, D ($mg/m^2/day$, 30-day average)	Comment
Residential	D < 600	Two within a year, not sequential months.
Non residential	600 < D < 1200	Two within a year, not sequential months.

3.1.2.3 Oxides of Nitrogen

Air quality guidelines and standards issued by most other countries and organisations tend to be given exclusively for NO_2 concentrations as NO_2 is the most important species from a human health point of view. International and South African standards for NO_2 are presented in the table below.

Table 3.3: Ambient Air Quality Guidelines and Standards for Nitrogen Dioxide.

Averaging Period	South Africa		WHO		EC		Australia	
	µg/m³	ppm	µg/m³	ppm	µg/m³	ppm	µg/m³	Ppm
Annual Ave	40	0.021	40	0.021	40	0.021	57	0.03
Max. 1-hr	200	0.10	200	0.10	200	0.10	240	0.12

NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function.

3.1.2.4 Sulphur Dioxide

SO_2 is an irritant that is absorbed in the nose and aqueous surfaces of the upper respiratory tract, and is associated with reduced lung function and increased risk of mortality and morbidity. Adverse health effects of SO_2 include coughing, phlegm, chest discomfort and bronchitis.

Table 3.4: Ambient Air Quality Guidelines and Standards for Sulphur Dioxide.

Origin	Annual Average Maximum (µg/m³)	24-Hour Maximum (µg/m³)	1-Hour Maximum (µg/m³)	<1-Hour Maximum (µg/m³)
RSA	50	125	350	500 (10 min average)
WHO	50 10-30	125	-	500 (10 min average)
EC	20	125	350	
UK	20	125	350	266 (15 min mean)
World Bank	50	125	-	-
US-EPA	80	365	-	-
Australia	53	209	520	-

3.1.2.5 Licensing requirements

The National Environmental Management: Air Quality Act (39 of 2004) includes the following regarding Atmospheric Emission Licenses.

22. No person may without a provisional atmospheric emission license or an atmospheric license conduct an activity: (a) Listed in the National List anywhere in the Republic; or (b) Listed on the list applicable in a province anywhere in that province; **AQA Implementation** Listed Activities and Minimum Emission Standards Listed Activities and associated minimum emission standards identified in terms of section 21 of the National Environmental Management: Air Quality Act, 39 of 2004 (31 March 2010 GG Vol. 537 No. 33064) **Category 5. Mineral Processing Industry** Number 5.1: Storage and handling of ore and coal not situated on the premises of a mine or works as defined in the Mines Health and Safety Act 29/1996. Locations designed to hold more than 100 000 tons. Notes: Should this be triggered an Atmospheric Emissions licence would be required.

3.2 Other Polluting Sources in the Area

A detailed emissions inventory for the Chapudi Project area is not available. Based on satellite imagery and Baseline studies carried out by SRK consulting, the following sources of air pollution have however been identified. These sources are important when considering cumulative impacts on air quality in the region;

- Domestic fuel burning
- Agricultural activities
- Unpaved roads
- Veld fires

3.2.1 Domestic fuel burning

The surrounding area can be classified as predominantly rural. The use of domestic fuels is anticipated in low income households and communities such as the Waterpoort Town, Soja Village, Mamvuka Village, Mudimeli and Manyii for cooking and space heating. The use of coal, wood and paraffin for both cooking and heating purposes is a common medium used, as the resource is cheap and easily attainable.

Biomass and coal smoke contain a large number of pollutants and known health hazards, including criteria pollutants such as Particulate matter, Carbon monoxide, Nitrogen dioxide, Sulphur dioxide (mainly from coal) as well as formaldehyde, and polycyclic organic matter, including carcinogens such as benzo[*a*]pyrene (Ezzati and Kammen, 2002).

The combustion of coal is an incomplete process which results in the emission of carbon monoxide, methane and nitrogen dioxide. Exposure to indoor air pollution (IAP) from the combustion of solid fuels has been implicated, with varying degrees of evidence, as a causal agent of several diseases in developing countries, including acute respiratory infections (ARI) and otitis media (middle ear infection), chronic obstructive pulmonary disease (COPD), lung cancer (from coal smoke), asthma, cancer of the nasopharynx and larynx, tuberculosis, perinatal conditions and low birth weight, and diseases of the eye such as cataract and blindness (Ezzati and Kammen, 2002).

Even in electrified areas, households make use of domestic fuels due to high electricity costs and due to continued traditional use of such fuels.

3.2.2 Agricultural activities

Agricultural activity can be considered a significant contributor to particulate emissions, although tilling, harvesting and other activities associated with field preparation are seasonally based. The main focus internationally with respect to emissions generated due to agricultural activity is related to animal husbandry, with special reference to malodours generated as a result of the feeding and cleaning of animals. Vegetables and fruits such as tomatoes, pepper-dew, sweet corn, water melon, guavas, citrus, butternut, mangos and Lucerne are produced in the Chapudi project area under irrigation. The activity associated with irrigation farming includes the application of pesticides, herbicides, weed control, fertilizers, harvesting activities, and phosphate and nitrogen addition.

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 gases 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.

3.2.3 Unpaved Roads

A concern resulting from unpaved road in the Chapudi project area is fugitive dust emissions and particulate matter. Dust is transport by the prevailing wind condition. When vehicles travel on unpaved roads, the force of the wheels on the road surface causes the pulverisation of surface materials. Particle are lifted and dropped from the rolling wheels and the road is exposed to stronger air currents in turbulent shear with the surface.

3.2.4 Veld Fires

Limpopo has a high risk of veld fires (Figure 3.1). A veld fire is defined as a large scale natural combustion process that consumes various ages, sizes, and types of flora growing outdoors in a geographical area. Consequently, veld fires are potential sources of large amounts of air pollutants that should be considered when attempting to relate emissions to air quality. The size and intensity, even the occurrence, of a veld fires depend directly on such variables as meteorological conditions, the species of vegetation involved and their moisture content, and the weight of consumable fuel per hectare (available fuel loading).

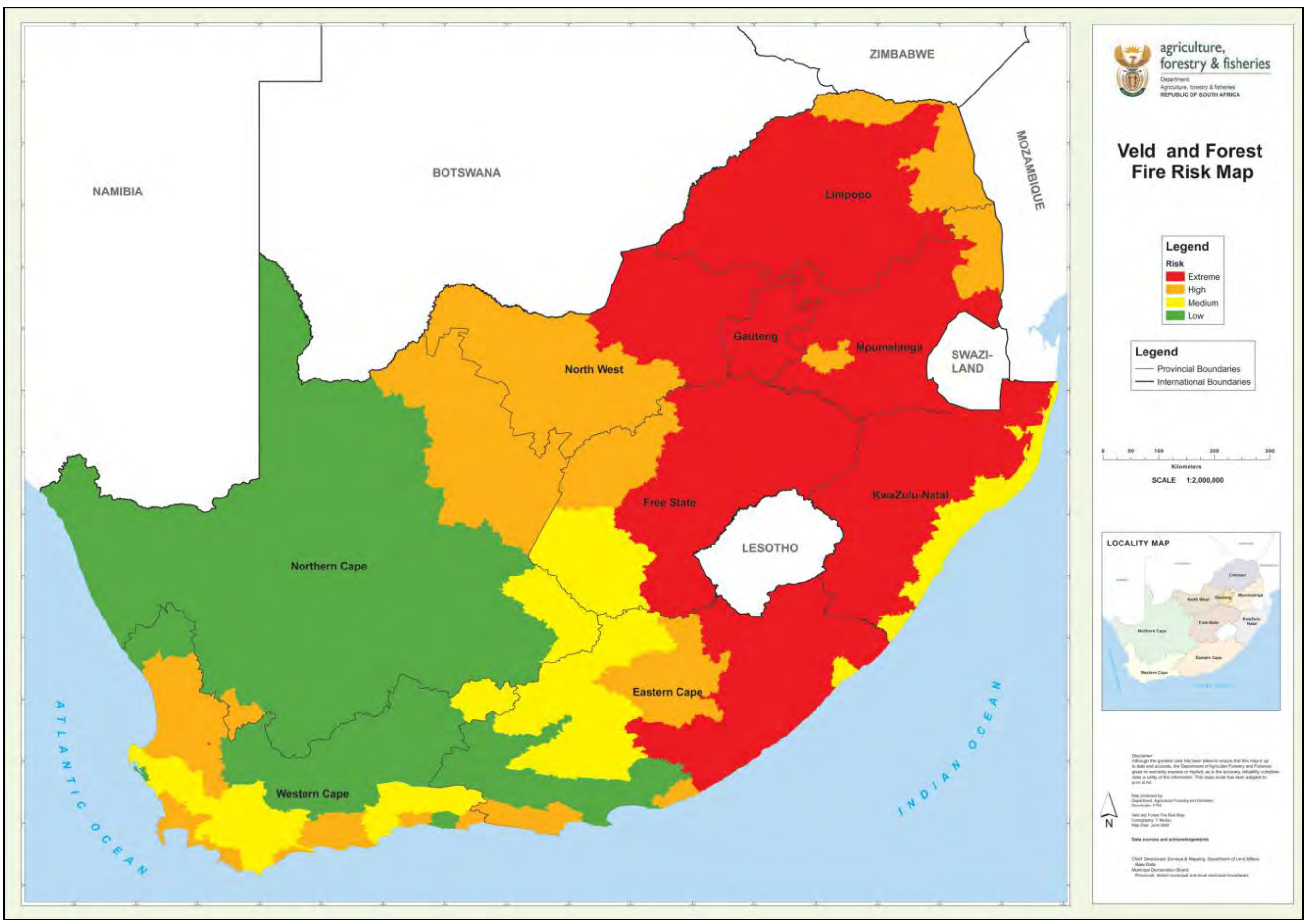

Figure 3.1: Veld and forest fire risk map

The major pollutants from veld burning are PM, CO and VOCs. Nitrogen oxides are emitted at rates of from 1 to 4 g/kg burned, depending on combustion temperatures. Emissions of SO_x are negligible (USEPA, 1996). A study of biomass burning in the African savannah estimated that the annual flux of particulate carbon into the atmosphere is estimated to be of the order of 8 Tg C, which rivals particulate carbon emissions from anthropogenic activities in temperate regions (Cachier *et al*, 1995).

3.3 Sensitive Receptors

A sensitive receptor is defined as a place or activity which could involuntarily be exposed to air emissions from the mining activities. Based on this definition, the residential, educational and recreational land uses in the area are considered to be sensitive receptors. The Proposed mine is boarded near communities such as the Waterpoort town, Soja Village, Waterpoort Property Labour Tenant Village and the Mamvuka Village. Figure 3.2 below illustrates the positions of the sensitive receptors around the project location.

Other sensitive receptors within the area would be the local fauna and flora. It has been identified that dust may result in sickness and associated lung disease for wildlife and human which will arise as a result of mining operations.

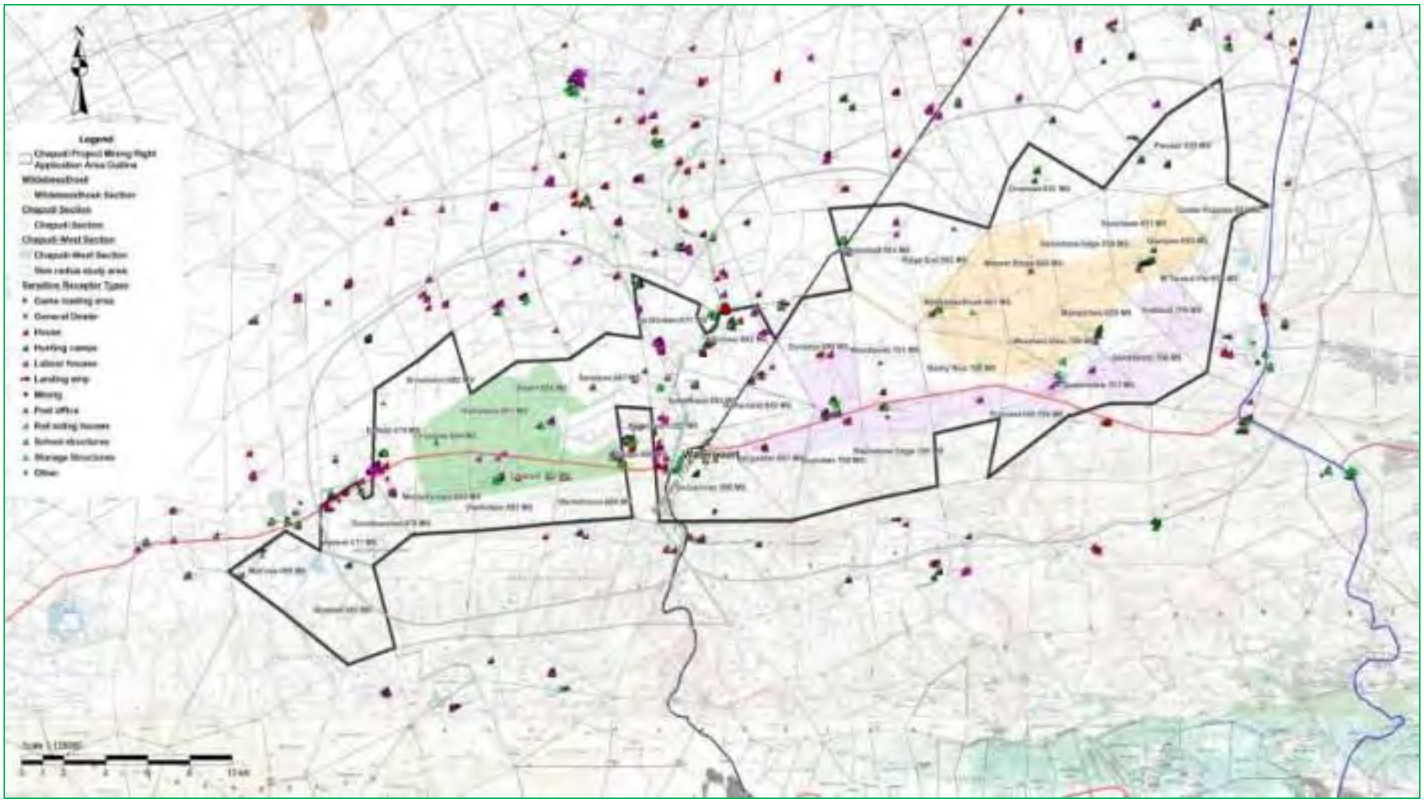

Figure 3.2: Sensitive receptors in and around the project area.

3.4 Ambient monitoring

SRK consulting was commissioned by Chapudi Coal (Pty) Ltd to undertake baseline monitoring for the proposed mining area. Dust fallout sampling and Gas monitoring for sulphur and nitrogen dioxide was conducted during 2008-2009 on 10 locations expanding through out the Chapudi and Wildebeesthoek mining sections (Figure 3.3. And Figure 3.4).

Figure 3.3: Ambient monitoring network at the Chapudi section

Figure 3.4: Ambient monitoring network at Wildebeesthoek.

3.4.1 Dust fallout monitoring

Figure 3.5 below illustrates the dust fallout monitoring conducted by SRK consulting during the July 2008 – June 2009 monitoring period. Majority of the dust fallout results remained within the residential limit of 600 mg/m^2/day. The following sites exceeded the residential limit of 600 mg/m^2/day:

- Kliprivier – 735 mg/m^2/day (June '08), 794 mg/m^2/day (Oct '08), 753 mg/m^2/day (Nov '08) and 748 mg/m^2/day (Feb '09).
- Waterpoort – 963 mg/m^2/day (Aug '08) and 784 mg/m^2/day (Jun '09).
- Princess Hill - 623 mg/m^2/day (Dec '08)
- Wildebeestehoek – 806 mg/m^2/day (Sep '08), 719 mg/m^2/day (Feb '09) and 665 mg/m^2/day (Mar '09)

There were two exceedences of the 1200 mg/m^2/day non residential limit which occurred at the site Coniston with 1391 mg/m^2/day and 1301 mg/m^2/day during the month of October and November respectively.

The activities contributing to the dust fallout in the area can arise from farming and agricultural activities as well as the action of vehicles on unpaved roads.

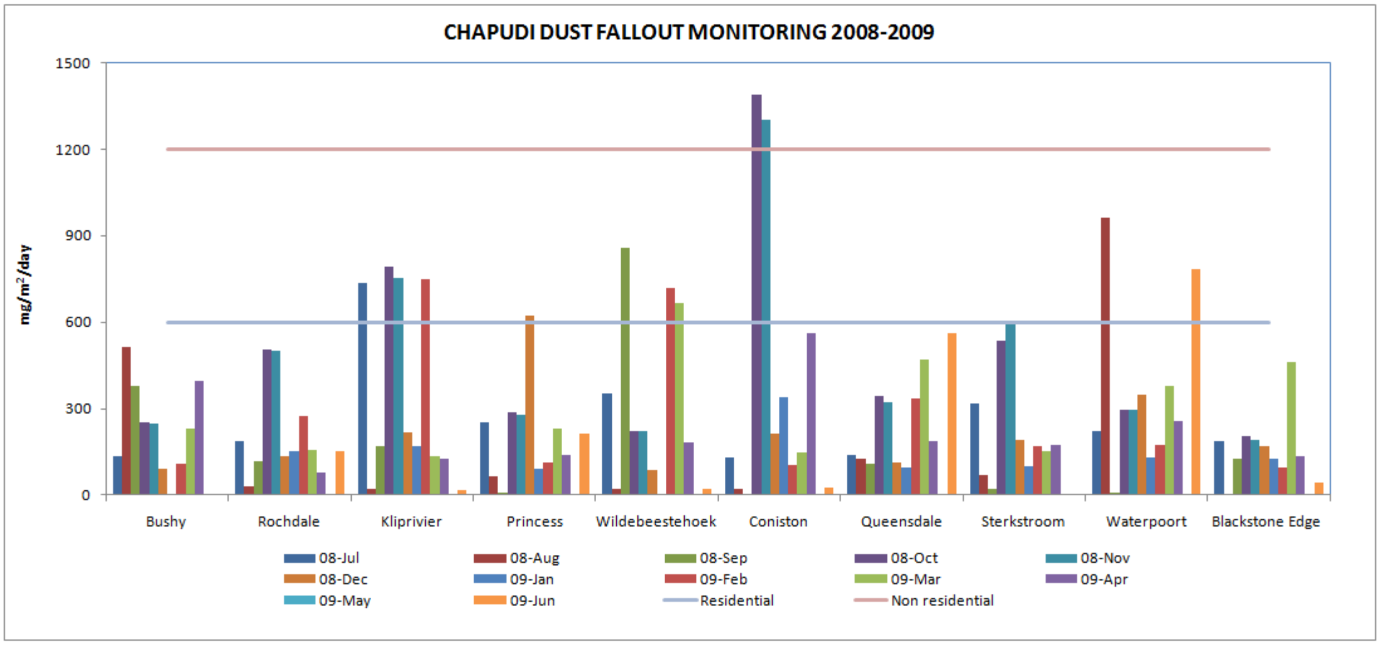

Figure 3.5: Dust fallout monitoring results for the Chapudi project.

3.4.2 Gas monitoring

Gas monitoring was carried out by SRK consulting using Radiello passives. Table 3.5: Sulphur dioxide concentration (µg/m^3) for the June 2008 – June 2009 monitoring period. and Table 3.6 below shows the concentration of So_2 and No_2 for the June 2008 – June 2009 monitoring period.

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Table 3.5: Sulphur dioxide concentration (µg/m^3) for the June 2008 – June 2009 monitoring period.

Sites	Jun Jul' 08	Jul Aug' 08	Aug Sep '08	Sep Oct '08	Nov'08	Dec'08	Jan'09	Feb'09	Mar'09	Apr'09	May'09	Jun'09
Sterkstroom	0.01	0.2	0.04			0.01	0.14	0.06	0.03	0.04		0.061
Kliprivier	0.11	0.09	0.03	0.02	0.02	0.1	0.06	0.07	0.03	0.01		0.037
Waterpoort	0.11	0.07	0.02	0.02	0.02	0.1	0.05	0.01	0.03	0.02		0.135
Rochdale	0.13	0.09	0.03	0.04	0.02	0.12	0.06	0.04	0.05	0.02		0.073
Coniston	0.15	0.16	0.04	0.02	0.02	0.14	0.11	0.05	0.03	0.02		0.049
Blackstone	0.11	0.12	0.02	0.01	0.01	0.1	0.09	0.03	0.01	0.01		0.061
Bushy	0.14	0.11	0.02	0.02	0.02	0.13		0.03	0.03	0.02		
Queensdale	0.14	0.09	0.02	0.01	0.01	0.13	0.06	0.03	0.01	0.01		0.073
Princess		0.09	0.03	0.02	0.02	0.1	0.06	0.05	0.03	0.02		0.049
Wildebeesthoek		0.11	0.04	0.03	0.03	0.14		0.04	0.08	0.05		0.061
South African Standard	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**	**125**

Table 3.6: Nitrogen dioxide concentration (µg/m³) for the June 2008 – June 2009 monitoring period.

Sites	Jun Jul' 08	Jul Aug' 08	Aug Sep '08	Sep Oct '08	Nov'08	Dec'08	Jan'09	Feb'09	Mar'09	Apr'09	May'09	Jun'09
Sterkstroom	0.01	0.01	0.03			0.01	0.01	0.02	0.02	0.02		0.004
Kliprivier	0.01	0.01	0.02	0.003	0.004	0.01	0.01	0.02	0.01	0.02		0.002
Waterpoort	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.02	0.02		0.003
Rochdale	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.03	0.01	0.02		0.003
Coniston	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0.02	0.01	0.01		0.002
Blackstone	0.01	0.02	0.02	0.001	0.001	0.01	0.01	0.02	0.002	0.02		0.002
Bushy	0.01	0.01	0.02	0.01	0.01	0.01		0.02	0.01	0.01		
Queensdale	0.01	0.01	0.02	0.003	0.003	0.01	0.01	0.02	0.004	0.02		0.0005
Princess		0.01	0.03	0.004	0.004	0.01	0.003	0.02	0.02	0.02		0.002
Wildebeesthoek		0.01	0.02	0.01	0.01	0.01		0.02	0.02	0.02		0.002
South African Standard	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**

3.4.3 Makhado ambient monitoring

Ambient monitoring for the Makhado colliery was conducted for the June 2012 to April 2013 monitoring period. Dust fallout monitoring was conducted at three sites; Fripp, Windhoek and MCC for the August 2010 – April 2013 monitoring period. Figure 3.6 below illustrates the dust fallout results for the Makhado colliery. The industrial limit of 1200 mg/m^2/day was exceeded at MCC monitoring point during August 2012 (1254 mg/m^2/day). The domestic standard of 600 mg/m^2/day was exceeded at MCC monitoring point on 7 occasions. The domestic standard of 600 mg/m^2/day was exceeded at the Windhoek monitoring point on 4 occasions. The Fripp monitoring point recorded no exceedences during the monitoring period.

There is a correlation between the Chapudi and Makhado dust monitoring concentrations. High dust fallout were noted during the winter and spring months. The predominant wind direction is south easterly. Chapudi project lies west of the Makhado monitoring sites.

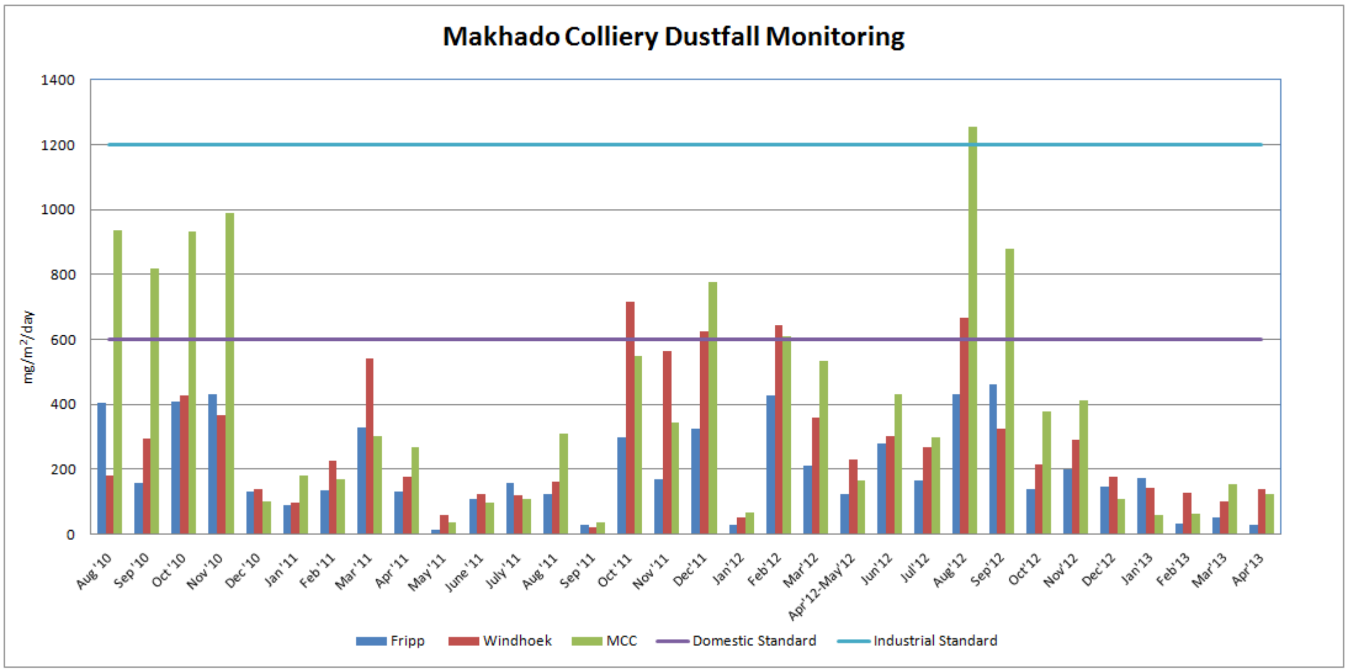

Figure 3.6: Makhado Colliery dust fallout monitoring for the Aug 2010 - April 2013 monitoring period.

Error! Reference source not found. shows the PM results for the July 2012 – April 2013 monitoring period. Ambient monitoring of Particulate matter is carried out within the Mudimeli village using the Grimm and Davis monitoring equipment, which meets the quality standards of SANS (South African National Standards). Figure 3.7 below illustrates PM_{10} and $PM_{2.5}$ levels for the July 2012 – April 2013 monitoring period. Figure 8 below illustrates the predominant wind direction during the July 2012 – April 2013 monitoring period. Variable levels of PM were experienced. The SANS standard of 120 µg/m^3 were exceeded on 5 occasions:

- 28 July (130.3 µg/m^3)
- 16 August (120.95 µg/m^3)
- 26 August (169.66 µg/m^3)
- 1 September (120.95 µg/m^3)
- 2 September (175.2 µg/m^3)

There were no exceedences of the newly gazetted $PM_{2.5}$ standard of 65 µg/m^3.

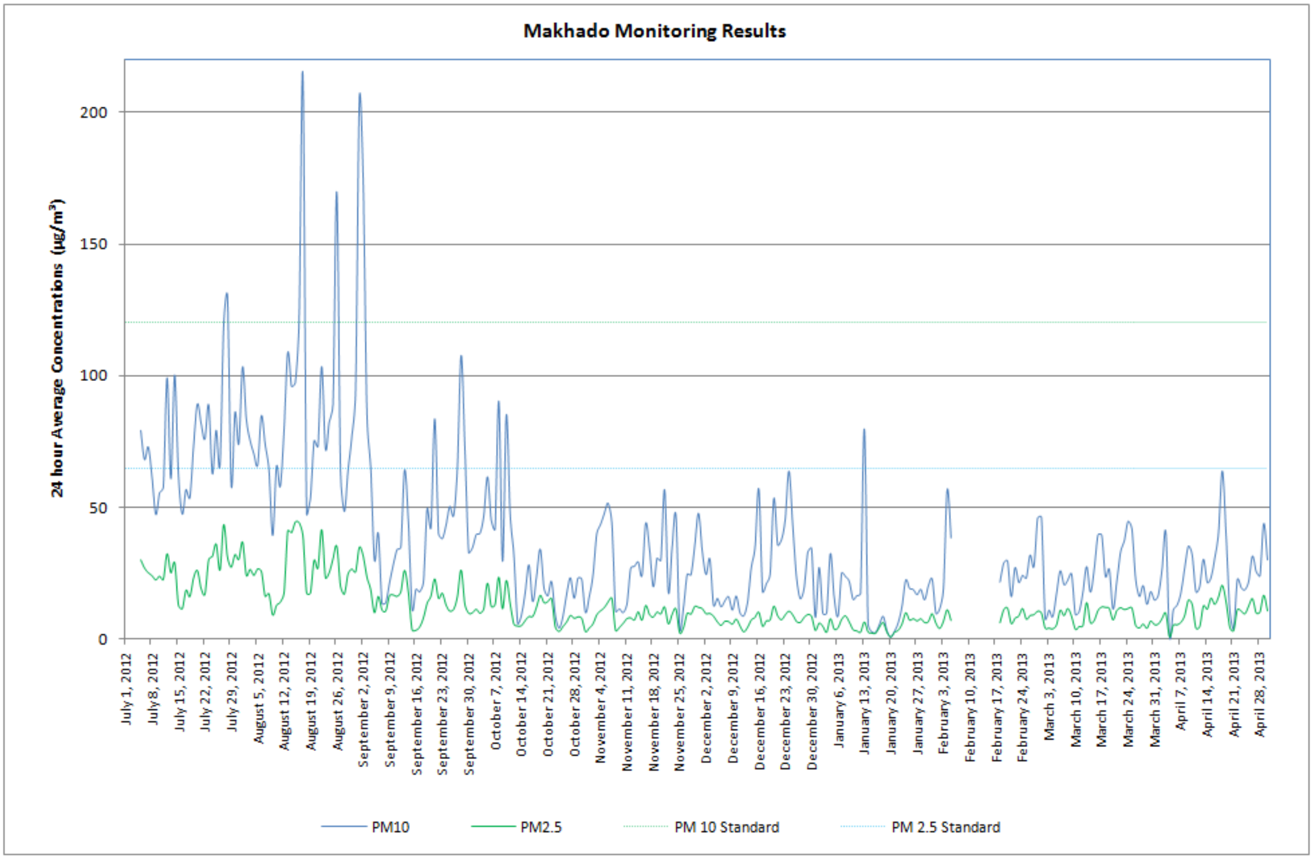

Figure 3.7: Makhado monitoring Pm results July 2012 – April 2013.

4 IMPACT ASSESSMENT

This section of the report outlines the potential ambient air quality impacts associated with the proposed activities. A detailed emissions inventory was compiled as part of this assessment to determine emissions released from the landfill, brickworks and mine. Dispersion modelling simulations were undertaken using the AERMOD dispersion model and presented graphically as isopleths plots.

4.1 Methodology

4.1.1 Model Overview

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

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

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

4.1.2 Model Requirements

Input data requirements for Aermod include meteorological and emissions source data. Meteorological data which includes wind speed, wind direction, relative humidity, pressure and temperature was obtained from the South African weather services for the Jan 2008 – Dec 2011 monitoring period. Source and emission parameters for the model are detailed in the section below.

The emissions inventory will need to be developed to determine the emissions generated from each source. This is likely to be undertaken using the US-EPA AP42 emission factors. These emission factors will be calculated based on standard operating conditions for various industries, and activities, and are used as an accepted alternative if no site specific or monitored data are available. The inventory will be developed based on the mine and plant operations and will require information relating to processes for mineral concentrate, tonnages processed and mining activity information

4.2 Emissions Inventory

The emissions inventory is developed to determine the emissions generated from each source. This is likely to be undertaken using the US-EPA AP42 emission factors. These emission factors will be calculated based on standard operating conditions for various industries, and activities, and are used as an accepted alternative if no site specific or monitored data are available. The inventory will be developed based on the mine and plant operations and will require information relating to processes for mineral concentrate, tonnages processed and mining activity information.

Emissions for the Chapudi Project were based upon the US EPA's AP42 Sections: 11.9: Western surface coal mining; 13.2.3 heavy construction operations, 13.2.4: Aggregate Handling and Storage piles and the Australian NPI (National pollutant inventory). Calculations were applied to individual processes in order to obtain an emission to air estimate, based on mass balance information sought from literature review and the client.

The anticipated key pollutants expected to be released from the proposed mining activities are particulate matter and nuisance dust. Mining operations in arid, open and frequently windy areas create significant amount of particulate matter. Wind blown dust emissions occur during nearly every phase of coal mining. The most significant sources are removal of the overburden through blasting and use of draglines, truck haulage of the overburden and mined coal, drilling, road grading and wind erosion of reclaimed areas. Diesel trucks and equipments used in mining are also a source of particulate matter emissions.

Particulate matter is a criteria pollutant which represents a broad and diverse class of chemically and physically diverse substances. Particulates can be described by size formation mechanism, origin, chemical composition, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (USEPA, 1996). Particulate matter includes dust, smoke, soot, pollen and soil particles (Kemp, 1998). Particulate matter 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**)**.

4.2.1 Heavy Construction Activities

Particulate emissions estimates from the construction activity of the Chapudi project are presented below.

$$E_{TSP} = 1.2 \text{ (ton/ha/month of activity)}$$

The quantity of emissions arising from construction activities is proportional to the area of land being worked and to the level of construction. There is currently no emission factor for PM 10 for construction activities, therefore a factor of 50% was applied to the calculated TSP emission rates according to best international practice, unless specified elsewhere in the emissions inventory. Table 4.1 below shows the calculated emission rates for heavy construction activities. Two scenarios were evaluated namely mitigated and unmitigated. The mitigated scenario was based on a control efficiency of 85%.

Table 4.1: Heavy Construction emission rates for Wildebeesthoek, Chapudi West and Chapudi Section.

	Area (ha)	TSP (g/s)	PM_{10} (g/s)
Unmitigated			
Wildebeesthoek	3254	1.22E-08	6.09E-09
Chapudi (Chapudi west and Chapudi section)	4321	9.17E-09	4.59E -09
Mitigated			
Wildebeesthoek	3254	1.83E -09	9.14E -10
Chapudi (Chapudi west and Chapudi section)	4321	1.38E -09	6.88E -10

4.2.2 Bulldozing

The USEPA provides an emissions equation specifically for activities from bulldozers since this equation takes silt content and moisture into account. This was taken from the AP42 Western Surface Coal Mining specifications for opencast mining activities. Emissions from dozing of overburden, interburden and coal were calculated using the following equations:

$$E_{TSP} = 2.6 \times \frac{(s)^{1.2}}{(M)^{1.3}}$$

$$E_{PM10} = 0.34 \times \frac{(s)^{1.5}}{(M)^{1.4}}$$

Where:

E_{TSP} = Total Suspended Particulates emission factor (kg dust/hr)

E_{PM10} = Particulate emission factor (kg dust/hr) for particulates less than 10 μm

M = material moisture content (%)

s = material silt content (%)

Table 4.2: Emission rates for Bulldozing activities for the Chapudi Project.

	TSP (g/s)	PM_{10} (g/s)
Overburden	4.65	1.12
Inter-burden	4.65	1.12
Coal	2.27	0.48

4.2.3 Blasting

The US EPA provides an emission equation for blasting activities. This was taken from the AP42 western coal mining specifications for open cast coal mining. Blasting was calculated based on 3 times per week.

$$EF_{TSP\,(kg/blast)} = 0.00022 \times A_{(m^2)}^{1.5}$$

Where:

A (m^2) = the area blasted (m^2)

M (%) = the moisture content of the blasted material (% by weight)

D (m) = the depth of the blast hole (m)

Table 4.3:Emission rates for blasting activities for the Chapudi Project.

	TSP (g/s)	PM_{10} (g/s)
Blasting activities (3 times per week)	1.435	0.746

4.2.4 Materials Handling (Tipping Activities)

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

The USEPA does not have an emission factor or equation specific for calculating emissions from excavators or shovels. The Australian NPI, however, provides the same equation as for tipping to be applied to excavators and shovels. The following equations were used to calculate TSP and PM_{10} emissions respectively:

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

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

Where:

U = mean wind speed

M = the moisture content of material (%)

k = the empirical constant per size fraction

Table 4.4: Empirical constant for Total suspended particles and Particulate Matter.

Empirical constant	TSP	PM_{10}
Empirical constant for Materials handling activities	**0.74**	**0.35**

Table 4.5: Emission rates for material handling activities.

	TSP (g/s)	PM_{10} (g/s)	Total
Wildebeesthoek Stockpiles	0.12	0.04	0.16
Chapudi section and Chapudi west stockpiles	0.12	0.04	0.16

4.2.5 Wind Erosion from exposed areas

Dust emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded (Cowherd *et al.*, 1988; EPA, 1995). The threshold wind speed is dependent on the erosion potential of the exposed surface, which is expressed in terms of the availability of erodible material per unit area (mass/area). Any factor which binds the erodible material or otherwise reduces the availability of erodible material on the surface thus decreases the erosion potential of the surface. Studies have shown that when the threshold wind speeds are exceeded, particulate emission rates tend to decay rapidly due to the reduced availability of erodible material (Cowherd *et al.*, 1988).

Significant amounts of dust will be eroded from open, exposed areas at the proposed mine under wind speeds of greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s). Fugitive dust generation resulting from wind erosion under high winds (i.e. > 5.4 m/s) is directly proportional to the wind speed.

The particulate matter equation from the wind erosion of exposed ground was calculated using the following equation (NPI Mining):

$$E_{TSP} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right)$$

$$E_{PM10} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right) \times 0.5$$

Where:

E_{TSS} = total suspended particles emission factor, kg/day/ha

S = silt content of aggregate (%)

p = number of days with .0.25mm of precipitation per year

f = percentage of time that the unobstructed wind speed exceeds 5.4m/s.

Table 4.6: Emission Rates for wind erosion of stockpiles.

Source	Emission rate
Wildebeesthoek stockpiles	3.07
Chapudi west stockpiles	3.07
Chapudi stockpiles	3.07

4.2.6 Methane Emissions

The first emissions released from coal production are methane. Methane is a powerful heat trapping gas and is the second contributor to global warming after Carbon dioxide. Methane is non toxic to humans but is of concern in terms of its explosive potential and its impact on the global climate. Methane is one of the most significant greenhouse gases and is 21 times stronger than carbon dioxide (Campbell, 1996).

Methane is produced during coalification (process of coal formation). Only a fraction remains trapped under pressure within the coal seams and surrounding strata. The trapped methane is released during mining when the coal seams are fractured. Methane released in this fashion will escape into the mine works and eventually diffuse into the atmosphere (Irving and Tailakov, 2000).

The amount of coal released during mining depends on a number of factors, the most important of which is the coal rank, seam depth and method of mining. As coal rank increases so does the amount of methane produced. At surface mines, methane escapes from newly exposed coal faces /surfaces as well as from areas of coal rubble created by blasting operations. Methane is also present in the overburden which breaks down during the mining process and the underlying strata can be fractured due to the removal of overburden. Methane emission per ton of coal is much lower from surface than underground mining as the gas content is lower with shallow seams (Irving and Tailakov, 2000).

4.3 Impact Assessment

Dispersion modelling simulations were undertaken to determine the potential air quality impacts associated with the proposed activities. These impacts are reflected as isopleths plots. The isopleths plots reflect the gridded contours (lines of equal concentration) of zones of impact at various distances from the contributing sources. The patterns generated by the contours are representative of the maximum predicted ground level concentrations for the averaging period being represented. The impact assessment for the Chapudi mine is based on two scenarios namely; scenario 1 which assess the impacts arising from the construction activities and scenario 2 which assess the LOM (life of mine) activities taking place on site.

4.4 Construction impacts

The major impact associated with construction activities is the high potential for dust generation which may have a substantial impact on the local air quality.

Emissions released during the construction of a mine are associated with land clearing activities, drilling and blasting, ground excavation and construction of mining facilities. Dust emissions will vary from day to day and will depend on the duration, the type of activity and the prevailing wind conditions (USEPA, 1996). However the majority of dust impacts are generated by construction vehicles and equipment over unpaved roads (USEPA, 1996).

The temporary nature of construction activities is what distinguishes it from other fugitive sources present within the locality. Emissions from construction activities are expected to have a definitive start and end period and will vary depending on the various construction phases. In contrast to other fugitive sources, here the emissions occur in a steady state or follow a discernible pattern.

The impact on air quality and air pollution of fugitive dust is dependent on the quantity and drift potential of the dust particles (USEPA, 1996). Large particles settle out near the source causing a local nuisance problem. Fine particles can be dispersed over much greater distances. Fugitive dust may have significant adverse impacts such as reduced visibility, soiling of buildings and materials, reduced growth and production in vegetation and may affect sensitive areas and aesthetics. Fugitive dust can also adversely affect human health.

The following components of the environment which may be impacted upon during the Chapudi project construction phase:

- The ambient air quality
- Local residents, farms and neighbouring communities
- Mine employees
- The surrounding environment and possible the fauna and flora.

A quantitative assessment of the construction impacts was based on the activities carried out in the respective mining pits. Emission rates were calculated based on the USEPA heavy construction emission factors. Wildebeesthoek, Chapudi west and Chapudi mine were modelling simultaneously.

Figure 4.1 and Figure 4.2 below illustrates the maximum predicted daily and annual ground level concentration of PM_{10} from construction activities respectively. The predicted PM_{10} concentration falls below the respective daily and annual standards (Table 4.7). The PM_{10} construction impacts are highest from the Wildebeesthoek and Chapudi mine sections. The resultant impacts arising from construction activities of all three mines are minimal.

Table 4.7: Maximum predicted ambient ground level concentration (µg/m^3) of Particulate Matter during the construction phase.

Source	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard	Fraction of the standard (%)
Daily			
Cumulative construction impacts	0.20	120	0.17
Annual			
Cumulative construction impacts	0.07	50	0.14

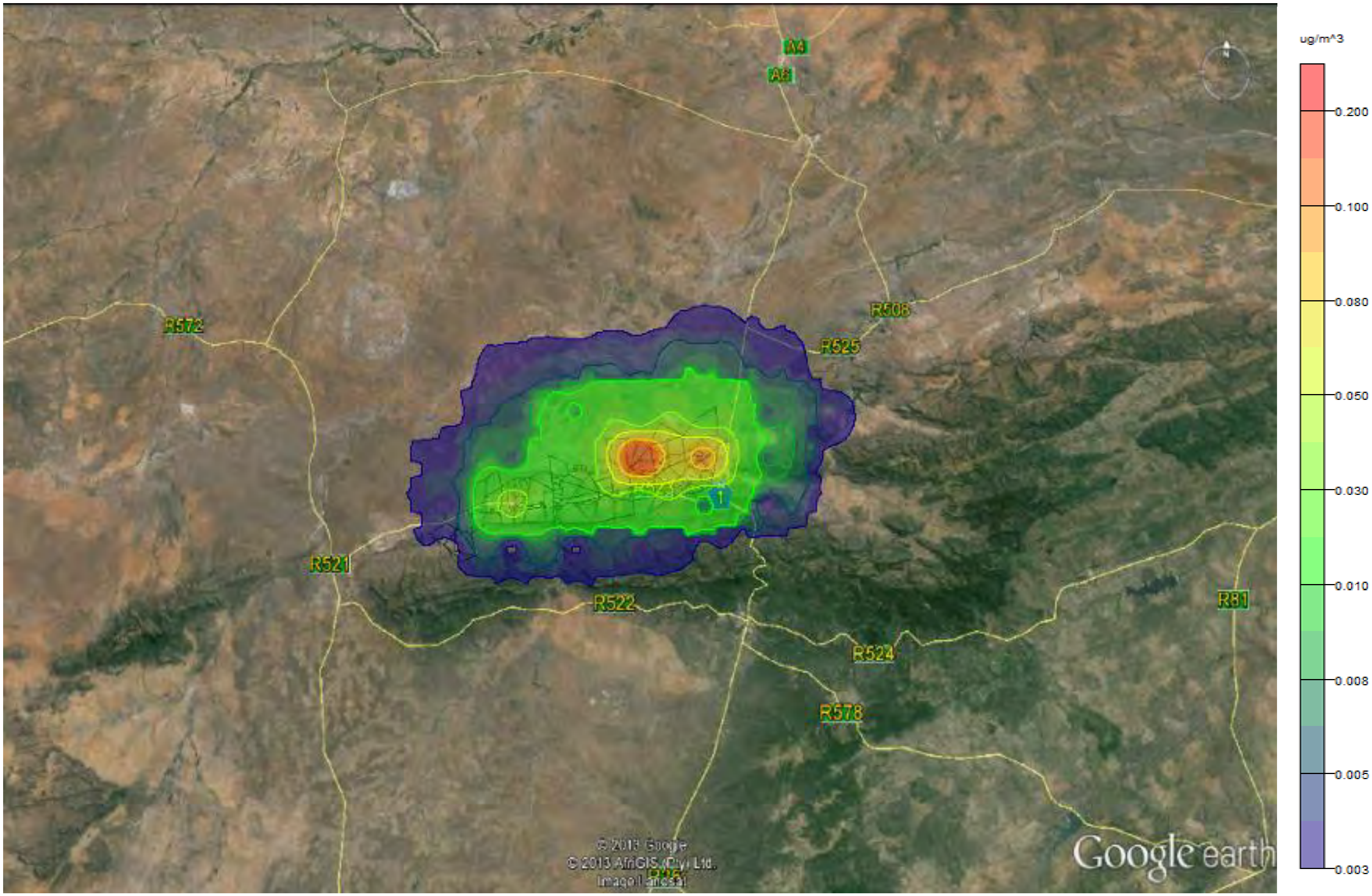

Figure 4.1: Maximum predicted daily concentration (µg/m^3) of Particulate matter during construction activities.

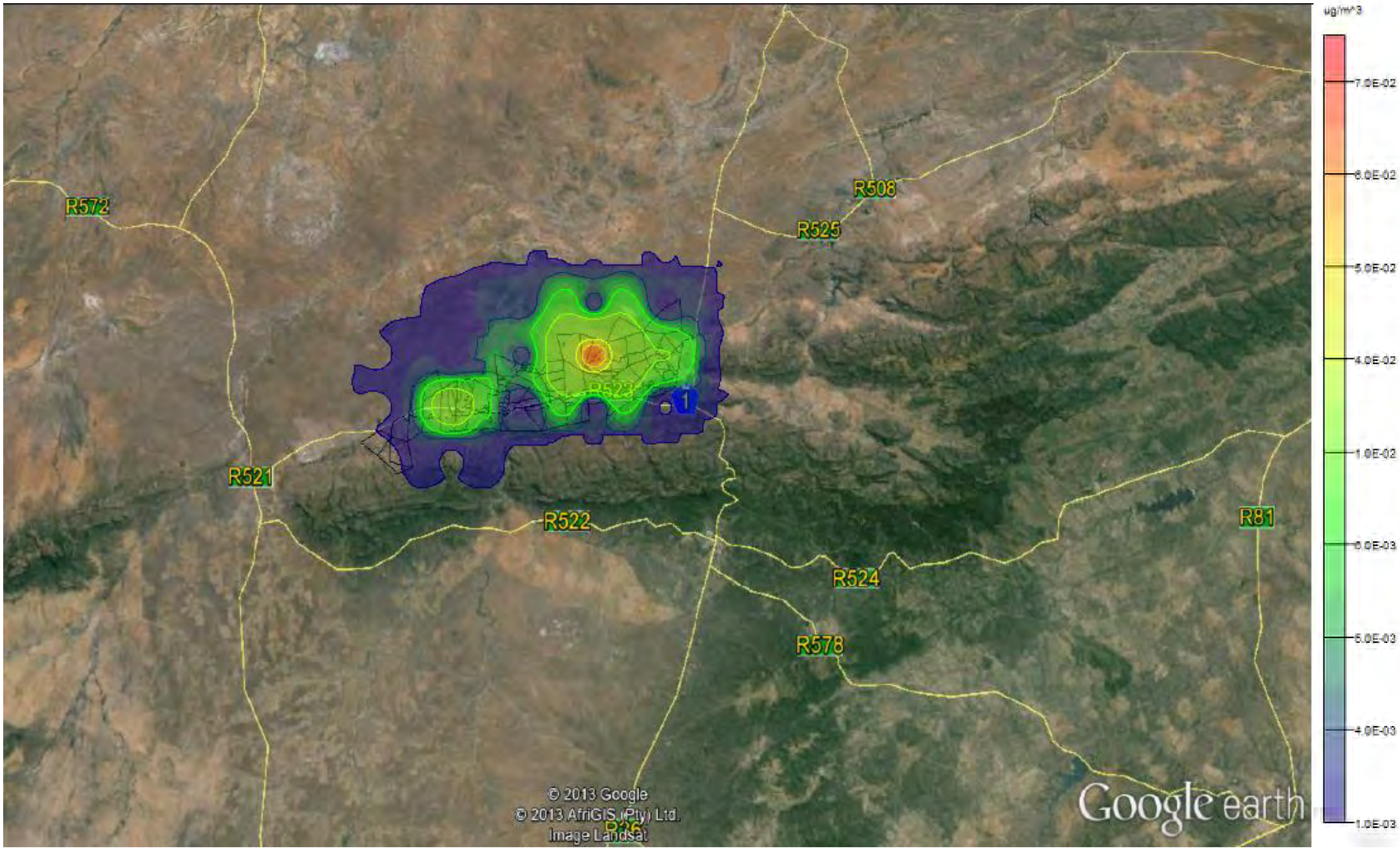

Figure 4.2: Maximum predicted daily concentration (µg/m^3) of Particulate matter during construction activities.

4.5 Operational Impacts

This section of the report aims to deal with the air quality impacts associated with the proposed mining activities scheduled to commence at Wildebeesthoek at a mining rate of 12.5 Mtpa for a period of 31 years and at Chapudi west and Chapudi mine at a mining rate of 12.5 Mtpa for a period of 43 years. Construction and mining will commence at the Wildebeesthoek section where the coal yield are highest.

The details regarding the source characteristics were extrapolated from site layout plans. Sources that were included in this impact assessment are:

- Coal processing (storage piles, crushing and screening activities);
- Open cast mining and in – pit activities (drilling, blasting, bulldozing and tipping)
- Wind erosion from exposed surfaces

Table 4.8 below indicated the maximum predicted daily ground level concentration of PM_{10}during the operational phase at the Chapudi Project. The cumulative impact of 70 µg/m^3 falls below the daily South African standard of **120** µg/m^3 for PM_{10} (Figure 4.3). When compared against the standard to be implemented in 2015, the predicted concentration is just below the 75 µg/m^3 standard. Mitigation measures should be considered in order to maintain compliance with the 2015 PM_{10}standards.

The highest contributor to the PM_{10} concentration is activities carried out in the mining pit with emissions from stockpile being minimal.

Table 4.8: Maximum predicted daily ground level concentration for PM_{10}during the operation conditions at the Chapudi project.

Source	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard (µg/m^3)	Fraction of the standard (%)
Mining Pits	67.6	120	56
Wildebeesthoek Mining Pit	26.4	120	22
Chapudi west mining pit	30.9	120	26
Chapudi	61.2	120	51
Stockpiles	3.1E-02	120	0.02
Cumulative impacts	70.0	120	58

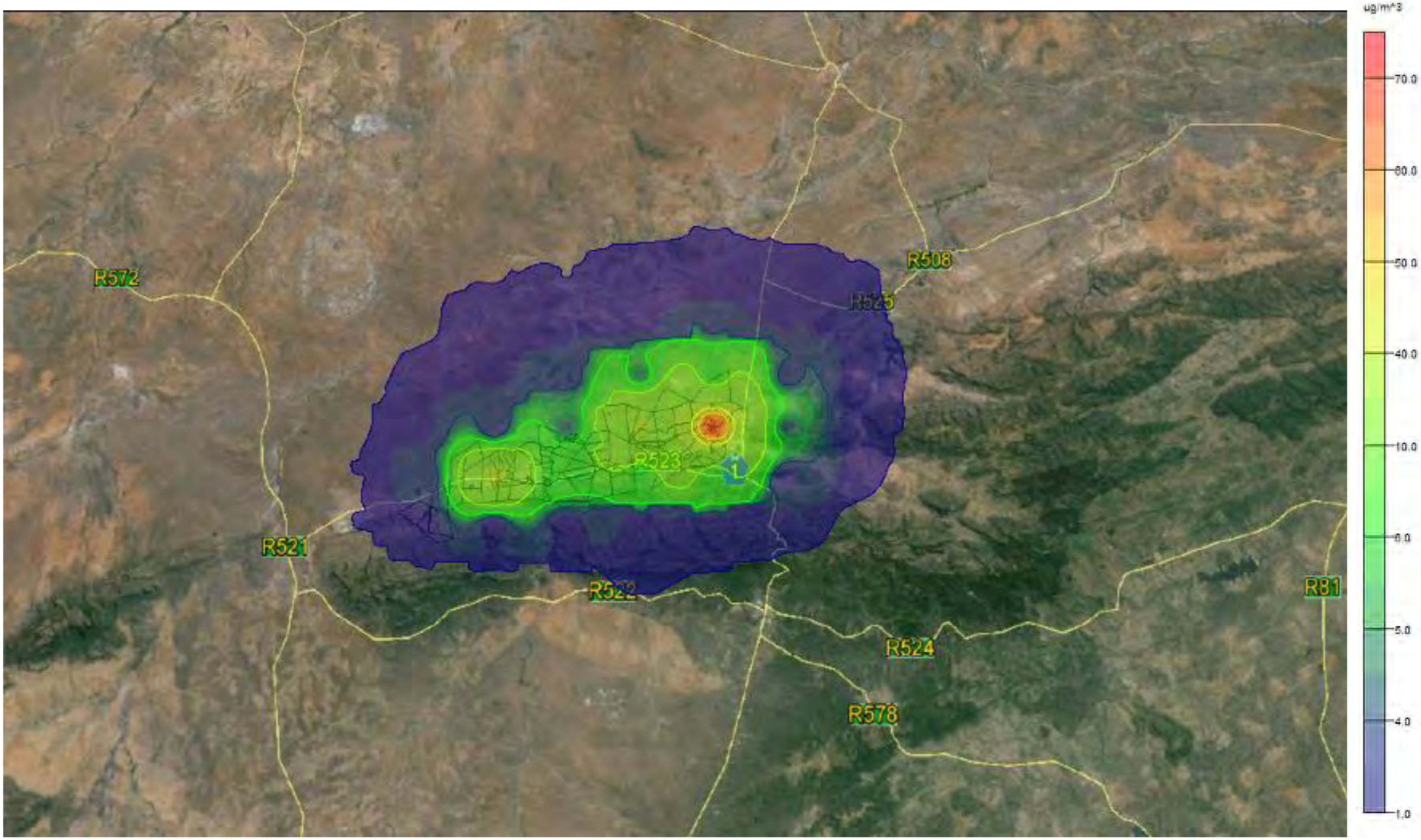

Figure 4.3: Maximum predicted daily ground level concentration (μg/m^3) of Particulate matter during operational phase at the Chapudi Project.

Table 4.9 below indicated the maximum predicted annual ground level concentration of PM_{10} during the operation phase at the Chapudi Mine. The cumulative predicted impact of 20 µg/m^3 for PM_{10} (Figure 4.4) falls below the annual South African standard of **50 µg/m^3**. The highest contributor to the predicted annual concentration is emissions from the mining pits, particularly Chapudi west mining pit with 11.8 µg/m^3.

Table 4.9: Maximum predicted annual ground level concentration for PM_{10} during the operation conditions at the Chapudi project.

Source	Maximum predicted ground level Concentration of PM_{10} (µg/m^3)	Ambient air quality standard (µg/m^3)	Fraction of the standard (%)
Mining Pits	12.0	50	24
Wildebeesthoek Mining Pit	9.74	50	20
Chapudi west mining pit	11.8	50	24
Chapudi	7.36	50	15
Stockpiles	4.8E-03	50	<0.1
Cumulative impacts	20.0	50	40

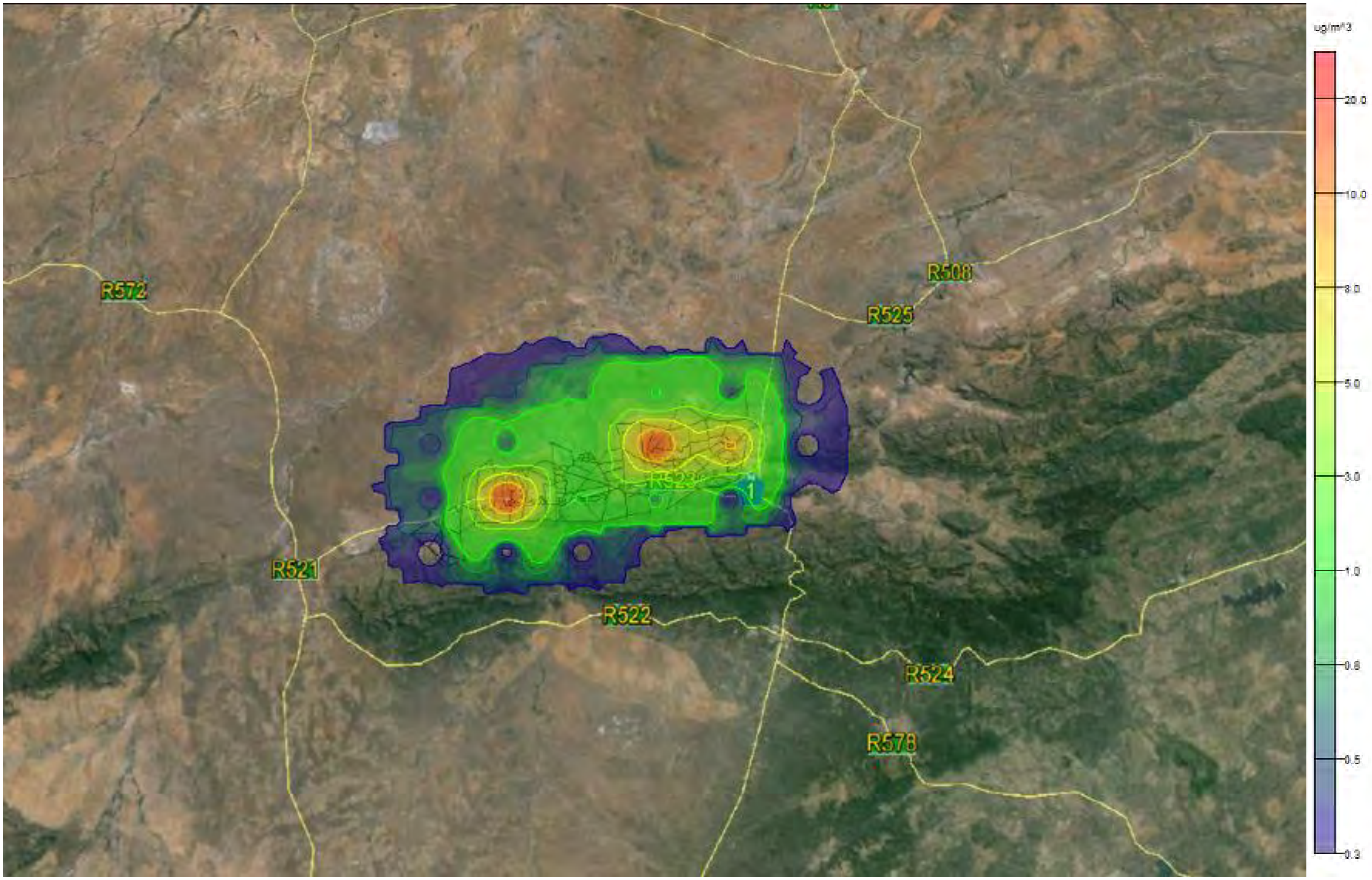

Figure 4.4: Maximum predicted annual ground level concentration (µg/m^3) of Particulate Matter during operational phase at the Chapudi Project.

The blasting impacts were modelled separately as blasting was modelled at an average of 3 times per week for intervals of approximately 10 minutes. Figure 4.5, Figure 4.6 and Figure 4.7 below illustrates the hourly, daily and annual concentrations of particulate matter from blasting activities. The daily and annual standard of PM_{10} for blasting activities falls below the daily and annual South African standard of 120 µg/m^3 and 50 µg/m^3 respectively.

Blasting is not a continuous activity and is limited to a maximum of three times a week, thus the initial impact of blasting is relatively high with the annual concentration being minimum.

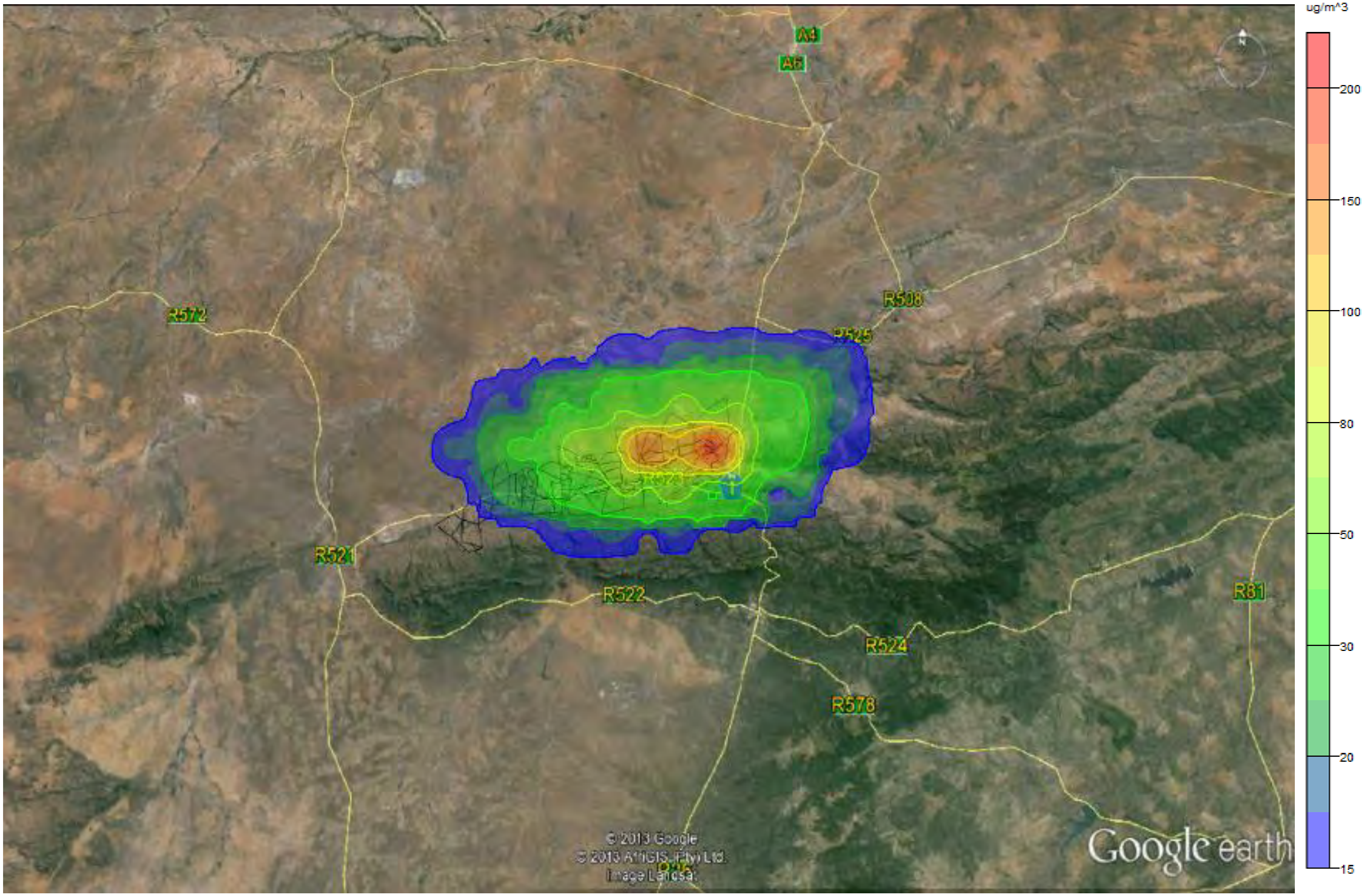

Figure 4.5: Maximum predicted hourly concentration (µg/m^3) of PM_{10} from blasting activities at the Chapudi Project.

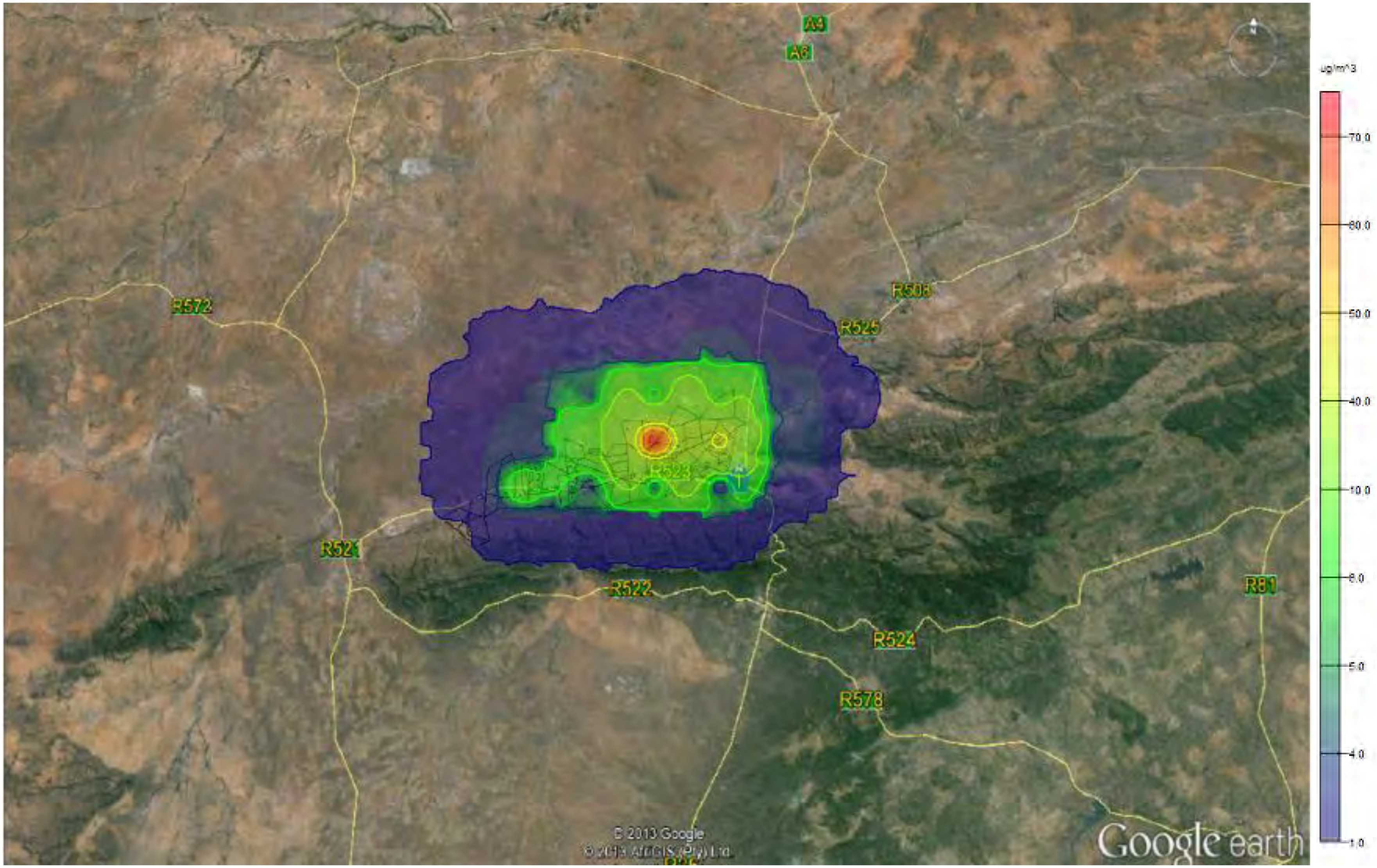

Figure 4.6: Maximum predicted daily concentration (µg/m^3) of PM_{10} from blasting activities at the Chapudi Project.

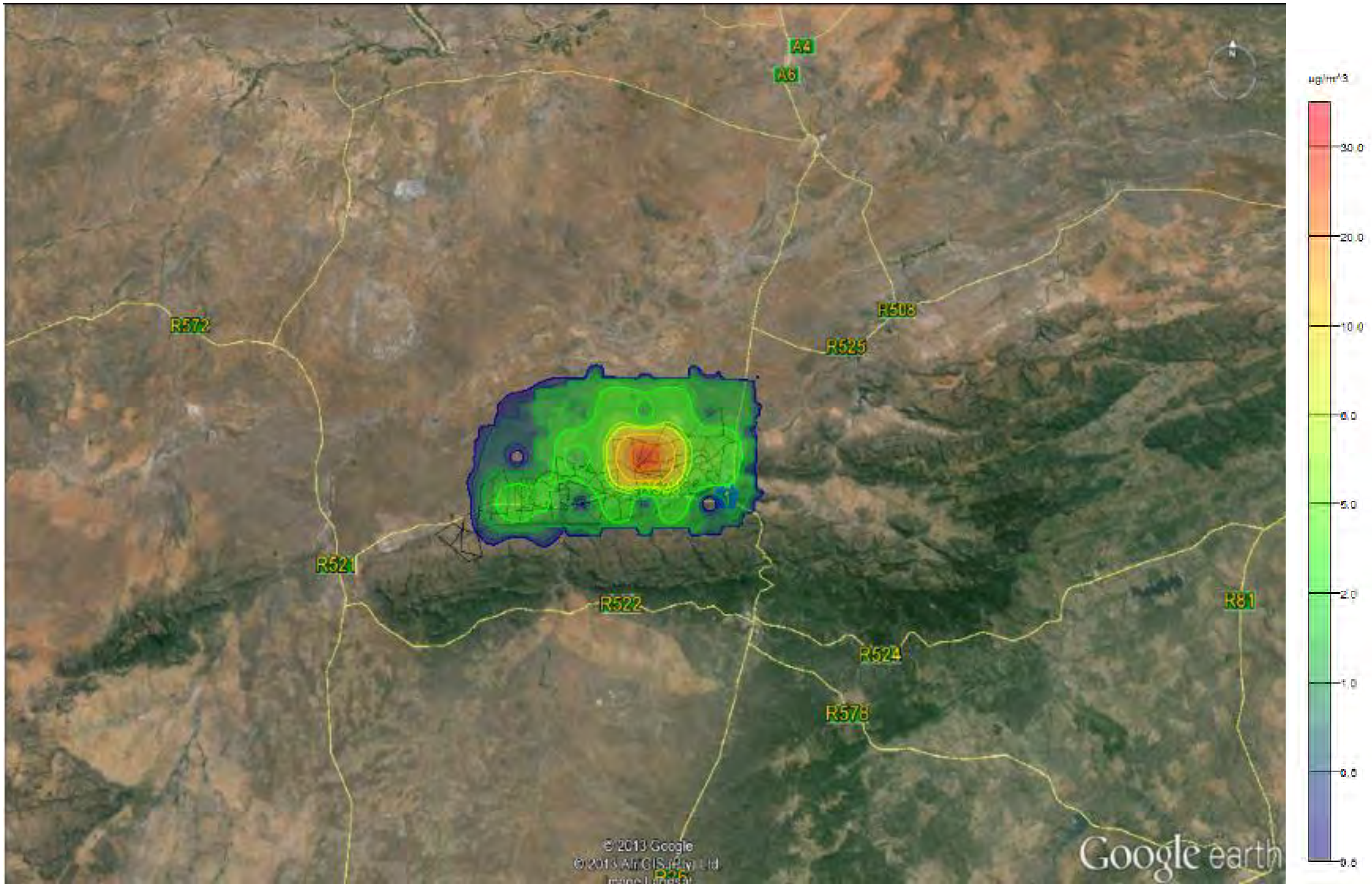

Figure 4.7: Maximum predicted annual concentration (µg/m^3) of PM_{10} from blasting activities at the Chapudi Project.

Figure 4.8: Dust fallout impacts recorded during the operational phases of the Chapudi project.

Dust fallout rate (mg/m^2/day)	300	600

Figure 4.8 above illustrates the dispersion potential of the predicted dust fallout impacts arising from the operational phase at the Chapudi project. The 600 mg/m^2/day dust fallout standard is concentrated at the Wildebeesthoek mining pit and doesn't extend beyond the mining boundary.

When comparing the modelled result to monitored results of August 2010- April 2013, the average dust fallout results was 390 mg/m^2/day compared to the modelled data of 300 mg/m^2/day. Higher dust fallout rates are expected during the winter months of July – August. Increase in the activity will result in an increase in the dust fallout rate.

4.6 Decommissioning impacts

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The total rehabilitation will ensure that the total area will be a free draining covered with topsoil and grassed. 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;
- Topsoil replaced using topsoil recovered from stockpiles; and
- Land and permanent waste piles prepared for re-vegetation.

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 re-vegetation – 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). Re-vegetation of exposed areas for long-term 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 re-vegetation 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.

4.7 Assumptions and Limitations

The following assumptions were made as part of this assessment:

- The volume and height of the stockpiles and discard dumps were estimated based on previous impact assessments and the US-EPA emission models for mining activities.
- The moisture content for the different type of materials was not available therefore use was made of the moisture content values given in the USEPA for quarrying and processing.
- Use was made of the US-EPA AP42 for all calculations as no detailed source specific information is available at the commencement of this project.

4.8 Proposed Mitigation

4.8.1 Construction Impacts

Due to the relatively short nature of construction activities, some control measures are more effective than others. Wet suppression and wind speed reduction are two common methods used to control open dust sources at construction sites. Table 4.10 below shows the different type of mitigation measures used for dust control and particulate matter emissions.

Table 4.10: Recommended mitigation measures during construction activities (US EPA,1996)

Emission source	Recommended control method
Debris handling	Wind speed reduction
	Wet suppression [1]
Truck Transport [2]	Wet suppression
	Paving
	Chemical stabilization [3]
Bulldozing	Wet suppression [4]
Material handling	Wind speed reduction
	Wet suppression
General construction	Wet suppression
	Wind speed reduction
	Early paving of permanent roads

1- Dust control plans should contain precautions against watering programs that cofound track out problems.

2- Loads should be covered to avoid loss of material in transport, especially if material is transported offsite.

3- Chemical stabilization usually cost effective for relatively long term or semi-permanent unpaved roads.

4- Excavated material may already be moist and not require additional wetting.

Water may be combined with a surfactant as a wetting agent. Surfactants increase the surface tension of water, reducing the quantity of water required. Chemical stabilisation is of longer duration but is not cost effective for small-scale operations. Dust-A-Side (DAS) represents an example of a chemical product, which is commercially available and widely used by mines and quarries. The DAS product binds with the aggregate used to build on-site roads. It should be noted however, that the treatment with chemical stabilisers can have adverse effects on plant and animal life and can contaminate the treated material (USEPA, 1996).

Dust and mud should be controlled at vehicle exit and entry points to prevent the dispersion of dust and mud beyond the site boundary. Facilities for the washing of vehicles could be provided at the entry and exit points. A speed limit of 40 km/hr should be set for all vehicles travelling over exposed areas or near stockpiles. Traffic over exposed areas should be kept to a minimum (USEPA, 1996). Additional preventative techniques include the reduction of the dust source extent and adjusting work processes to reduce the amount of dust generation (USEPA, 1996).

4.8.2 Operational Impacts

Based on studies undertaken by C.B. Arpacioglu and C.Er, they indicate that most of the dust impacts associated with mining will occur within the mine site area, and will not be very significant and unlikely to exceed World Bank ambient air quality standards.

Table 4.11: Recommended Mitigation measures during operational phase.

Emission source	Recommended control method
Materials handling	Wet suppression [1]
Truck transport[2]	Wet suppression
	Chemical stabilisation[3]
	Paving
Blasting	Wet suppression during blasting activities
Bulldozers	Wet suppression

1- Dust control plans should contain precautions against watering programs that cofound track out problems.

2- Loads should be covered to avoid loss of material in transport, especially if material is transported offsite.

3- Chemical stabilization usually cost effective for relatively long term or semi-permanent unpaved roads.

Watering and the use of chemical wetting agents are the principle means for control of aggregate and storage pile emissions. The covering and enclosure of inactive piles can reduce wind blown emissions. The use of water is particularly useful in the reduction of emissions due to vehicle traffic in and around storage pile areas. Watering storage piles has a very temporary effect on total emission. A much more effective technique is the use of chemical agents such as a surfactant that permits extensive wetting. The continuous chemical treating of material loaded onto piles, couples with watering or treatment of roadways can reduce total particulate emissions from aggregate storage operations by up to 90% (US EPA, 1996).

The watering of unpaved surfaces by use of wet suppression prevents fine particulates from leaving the surface and becoming airborne through the action of mechanical turbulence and wind. Water binds smaller particles to larger ones thus reducing the emission potential.

4.8.3 Decommissioning Phase

Revegetation of exposed areas for long-term dust and water erosion control is commonly used and is the most cost-effective option. The area should be re-vegetated as soon as the mining within the open pit stops. Plant roots bind the soil, and vegetation cover breaks the impact of falling raindrops, thus preventing wind and water erosion. Plants used for re-vegetation 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.

4.9 Conclusion

The air quality impact assessment undertaken for the Chapudi Project includes a meteorological overview of the area. Meteorological data was obtained from the South African Weather Services for the period Jan 2008- Dec 2012. An emissions inventory was undertaken with the aim of quantifying emissions associated with the activities involved in the mining and processing of coal. The emissions for specific activities such as bulldozing, blasting, tipping, wind erosion and materials handling activities were calculate and the cumulative impacts were compared to the relevant ambient air quality standards to determine legal compliance.

The construction and operational phases were assessed. Based on the dispersion modelling simulations, the following conclusions can be summarised as follows:

- Construction impacts

The maximum predicted annual ground level concentration of PM_{10} resulting from all construction activities at Wildebeesthoek, Chapudi and Chapudi West were predicted at 7.0E-02 µg/m^3. The maximum predicted daily ground level concentration of PM_{10} was estimated at 2.00E-02 µg/m^3. Both the annual and the daily predicted concentrations complied with the South African standard of 50 µg/m^3 and 120 µg/m^3 respectively.

- Operational phase

The maximum predicted annual ground level concentration of PM_{10} for all activities taking place during the Life of mine was estimated at 20.0 µg/m^3. This falls below the annual standard of 50 µg/m^3. The maximum predicted daily concentration of PM_{10} was estimated at 70 µg/m^3, this also falls below the daily South African standard of 120 µg/m^3. The highest contributors to the particulate matter emissions were activities taking place within the mining pit such as bulldozing, tipping and materials handling. The daily and annual blasting emissions were below the daily and annual South African standard.

Dust fallout concentrations were highest at the Wildebeesthoek and Chapudi mining pit with 600 mg/m^2/day. There were no exceedances of the 1200 mg/m^2/day limit for a non residential site. The average concentration of dust fallout at the mine boundary is estimated at 300 mg/m^2/day.

The impacts from dust fallout and Particulate matter can be reduced by implementing dust control measures. The highest intensity of the construction work should be carried out during the summer months and not over the harsh winter months as this can result in increased dispersion of fugitive dust. The Chapudi project should ensure that unpaved roads are continuously watered and treated with dust-a-side products to reduce the volume of fugitive dust emitted from unpaved roads. The use of wind screens on open ground surfaces during periods of extreme windy conditions.

Overall the impacts arising from the mining activities on the surrounding environment are within the ambient air quality standards.

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Appendix B – Nicole Singh CV

CURRICULUM VITAE

Name of Firm: **Royal HaskoningDHV**

Name of Staff: Nicole Singh

Profession: Environmental Scientist

Date of Birth: 25/02/1988

Years of Experience: 3 **Nationality:** South African

Nicole Singh is currently working as an Environmental consultant for Royal HaskoningDHV. Qualified with a BSc degree in Biological sciences from the University of Kwa Zulu Natal in 2009. Being extremely analytical and technically minded, this career path suited her well. Nicole worked as a nutrient analyst (laboratory assistant) for the School of Biological and Conservation Sciences, University of Kwa-Zulu Natal from June 2009 till June 2010. Her main role involved statistically analyzing all nutrient water samples for chemicals such as phosphate, silicate, nitrate, nitrite and ammonium for national leading institutes such as UKZN, UCT, ACEP (African coelomate ecosystem project) and ORI (Oceanographic research institute). Nicole then went on to work as a Specialist in Environmental Air Quality for SGS. Her main responsibilities were managing air quality projects for clients such as SASOL, Eskom, Anglo- American, Anglo Coal and RPM.

Education:	
2010	BSc Biological Science, University of Kwa Zulu Natal, South Africa

Employment History:

2013 (April) **Royal HaskoningDHV, South Africa**
Environmental Consultant

2012 (August – April 2013) **Royal HaskoningDHV, South Africa**
Junior Air Quality Specialist

2011 (November – August 2012) **SGS**
Specialist: Ambient reporting and client liaison

2011 (July – November) **SGS**
Junior specialist: Ambient reporting and client liaison

2010-2011 **University of KwaZulu-Natal, Westville, South Africa**
Nutrient analyst

Employment Experience:

2013 **EON Consulting Busby Renewable Energy project, South Africa**

Client: Farmsecure

Project Value: R40, 000.00

Brief Project Description: It is our standing that the air quality aims to assess the baseline environmental impacts associated with construction operational and decommissioning of the proposed biomass combustion plant located in Amsterdam Mpumalanga.

Position: Project Manager
Assigned Tasks: Fatal flaw assessment
Project Number : I10.JNB.400005

2013 **Eon Consulting Lazy Bend AQ, South Africa**

Client: Farmsecure

Project Value: R40, 000.00

Brief Project Description: It is our standing that the air quality aims to assess the baseline environmental impacts associated with construction operational and decommissioning of the proposed biomass combustion plant located in Amsterdam Mpumalanga

Position: Project Manager
Assigned Tasks: Fatal flaw assessment
Project Number :I10.JNB.400006

2013 **Verref Landfill Air Quality Impact Assessment**

Client: AECOM SA (Pty)Ltd

Project Value: R 72, 380.00

Brief Description: Air Quality Impact assessment and buffer zone delineation for a general waste disposal site. The study was aimed at assessing the potential environmental impacts associated with the gaseous and particulate emissions released from the proposed general waste disposal site in Springs.

Position : Project Manager

Assigned Tasks: Air Quality Specialist

Project Number: I10.JNB.400004

2012 **Appointment of professional services: Development of an environmental pollution control plan, South Africa**

Client: Amathole District Municipality

Project Value: R395,260.00

Brief Description: Development of a pollution plan for the Amathole District Municipality.

Position: Air Quality Specialist

Assigned Tasks: Technical input – Air Quality

Project Number: E02.ELS.000030

2012 **GGV Air Quality Impact Assessment**

Client: Jacana Environmentals CC

Project Value: R 80,050.00

Brief Description: Air Quality Impact assessment for an Environmental Impact assessment for a Coal Mine, located in Mpumalanga.

Position: Project Manager and Specialist

Assigned Tasks: Air quality specialist, EIA and modelling

E02.JNB.001293

2012 **Komati Power Station S24G Rectification Application Ash Dam, South Africa**

Client: Iliso Consulting (Pty)Ltd

Project Value: R 65,200.00

Brief Description: The project entails the assessment of several unauthorised activities which have begun at the Komati Power Station near Middelburg. The project would therefore involve an air quality impact assessment to provide specialist input into the S24G rectification application.

Position: Air Quality Specialist

Assigned Tasks: Technical input – Air Quality

Project Number: E02.JNB.001285

2012 **Meyerton Waste Water Treatment Works (Air Quality Assessment), South Africa**

Client: MSA Group Services

Project Value: R 86,400.00

Brief Description: Air Quality Impact Assessment and a determination of the Buffer Zone Study for the Meyerton Waste Water Treatment Works.

Position: Project Manager and Specialist
Assigned Tasks: Air quality specialist, EIA and modelling
E02.JNB.001280

2012 **Western Cape State of Environment Report (SOER)**

Client: Western Cape Department of Environmental Affairs and development planning.

Project Value: R 938,200.00

Brief Description: Compilation of the First update of the state of environment for the Western Cape province.

Position: Air Quality Specialist

Assigned Tasks: Air quality specialist

E02.CPT.000330

2012 **Waste Management License and Atmospheric emissions license for an Animal carcass incinerator, South Africa**

Client: NSL Distributors CC

Project Value: R 355,680.00

Brief Description: Royal HaskoningDHV was appointed by the JV of NSL Distributors and Plumbing Sewage Solutions to conduct an Air Quality Impact Study (required for the Emission Licence application) and obtain a Waste Management Licence for animal carcass incinerator, located in Middledrift in the Eastern Cape.

Position: Air Quality Specialist

Assigned Tasks: Technical input – Air Quality Modelling and AEL application

Project Number: E02.ELS.000006

2012 **Environmental Assessment services and water use license application for the proposed BRT line 1, South Africa**

Client: A-M Consulting Engineers (Pty) Ltd

Project Value: R551, 250.00

Brief Description: Appointment for conducting all the General Environmental Assessment Services and Public Participation Process work related to the managing the process in obtaining the required environmental authorisation and Water Use Licence for the relevant authorities, for the proposed BRT Line.

Position: Environmental Consultant

Assigned Tasks: Support during the Public participation process

E02.JNB.001167

2012 **Environmental Impact assessment for the Sasol Secunda Growth programme 1B Proposed retrofitting of Gas turbines, South Africa**

Client: Sasol Technology (Pty)Ltd

Project Value: R 302,175.00

Brief Description: Environmental Impact Assessment for the Sasol Secunda Growth Programme 1B.

Position: Air Quality Specialist

Assigned Tasks: Technical input – Air Quality Modelling and AEL application
Project Number : E02.PTA.000407