Proposed Neo 1 20MW Solar PV Plant, Lesotho

Air Quality Impact Assessment – Environmental Impact Report

PREPARED FOR:

Royal HaskoningDHV (Pty) Ltd.

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Proposed Neo 1 20MW Solar PV Plant, Lesotho: Air Quality Impact Assessment

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1. Introduction

EBS Advisory Services was commissioned to undertake an Air Quality Impact Assessment for the proposed Neo 1 Solar Power Project located in the Mafeteng Province, Lesotho (Figure 1). The proposed site is located approximately 1.2km west of the town of Sepechele. The development of the solar project will entail the construction of a 20 MW photovoltaic plant.

This study aims to assist in the development of an environmental impact study to determine the potential air quality impacts associated during the construction, operation and eventual decommissioning of the site.

Figure 1: Overall site location and substation relative to major towns within Lesotho

1.1. Background

Neo 1 proposes the development of a 20MW solar photovoltaic power generation plant, (including grid connection infrastructure) in Lesotho (Figure 2). The proposed plant will run for a minimum of 25 years, however is expected to run longer. The development of the power station with both increase the domestically-produced fraction of electricity to serve the population of Lesotho, as well as to put Lesotho on tract to demonstrate to the international community its commitment to use renewable resources.

1.2. Project Description

The Project will entail construction of a Photovoltaic Power Generation Plant that will include operation of the plant and generation of solar power that will be sold to Lesotho Electricity Corporation (LEC) and maintenance of the plant for up to 25 years. Approximately 70 000 solar panels will be used in construction of the generation plant. The project will also include the following infrastructures:

- Construction of a 33kV Powerline from the PV Plant to the Ramathole substation. The exact voltage and tower position will be subjected to a final design and agreement with the Lesotho Electricity Corporation. The powerline will be approximately 1.1km in length and with a servitude corridor of approximately 22m (11m in each side);
- Operation and Maintenance Building;
- Laydown areas;
- Inverter Station (internal substation) to increase ("step-up") the voltage of the electricity for transmission into the grid;
- The main site entrance road is gravel, 10m in length and 6m wide and will be connecting from the existing access road; and
- Total area to be fenced is approximately 66 hectares.

As a Corporate Social Responsibility (CSR) initiative the Project will build a standalone solar PV-battery-backup generation (LPG or Diesel) mini grid in the Raliemere community. The CSR initiative will operate as a micro-utility in the village providing modern energy access to 184 Households, 1 School and 4 Small Enterprises. The electricity will be supplied via Pay As You Go (PAYG) prepaid, metered 220VAC electricity through a Lesotho Grid Code compliant distribution network at the uniform retail tariff rate set by the Lesotho Electricity and Water Authority (LEWA). The village has been informed and surveyed through a consultative process.

The solar farm will sell electricity to LEC. There are existing access roads leading to the project site from the main road.

1.3. Project Technology

The power plant will use crystalline silicon PV technology to convert sunlight into electricity. This project employs tier 1 solar PV panels mounted on single axis East to West trackers. It is anticipated that Direct Current combiners will be utilized to route power to six 4MW Inverter blocks including a step-up transformer for a medium voltage connection to the off-takers electric grid.

1.4. Project construction

It is anticipated that construction will commence in the fourth quarter of 2019 however, this is dependent on finalization of negotiations with the Government of Lesotho and a Lenders due diligence process.

The site would be accessed from an existing, gravel access road. A 10 m long and 6 m wide, gravel access road would be constructed from the existing access road to the site. The existing access road would need to be graded for a length of approximately 1.3 km to ensure an acceptable surface for construction traffic. Temporary access roads will only be constructed, where necessary, and rehabilitated upon completion of construction. Solar panels will be shipped to the nearest port and transported to site via road transport (flatbed trucks) as normal loads.

It is anticipated that construction traffic will consist of seven vehicles per hour, of which four will be heavy duty and three will be motor vehicles.

Approximately 200 workers will be employed during the 9-11-month construction phase and this will consist of unskilled labourers from local communities who will perform general work and imported skilled labourers.

Minor levelling of the site may be needed. This would entail some cutting and filling but most likely more filling is required than cutting. Any additional fill material required will be obtained from commercial sources. Topsoil will be removed from any cut or fill areas and replaced once levelling has taken place. The grass/low vegetation on site will not be scraped clear in order to keep dust to a minimum. Small shrubs or trees may be removed, if required.

A permanent on-site Operations and Maintenance (O&M) building will be constructed for the operation of the plant and will include rain water harvesting tanks for domestic water usage and will be powered by the plant. All buildings will be single story.

Piles will be emplaced in predrilled pilot holes for anchoring the PV array structures to the subsurface, and concrete slabs will be poured for the inverters, step up transformers and switchgear, the power house (offices and control room), the parking lot, the back up LPG generator and fuel tank and the security guard house.

Crews for the solar field will mount tracking frames onto the concrete poles and completed tracking frames will have PV panels installed with mounting brackets. Wiring between panels and the inverter will be underground.

A security gate and associated guardhouse may be placed at the entrance to site. This is aimed at preventing unauthorised vehicular access to site during both construction and operation. The site will be fenced in with chain link fence or similarly visually permeable materials.

If possible, water will be sourced from an onsite borehole and stored on site in JoJo style tanks alternatively water will be trucked in from a municipal source. Approximately 150m^3/MW (or 3000 m^3 in total) of water is required for construction.

General and hazardous construction waste will be disposed of at an appropriate, licensed landfill facility. If there are no licenced facilities in Lesotho, then waste will be disposed of at a licenced facility in South Africa such as in Bloemfontein.

Temporary holding tanks will be utilized during construction to hold wastewater and waste will be disposed of in terms of relevant legislation / regulations.

1.5. Project operation

The project will sell power to LEC for a period of 25 years and has the option to extend this period. Activities during operation will be limited to maintenance, occasional visits by LEC, LEWA, government personnel or visitors and minimal delivery of supplies and materials.

Project traffic during operation will consist of an average of six vehicles per day of which one will be a heavy duty and five will be motor vehicles. It is anticipated that approximately 11 people will be employed for the operational phase of the project and will maintain the facilities mechanical and electrical systems and conduct routine maintenance and repairs (technical oversight, safety compliance, maintenance, reporting, site work, cleaning and security). Periodically, as indicated by visual inspection and metered output, the solar field will be cleaned with water.

Approximately 20m3/year of water is required during operation. Water will be sourced from onsite borehole (if possible) or trucked in from a municipal source and stored on site in JoJo style tanks.

It is proposed to build septic tanks on site for wastewater and designs will comply with relevant legislation and regulations.

General and hazardous waste will be disposed of at an appropriate, licensed landfill facility.

Electricity during operation would be obtained from the site or from a backup generator.

1.6. Project decommissioning

Should operations not be extended past the initial 25 years then full decommissioning will occur and the land will be returned as close as reasonably possible to its original state or better. Concrete foundations, should they be required for the panels, may be removed in totality or will be broken down such that they can be covered with topsoil and revegetated. Decommissioning is likely to be of similar duration to construction namely 9-11 months.

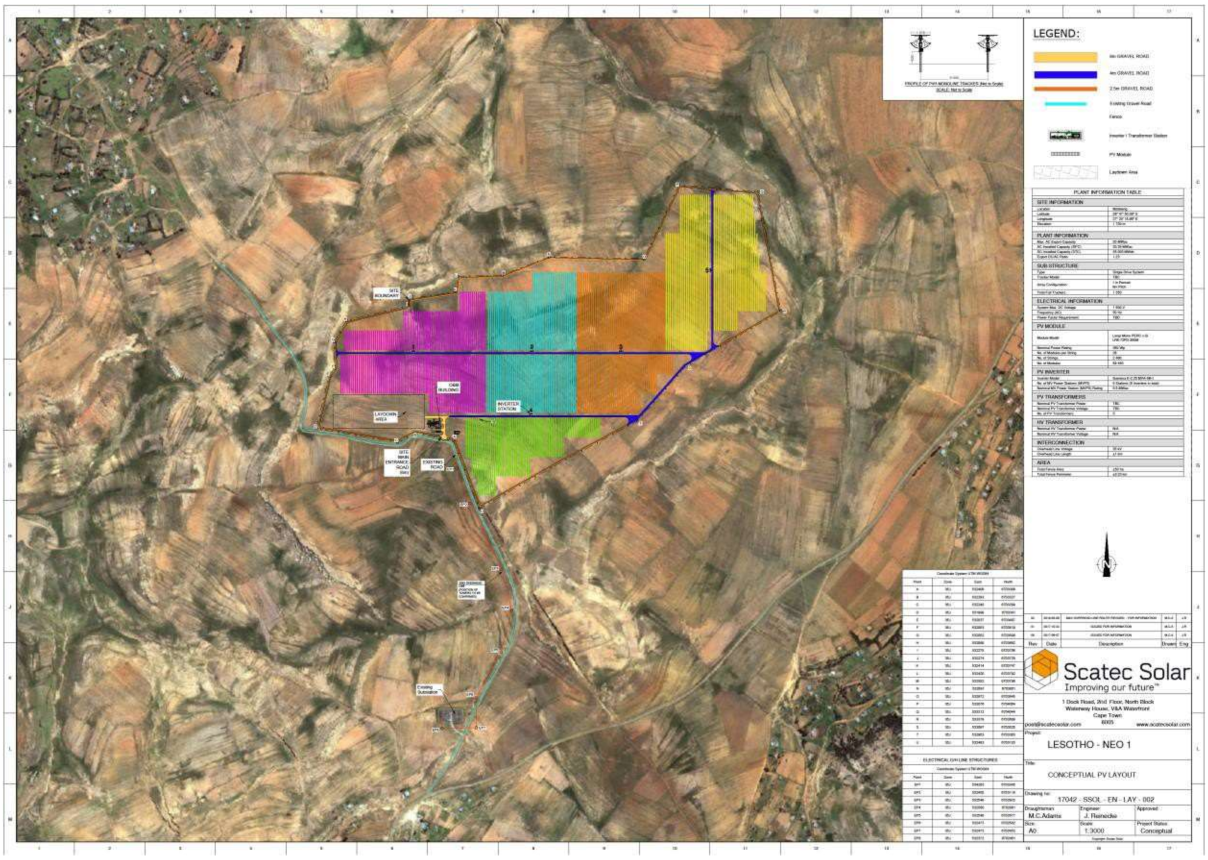

Figure 2: Neo 1 Project Locality Map

1.7. Study Limitations

Prior to the outline of the proposed impacts in the area, the following issues need to be highlighted, which are considered limitations to undertaking the terms of reference detailed above.

- As no long term on-site meteorological data was available during the current investigation, it was decided to make use of measured data from the Lesotho Meteorological Service to describe the micro meteorological aspects of the area.
- Ambient air quality monitoring has been undertaken by the Bureau of Statistics.
- All information provided in regards to infrastructure layouts and methodology is assumed to be correct.

1.8. Report Structure

Section 1 of the report provides background of the project. **Section 2** focuses on a review of the applicable air quality legislation, pollutants and their potential health effects the process summaries and various operations involved in the project**. Section 3** includes a meteorological overview of the proposed project. **Section 4** provides details regarding the potential environmental impacts, **Section 5** gives a summary of the general conclusions. The references and glossary are provided in S**ection 6** and S**ection 7** respectively.

2. Applicable Air Quality Legislation

This Chapter is intended to identify all policies, legislation, regulations plans, guidelines, etc. which impact on the proposed planning, development and operation of the proposed project. The key pieces of legislation that have a direct bearing on the successful implementation of the proposed development are highlighted below.

2.1. Lesotho National Legislation

EIA practice in Lesotho adheres to the provisions of the Environment Act, 2008 and the EIA Guidelines. The Environmental act provides the following with reference to Air quality standards for the country.

37. (1)	The Authority shall, in consultation with the relevant Line Ministry-
(a)	establish criteria for the measurement of air quality;
(b)	establish-
	(i) ambient air quality standards;
	(ii) occupational air quality standards;
	(iii) emission standards for various sources;
	(vi) criteria and guidelines for air pollution control for both mobile and stationary sources; and
	(v) any other air quality standards, which may be prescribed from, time to time;
(c)	take measures to reduce existing sources of air pollution by requiring the redesign of plants or the installation of new technology or both in order to meet the requirements of standards established under this section;
(d)	make guidelines to minimize emissions of greenhouse gases and identify suitable technologies to minimize air pollution;
(e)	consider the rate of emission concentration and nature of pollutants emitted;
(f)	consider the best practicable technology available in controlling pollutants during the emission process;
(g)	determine the analytical technology available in controlling pollutants during the emission process;
(h)	order or carry out investigations of actual or suspected air pollution including pollution produced by aircraft, motor vehicles, factories and power generating stations;
(i)	order an industry or any other source of air pollution to file returns and provide any information as it may require; and
(j)	do any other thing, which may be necessary for the monitoring and controlling of air pollution.
(2) No person shall emit or cause to emit a substance, which causes air pollution in contravention of emissions standards, established under this Act.	
(3) A person who contravenes the provisions of subsection (2) commits an offence and is liable on conviction to a fine not less than M5,000 but not exceeding M100,000 or to imprisonment for a term not less than 2 years but not exceeding 10 years or to both.	
(4) A person who is convicted under subsection (3) shall in addition to a fine or imprisonment-	
(a)	pay the costs which may be incurred by any Line Ministry or the Authority in the restoration of the environment damaged or destroyed as a result of the emission; and
(b)	pay the costs incurred by a third party in the form of reparation, restoration, restitution or compensation as may be determined by a court of law.

No other regulations relating to air quality have however been formulated, but provision has been made in the 2008 Act for regulations to be made. In the absence of local standards for other pollutants, developers should refer to World Health Organisation, World Bank and/or donor country standards.

Comparison is also often made to the neighbouring country, namely South Africa when referencing both ambient and emission air quality standards.

The main pollutant of concern which may poses a health risk to surrounding sensitive receptors and possible communities during the current investigation is particulate matter. Particulate matter is a 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). As there are no local air quality ambient standards set for Lesotho, reference will be made to international guidelines and standards prescribed for inhalable particulate and nuisance dust exposure, these include the World Bank (WB), World Health Organisation (WHO), and South African (RSA) Limits

2.1.1. Particulate Matter with an aerodynamic diameter of less than 10microns (PM_{10})

Particulate matter (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 increased risk of myocardial infarction (USEPA, 1996).

PM 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 airvaries across space and time and is related to the source of the particles and the transformations that occur in the atmosphere (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.

Table 1 outlines the local and international health risk criteria used for the assessment of inhalable particulate matter (PM10). Guidelines and standards are provided for a 24-hour exposure and annual average exposure period respectively

Table 1: Available International Standards used for the Evaluation of Inhalable Particulate Matter (PM10).

Origin	24-Hour Exposure (µg/m³)	Annual Average Exposure (µg/m³)
RSA	75	40
World Bank	500	100
WHO	50	20

With regard to the setting of limit values for particulate matter, SANS 1929:2011 recognises the following:

- different types of particles can have different harmful effects on human health;
- there is evidence that risks to human health associated with exposure to man-made PM_{10} are higher than risks associated with exposure to naturally occurring particles in ambient air; and
- as far as they relate to PM_{10}, action plans and other reduction strategies should aim to reduce concentrations of fine particles as part of the total reduction in concentrations of particulate matter.

Stringent Limit and Target Values for particulate matter (expressed in µg/m³) have been suggested as guidelines in SANS 1929:2009 and revised 2011. These were developed by a panel of experts on the basis of best international practice. However, the latest regulations emanating from NEM:AQA (GNR 1210) were promulgated in late 2009 and stipulate a phased approach towards the implementation of national ambient air quality standards as tabulated below (Table 2). The newer SANS 1929:2011 document differentiated between the phased in approach and now specifies two pollutant levels, Interim and Target levels.

Table 2: National Ambient Air Quality Standards for Particulate Matter (PM_{10})

Averaging Period	Concentration	Frequency of Exceedence (per calendar year)
24-hour	75 µg/m³	4
Annual	40 µg/m³	0

2.1.2. Dust Fallout (DFO)

Nuisance dust is known to result in the soiling of materials and has the potential to reduce visibility. Atmospheric particulates change the spectral transmission, thus diminishing visibility by scattering light. The scattering efficiency of such particulates is dependent upon the mass concentration and size distribution of the particulates. 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. Dust fall 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).

The physical smothering of the leaf surface of plants by dust particles causes reduced light transmission, affecting photosynthetic processes resulting in growth reduction (Thompson et al., 1984; Pyatt and Haywood, 1989; Farmer, 1993). Increases in the temperature of particle-covered leaves result in a positive impact on respiration and a negative impact on photosynthesis and productivity (Eller, 1977). The physical obstruction of the stomata has been observed to reduce stomatal resistance, resulting in the potential for higher uptake of pollutant gases, and it may also affect the exchange of water vapour (CEPA/FPAC Working Group, 1999). Particle accumulation on leaf surfaces may cause plants to become more susceptible to other stresses such as disease (CEPA/FPAC Working Group, 1999).

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 marked 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.

South Africa is one of the only countries who have issued guideline limits for the evaluation of nuisance dust levels. A banding system has traditionally been used which describes the dust deposition as resulting in a slight, moderate, heavy or very heavy nuisance impact. On the 7th of December 2012 the Minister of Water and Environmental affairs published the 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.

Table 3: Acceptable Dust Fallout Rates measured at and beyond the boundary of the premises where dust originates.

Restriction Areas	Dust Fallout rate (mg/m^2/30-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.

*Note – the measurement of dust fallout is in accordance with the methodology prescribed in **ASTM 1739:2017**

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 PM10 monitoring be conducted at the site.

"Slight" dustfall is barely visible to the naked eye. "Heavy" dustfall indicates a fine layer of dust on a surface, with "very heavy" dustfall being easily visible should a surface not be cleaned for a few days. Dustfall levels of > 2000 mg/m²/day constitute a layer of dust thick enough to allow a person to "write" words in the dust with their fingers. Local experience, gained from the assessment of impacts due to dust from mine tailings dams in Gauteng, has shown that complaints from the public will be activated by repeated dustfall in excess of ~2000 mg/m²/day. Dustfall in excess of 5000 mg/m²/day impacting on residential or industrial areas generally provoke prompt and angry complaints.

The main limitation in using this type of classification system is that it is purely descriptive and does not provide an indication as to what action needs to be taken to remediate the problem. The South African Bureau of Standards in their SANS 1929:2005 publication, “Ambient air quality – limits for common pollutants”, provides additional criteria which can be used for the evaluation of fallout dust deposition.

3. Baseline Description of the Area

3.1. Meso-Scale Meteorology

The data was gathered from the Lesotho Meteorological Services. The period data that is under investigation range from 1 January 2007 to 31 December 2011.

The macro-ventilation characteristics of a region are determined by the nature of the synoptic systems that dominate the circulations of the region, and the nature and frequency of occurrence of alternative systems and weather perturbations over the region. Meso-scale processes affecting the dispersion potential include thermo-topographically induced circulations, the development and dissipation of surface inversions, and the modification of the low-level wind field and stability regime by urban areas.

Atmospheric processes at meso-scale were taken onto account in the characterisation of the atmospheric dispersion potential of the study area. Parameters that need to be taken into account in the characterisation of meso-scale ventilation potentials include wind speed, wind direction, extent of atmospheric turbulence, ambient air temperature and mixing depth.

The nature of the local climate will determine what will happen to pollutants when it is released into the atmosphere (Tyson & Preston-Whyte, 2000). Pollution levels fluctuate from day to day and from hour to hour, in response to changes in atmospheric stability and variations in mixing depth. Wind systems will have an effect on the transportation and dispersion of pollution.

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 day. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped in 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 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 usually dissipate as soon as the sun rises and warms the earth's surface. With the absence of surface inversions, the pollutants are able to diffuse freely upward, but this upward motion may, however, be prevented by the presence of elevated inversions (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 (Tyson & Preston-Whyte, 2000).

3.1.1. Wind

Dispersion comprises vertical and horizontal components of motion. The wind field largely determines the horizontal dispersion of pollution in the atmospheric boundary layer. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume stretching. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extend of cross-wind spreading.

The mesoscale wind map and data for the Lesotho Wind Resource Analysis is provided.

The spatial analysis of wind resources in the region of Lesotho presented in this report is based on a period of one year (from 1 January 2007 to 31 December 2011) simulated data using a non-hydrostatic model of regional primitive-equation of the atmosphere. A whole year of data was generated by an individual simulation of each calendar day in which the year was chosen at random from a record corresponding to the period 2007 to 2011.

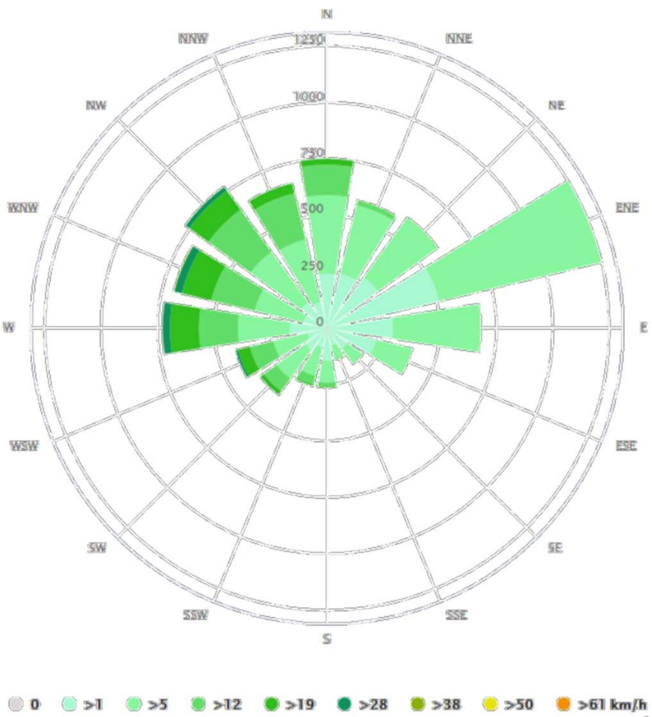

Figure 3: Wind Rose for Mafeteng

The wind rose for Mafeteng shows how many hours per year the wind blows from the indicated direction. Figure 3 shows the dominant wind direction is from the East North East (ENE) with a secondary wind direction from the North West.

The numerical model uses a nested grid layout. The size of the coarser grid was defined to consider the effects of synoptic weather events on the wind resource in the region of interest, as well as allowing the development of the model circulations, caused by thermal factors.

Figure 4 below shows the map of annual average wind speed simulated with a resolution of 5 km at a height of 80m from January to December.

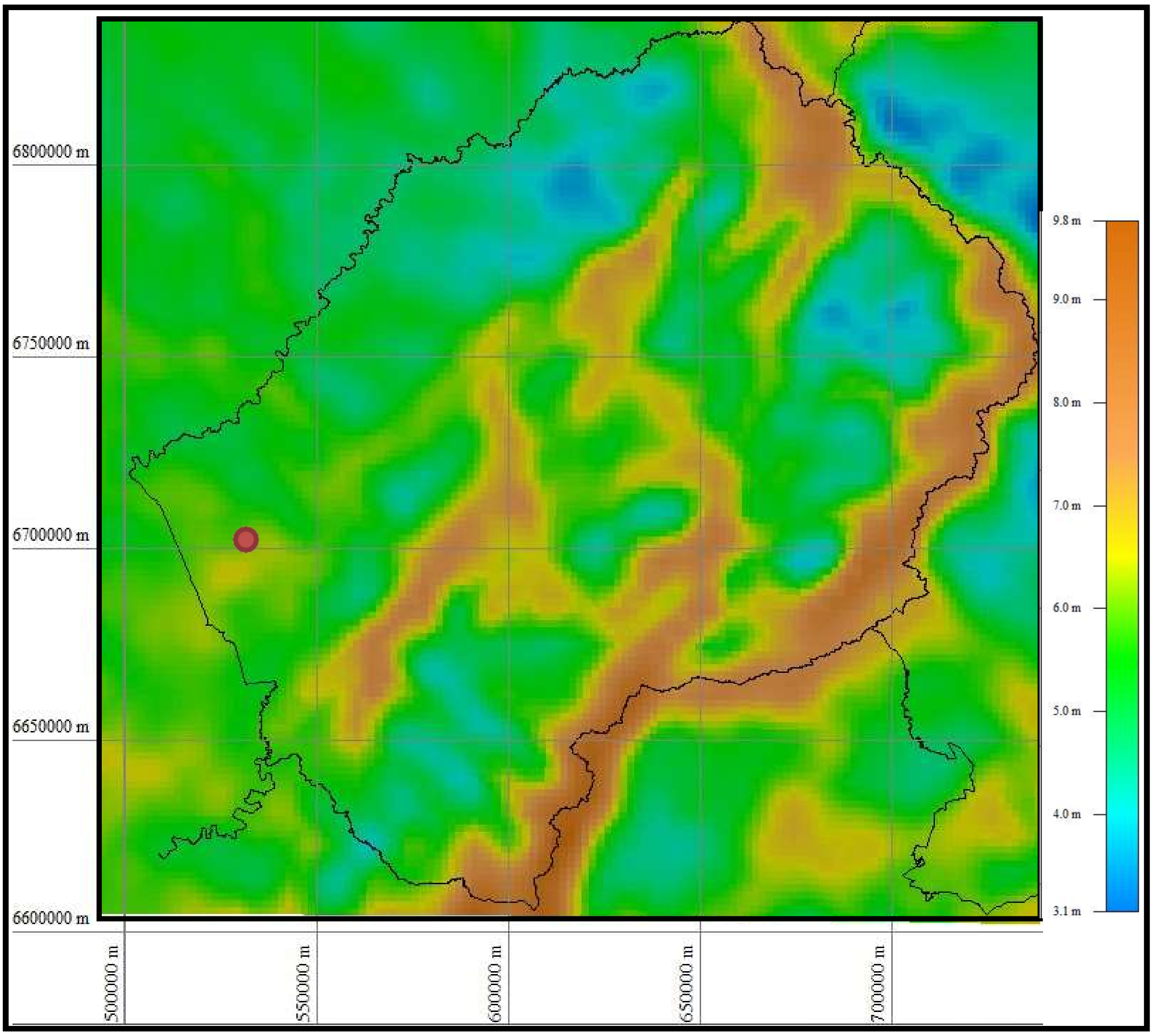

Figure 4: Average annual wind speed profile (Site highlighted in red)

The maps in Figure 5, Figure 6 and Figure 7 show the simulated monthly average wind speeds with a 5km resolution at a mast height of 10m

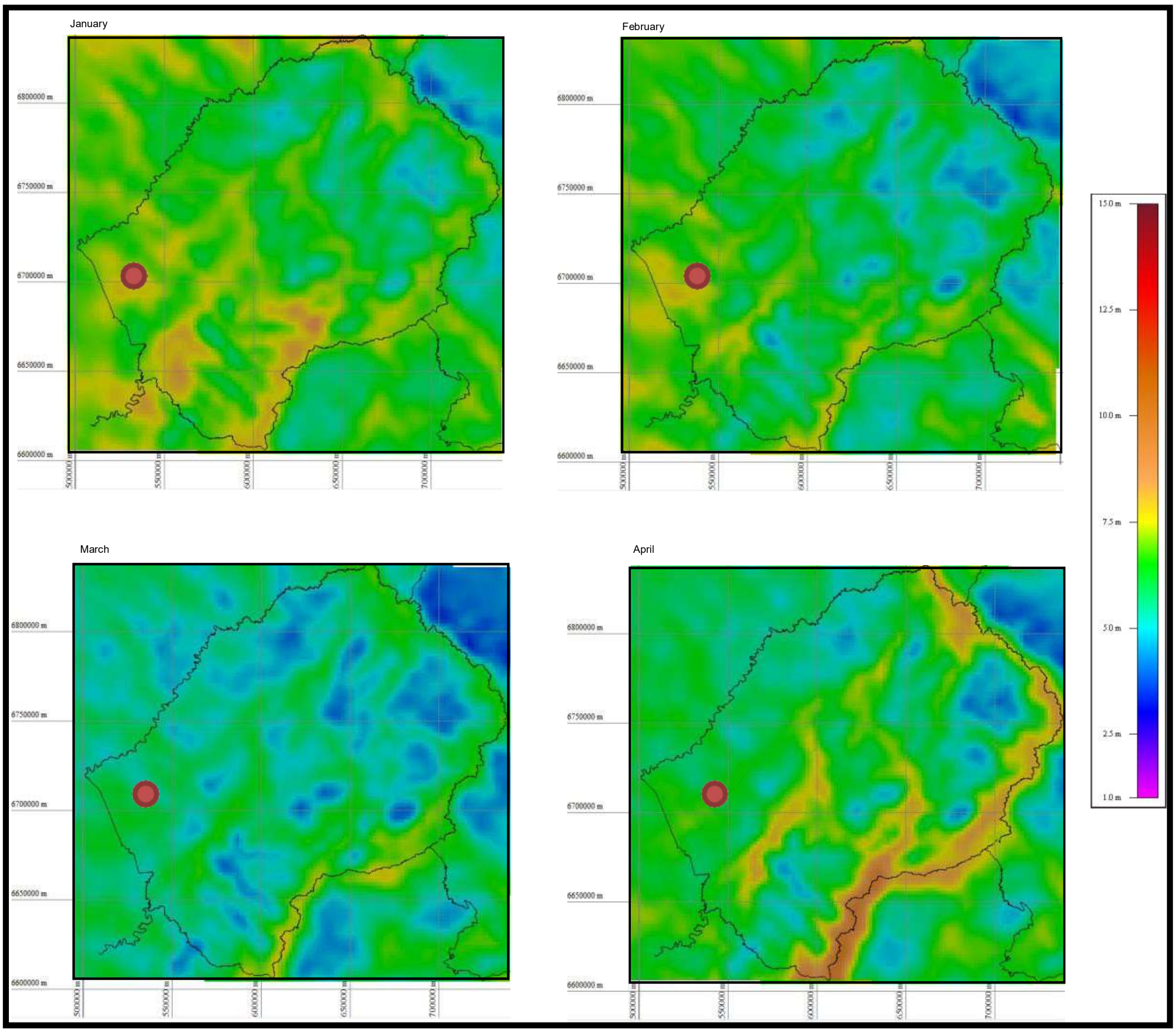

Figure 5: Monthly average wind speed from January to April (site highlighted in red)

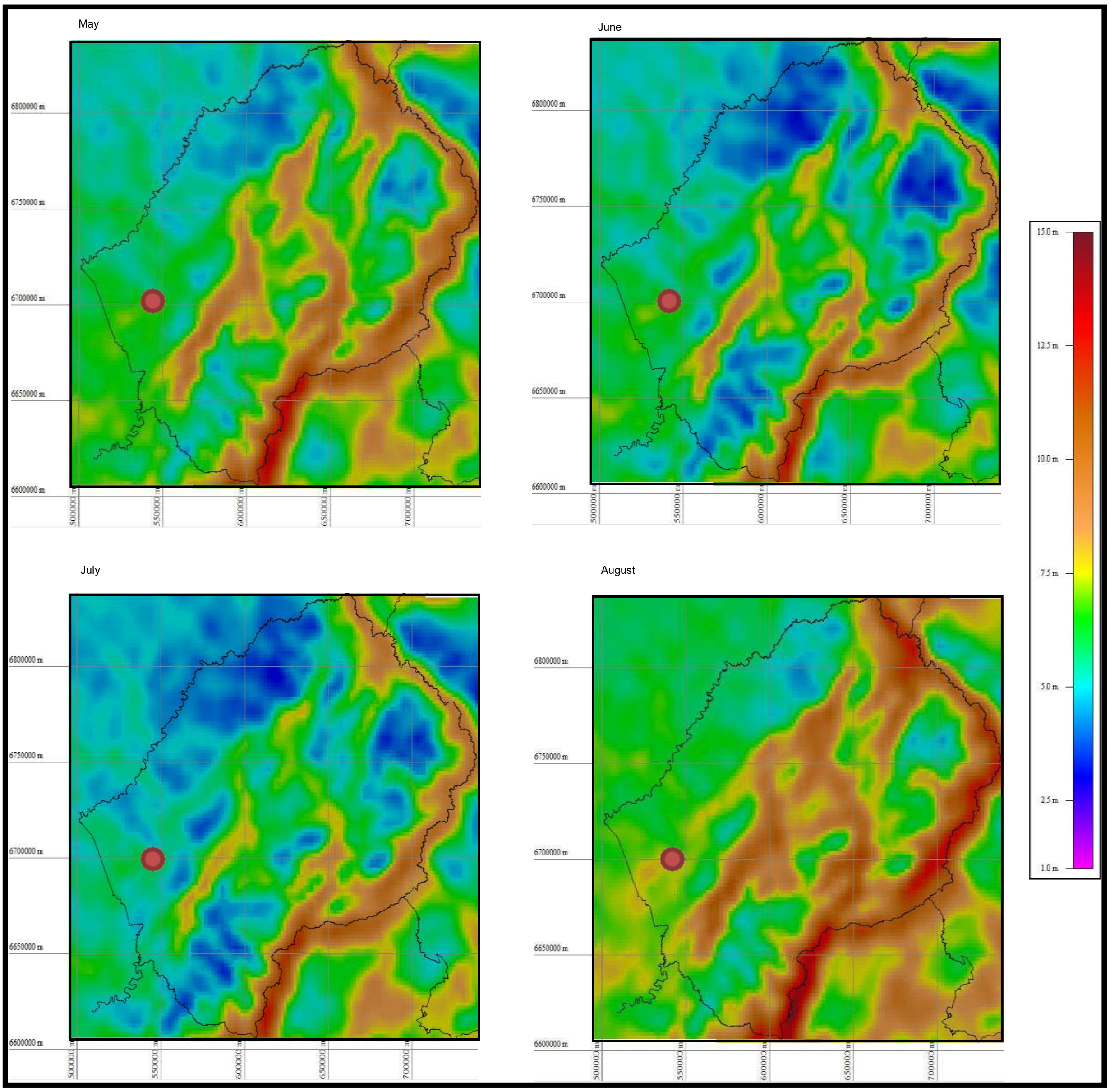

Figure 6: Monthly average from May to August (site highlighted in red)

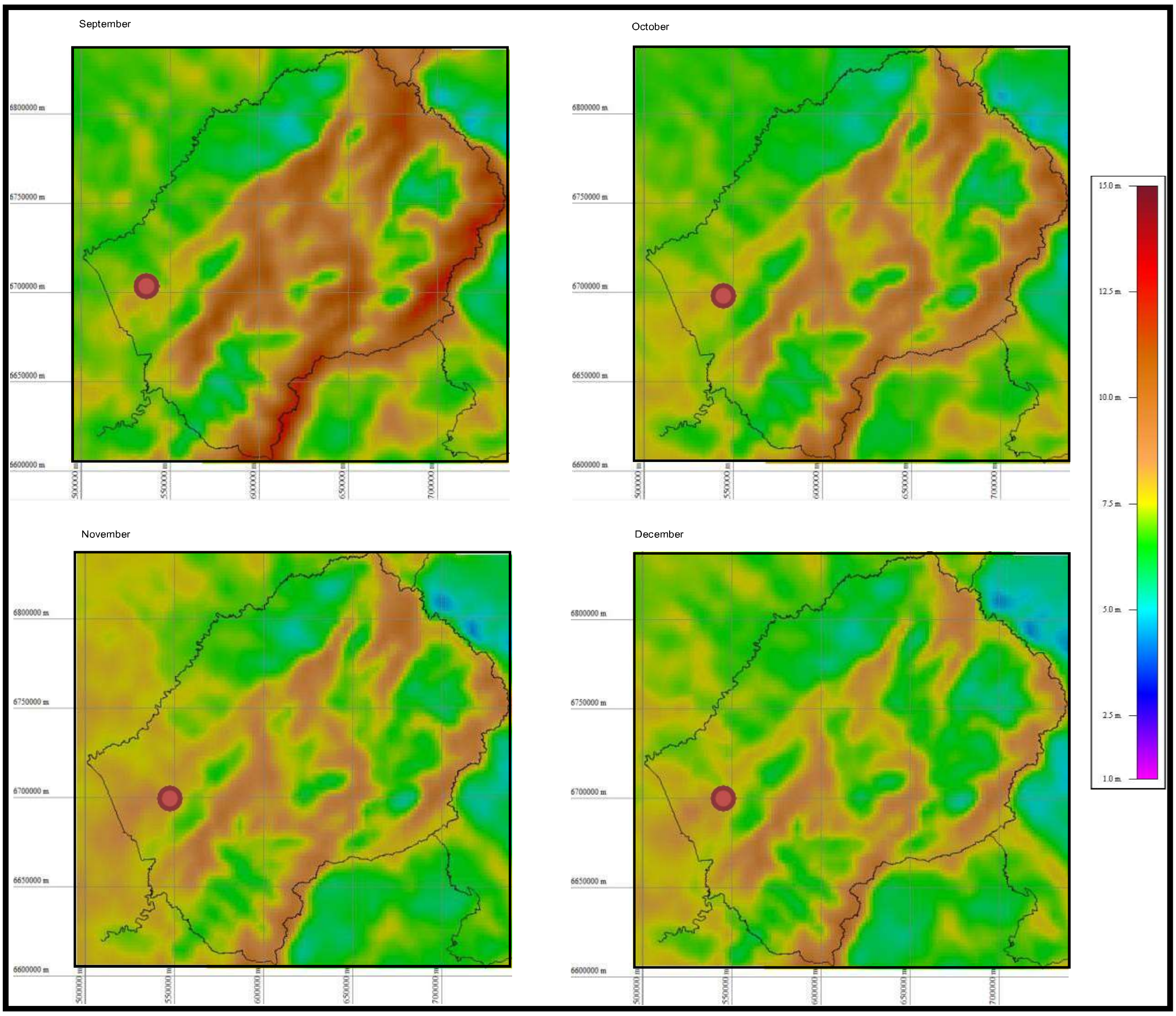

Figure 7: Monthly average wind from September to December (site highlighted in red)

3.1.2. 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 mixing and inversion layers.

The monthly distribution of average daily minimum temperatures (Figure 8) shows that the average temperatures were recorded in July 2009 with -2.5°C and the highest in January 2009 with 13.5°C

Figure 9 depicts the average maximum temperatures with the highest maximum being recorded in February 2007 with 27.6°C and the lowest in July 2011 with 12.3°C

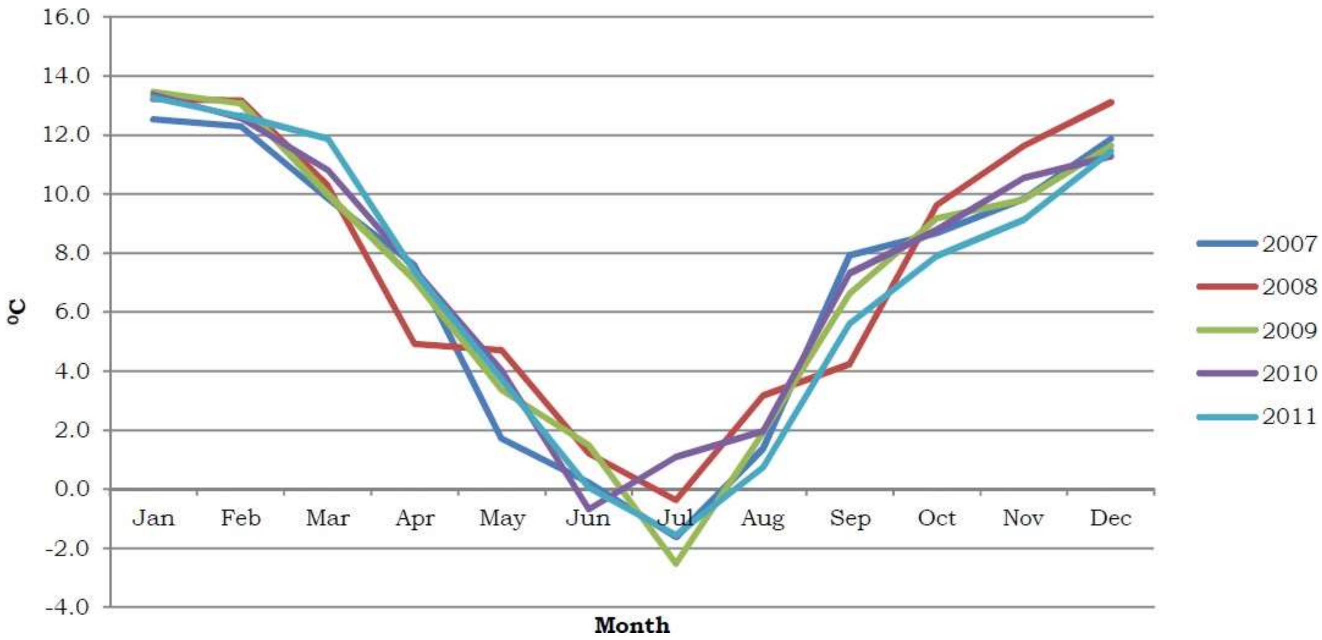

Figure 8: Average Minimum temperature

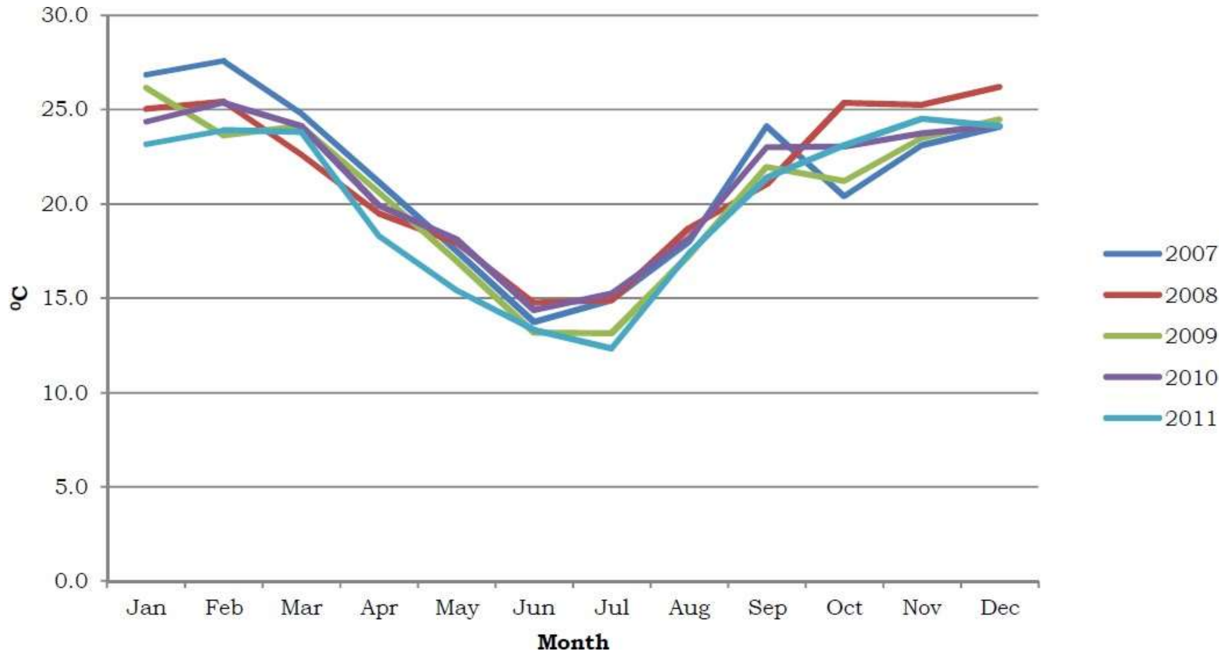

Figure 9: Average Maximum temperature

3.1.3. Precipitation

The average annual rainfall, for Mafeteng mainly occurring as a result of thunderstorms, with an average of 696mm per year.

The rainy season lasts from about October to March, the peak of the rainy season falling in January.

Precipitation represents an effective removal mechanism of atmospheric pollutants.

Table 4 shows annual rainfall, with a trend of increasing rainfall over the recorded period, of approximately 13.5%

Table 4: Annual Rainfall in mm for the years 2007 to 2011

District	**2007**	**2008**	**2009**	**2010**	**2011**
Botha-Bothe	759	753	951	1132	1068
Leribe	738	583	646	826	785
Berea	643	524	811	901	1022
Maseru	539	625	770	969	799
Mafeteng	**544**	**619**	**712**	**767**	**840**
Mohale's Hoek	630	846	877	793	799
Quthing	668	775	804	669	985
Qacha's Nek	721	758	896	882	809
Mokhltlong	500	641	478	918	583
Thaba-Tseka	563	599	676	795	810
Lesotho	**630**	**672**	**762**	**865**	**956**

3.2. Existing Sources of Air Pollution

A description of the emissions estimated from construction activities will be discussed below. During various site visits local airborne pollutant sources were identified, however the air quality in the region can be viewed as natural (rural). These are important to consider in terms of assessing the cumulative impact potential on air quality in the region:

- Subsistence agricultural activities;
- Vehicle emissions;
- Home Fires (Domestic fuel burning);

A qualitative discussion on each of these source types is provided in the subsections which follow.

3.2.1 Agriculture

Large scale agriculture is not commonly found within Lesotho, with the Mafeteng area being predominantly subsistence agriculture. This form of agriculture commonly results in areas of overgrazing. The airborne pollutant associated with the farming is Particulate Matter (TSP, PM10, PM2.5, etc.) or wind erosion from open tilled fields and planting.

3.2.2 Vehicles

The force of the wheels of vehicles travelling on unpaved roadways causes the pulverisation of surface material. Particles are lifted and dropped from the rotating wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic (USEPA, 1996). Due to the nature of construction activities, road networks can often be of a temporary nature, and are thus unpaved. An unpaved road network exists in the area. Due to the volume of heavy vehicles using the roads near the site, the expected volumes of entrained dust are likely to be considerable and will need to be addressed.

Exhaust fumes contain nitrogen, oxygen, carbon monoxide, water vapour, sulphur dioxide, nitrogen oxide, volatile hydrocarbons and polyaromatic hydrocarbons (PAHs) and their derivatives, acetylaldehyde, benzene and formaldehyde, carbon particles, sulphates, aldehydes, alkanes, and alkenes.

3.2.3 Home Fires

Domestic fuel burning continues partly due to poor availability of power. In the region of the power plant, the housing is associated with low-income housing with minimal electricity usage for heating during the colder winter months and for cooking. The open-fires are made from any combustible material (usually wood) and is often used to cook and to heat up the house. The associated emissions from these cooking fires differentiate from the type of material used for energy and the most common airborne pollutants are. Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Carbon monoxide (CO), Carbon dioxide (CO_2) and Particulate matter (TSP, PM_{10}, $PM_{2.5}$, etc.). During the winters cold day's inversions form over the surface of the land and cause the airborne pollutants from domestic fuel burning to be entrapped. The air movement cannot disperse the air pollutant from the region and causes the concentrations to build up. The inversion layer and domestic fuel burning takes place at the same time, which increases the severity of the situation at some locations. As the day heats up (midday) the inversion layer breaks up and the pollutants can disperse.

3.3 Sensitive Receptors

The proposed plant is located in a fairly sparsely populated area with rural dwellings making up the sensitive receptors near the plant. During the ESIA community participation was undertaken and more detail obtained as to the location of the dwellings within the area and the number of people who may be affected. Other sensitive receptors within the area would be the local fauna and flora. It has been identified that dust settling on the leaves of plants can result in damage to plants and inhalation of dust may result in sickness and associated lung diseases for wildlife and humans which will be present in the vicinity of the proposed plant.

4. Assessment of Environmental Impacts

4.1 Emission Inventory

This section of the report will outline the potential ambient air quality impacts associated with the proposed activities at the power plant. During the Impact Assessment phase, a detailed emissions inventory will be compiled to determine the emissions released from the proposed activities. Dispersion modelling simulations was undertaken using the AERMOD dispersion model and the impacts will be presented graphically as isopleths plots.

The emission inventory for emissions was compiled based on US EPA AP42 Emission factors for the construction industry aspects.

Emissions are calculated based on the impacted upon area within the overall study area. In the case of the proposed solar project this is defined as follows:

*Table 5: Surface area to be directly impacted upon (approximately 20.1% of total project area)**

Activity	Disturbed footprint (Ha)
Laydown Area	1.5 ha
Onsite Substation	1 ha
Internal Roads	1.8 ha
Civil Works required to implement Freshwater Ecologist recommendations and Stormwater Management	3.5 – 5 ha
Civil Works required for MV (trenching)	1 - 2 ha
Additional contingent area (worst case)	1.9 ha
TOTAL CLEARED (Worst Case)	Up to 13.2 ha

4.1.1 Construction Phase

During the construction assessment phase, it is expected that, the main sources of impact will result due to the construction of access roads, and the clearing of the plant area.

Construction is commonly of a temporary nature with a definite beginning and end. Construction usually consists of a series of different operations, each with its own duration and potential for dust generation. Dust emission will vary from day to day depending on the phase of construction, the level of activity, and the prevailing meteorological conditions (USEPA, 1996).

The following possible sources of fugitive dust have been identified as activities which could potentially generate dust during construction operations at the plant:

1. Product Transport
    - Scraping;
    - Debris handling;
    - Debris stockpiles; and

- Truck transport and dumping of debris.

2. Power Plant

    - Clearing of area for infrastructure;
    - Debris handling;
    - Debris stockpiles; and
    - Truck transport and dumping of debris.

Creation and Grading of Access Roads

Access roads are constructed by the removal of overlying topsoil, whereby the exposed surface is graded to provide a smooth compacted surface for vehicles to drive on. Material removed is often stored in temporary piles close to the road edge, which allows for easy access once the road is no longer in use, whereby the material stored in these piles can be re-covered for rehabilitation purposes. Current roads will be used for access with some additional upgrades, for approximately 1.3km. Onsite roads would require the addition of 2km of road (approximately 4m wide)

A large amount of dust emissions are generated by vehicle traffic over these temporary unpaved roads (USEPA, 1996). Substantial secondary emissions may be emitted from material moved out from the site during grading and deposited adjacent to roads (USEPA, 1996). Passing traffic can thus re-suspend the deposited material. To avoid these impacts material storage piles (whist not expected to be large) deposited adjacent to the road edge should be vegetated, with watering of the pile prior to the establishment of sufficient vegetation cover. Piles deposited on the verges during continued grading along these routes should also be treated using wet or chemical suppressants depending on the nature and extent of their impacts.

A positive correlation exists between the amount of dust generated (during vehicle entrainment) and the silt content of the soil as well as the speed and size of construction vehicles. Additionally, the higher the moisture content of the soil the lower the amount of dust generated.

The periodic watering or application of chemical suppressant to these road sections will aid in the reduction of dust generated from these sources. Cognisance should be taken to increase the watering rate during high wind days and during the summer months when the rate of evaporation increases, and during periods of low rainfall.

Preparation of areas identified for the construction of the plant and supporting infrastructure.

Removal of material usually takes place with a bulldozer, extracted material is then stored in piles for later use during rehabilitation procedures. Fugitive dust is generated during the extraction and removal of overlying material, as well as from windblown dust generated from cleared land and exposed material stockpiles. Dust problems can also be generated during the transportation of the extracted material, usually by truck, to the stock piles. This dust can take the form of entrainment from the vehicle itself or due to dust blown from the back of the trucks during transportation.

To avoid the generation of unnecessary dust, material drop height should be reduced and material storage piles should be protected from wind erosion. This can take the form of wind breaks, water sprays or vegetation of piles. All stockpiles should be damped down, especially during dry weather.

It should be noted that emissions generated by wind are also dependent on the frequency of disturbance of the erodible surface. Each time material is added to or removed from a storage pile or surface, the potential for erosion by wind is restored. Any crusting of the surface binds the erodible material (USEPA, 1996). Dust created during the transportation can be limited by watering or applying chemical suppressants to the road sections that are being used and by either wetting the material being transported or covering th3e back of the trucks, to limit the windblown dust from the load.

Overview of potential Impacts

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

- ambient air quality;
- local residents and neighbouring communities;
- employees;
- the aesthetic environment; and
- possibly fauna and flora

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. It is important to note that impacts will be of a temporary nature, only occurring during the construction period.

Particulate emission estimates from the construction activity of the solar project are presented below.

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

Table 6: Heavy Construction emission rates

Location	Area (m^2)	Emission Rate for TSP ($g/m^2/s$)	Emission Rate for PM10 ($g/m^2/s$)	Emission Rate for PM2.5 ($g/m^2/s$)
Stockpile Area	15 000	2.28×10^{-5}	1.14×10^{-5}	2.85×10^{-6}
Solar Surface Area*	114 000	5.06×10^{-6}	2.53×10^{-6}	6.33×10^{-7}
Site Access Road	7 800	2.68×10^{-5}	1.24×10^{-5}	2.85×10^{-6}
Unpaved Roads	18 000	2.29×10^{-5}	2.14×10^{-5}	1.85×10^{-6}

Wind Erosion

To quantify the particulate emissions created as a result of wind erosion on exposed surfaces, the following equation was utilised:

$$E_{TSP} = 0.4\ (kg/ha/hr)$$

$$E_{PM10} = 0.2\ (kg/ha/hr)$$

The equation relates the amount of particulate matter (in kg) emitted per hectare of exposed ground per hour (Table 7).

Table 7: Exposed open ground affected by wind erosion

Location	Area (m^2)	Emission Rate for TSP ($g/m^2/s$)	Emission Rate for PM10 ($g/m^2/s$)	Emission Rate for PM2.5 ($g/m^2/s$)
Stockpile Area	15 000	1.11×10^{-5}	5.56×10^{-6}	1.39×10^{-6}
Solar Surface Area*	114 000	2.46×10^{-6}	1.23×10^{-6}	3.09×10^{-7}
Site Access Road	7 800	1.14×10^{-5}	5.56×10^{-6}	1.39×10^{-6}
Unpaved Roads	18 000	1.31×10^{-5}	6.56×10^{-6}	1.18×10^{-6}

The emission rate for the existing road was assumed to be equal to the Roads emission rate. Only wind erosion is applicable to the existing road. The table below list some mitigation measure that can be implemented.

Table 8: Construction phase applicable mitigation measures

	General Housekeeping	Wet suppression	Wind breaks	Paving	Chemical stabilization
Material handling	X	X	X	X	X
Truck Transport		X		X	X
Construction	X	X	X	X	
Bulldozers		X			

4.1.2 Operational phase

During operational phase, access roads will need to be maintained to ensure entrained dust is kept to a minimum. A large amount of dust emissions are generated by vehicle traffic over these unpaved roads (USEPA, 1996). Substantial secondary emissions may be emitted from material moved out from the site during grading and deposited adjacent to roads (USEPA, 1996). Passing traffic can thus re-suspend the deposited material. To avoid these impacts material storage piles deposited adjacent to the road edge should be vegetated, with watering (or chemical suppressant applied) of the pile prior to the establishment of sufficient vegetation cover. Piles deposited on the verges during continued grading along these routes should also be treated using wet or chemical suppressants depending on the nature and extent of their impacts.

A positive correlation exists between the amount of dust generated (during vehicle entrainment) and the silt content of the soil as well as the speed and size of construction vehicles. Additionally, the higher the moisture content of the soil the lower the amount of dust generated.

Particulate emission estimates from trucks travelling on unpaved roads within the project area are presented below. The equation used to determine particulate emissions from trucks travelling on unpaved roads is presented below (NPI):

$$E_{(kg/VKT)} = \left(\frac{0.4536}{1.6093}\right) \times k \times \left(\frac{s}{12}\right)^{a} \times \left(\frac{W}{3}\right)^{b}$$

Where s is the surface material silt content (%), W is the mean vehicle weight, and a,b and k are empirical constants.

These emission factors relate the amount of particulate emissions (in kilograms) to the number of kilometres travelled by all vehicles on site (VKT). Table 9 presents the empirical constants used in the equation for different particle sizes; and Table 10 presents the vehicular statistics for the project, used in the calculations.

Table 9: Empirical constants for different particle sizes (unpaved roads)

Constant	TSP	PM10	PM2.5
k	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

Table 10: Vehicular statistics for the Solar project

Name of Location	No. Of trucks	Mean weight of fleet (tons)	Average Speed (km/h)	VKT per day	Emission Rate for TSP ($g/m^2/s$)	Emission Rate for PM10 ($g/m^2/s$)	Emission Rate for PM2.5 ($g/m^2/s$)
Existing Road	1	48	40	6.6	3.44×10^{-6}	4.04×10^{-7}	4.04×10^{-8}
Existing Road	5	3	40	33	1.72×10^{-5}	2.02×10^{-6}	2.02×10^{-7}

Wind Erosion

Particulate matter emissions from the wind erosion of **exposed ground** were calculated using the following equation (NPI):

$$E_{TSP} = 0.4\ (kg/ha/hr)$$

$$E_{PM10} = 0.2\ (kg/ha/hr)$$

The equation relates the amount of particulate matter (in kg) emitted per hectare of exposed ground per hour (Table 11

Table 11: Exposed open ground affected by wind erosion during operation (totalling approximately 13.2ha)

Location	Emission Rate for TSP ($g/m^2/s$)	Emission Rate for PM10 ($g/m^2/s$)	Emission Rate for PM2.5 ($g/m^2/s$)
Stockpile Area	1.00×10^{-5}	5.00×10^{-6}	1.25×10^{-6}
Solar Area*	8.64×10^{-7}	4.31×10^{-7}	1.08×10^{-7}
Roads	1.08×10^{-5}	5.4×10^{-6}	1.35×10^{-6}

These emissions are expected to decrease over time during the construction and operational phases due to the concurrent revegetation of the exposed and disturbed area. The figures above are for the worst case, and where vegetation takes longer than expected to recover.

Table 12: Operational phase applicable mitigation measures

	General Housekeeping	Wet suppression	Wind breaks	Chemical stabilization
Material handling	X	X	X	X
Truck Transport		X		X

General Area	X	X	X

4.1.3 Decommissioning Phase

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;
- Stockpiles to be smoothed and contoured;
- Topsoil replaced using topsoil recovered from stockpiles; and
- 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.

Emissions from decommissioning are expected to be similar to those generated during construction, and so similar impacts are likely to be noted.

4.1.4 Post Closure Phase

Revegetation 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 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.

Exposed soil is often prone to erosion by water. The erodibility 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).

4.2 AERMOD Dispersion Model Setup

4.2.1 Air Dispersion Modelling Software

During the assessment the ISC/AERMOD view dispersion model will be used to evaluate air quality impacts.

Dispersion modelling will be undertaken using the US-EPA approved Aermod View Dispersion Model, a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain.

There are two input data processors that are regulatory components of the AERMOD modelling system: AERMET, a meteorological data pre-processor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data pre-processor that incorporates complex terrain using USGS Digital Elevation Data. Other non-regulatory components of this system include: AERSCREEN, a screening version of AERMOD; AERSURFACE, a surface characteristics pre-processor, and BPIPPRIME, a multi-building dimensions program incorporating the GEP technical procedures for PRIME applications.

The Aermod View model is used extensively to assess pollution concentrations and deposition rates from a wide variety of sources. Aermod View is a true, native Microsoft Windows application and runs in Windows 2000/XP and NT4 (Service Pack 6).

Some of the modelling capabilities are summarised as follows:

- Aermod View may be used to model primary pollutants and continuous releases of toxic hazardous waste pollutants;
- Aermod View model can handle multiple sources, including point, volume, area and open pit source types. Line sources may also be modelled as a string of volume sources or as elongated area sources;
- Source emission rates can be treated as constant or may be varied by month, season, hour of day, or other periods of variation, for a single source or for a group of sources;
- The model can account for the effects of aerodynamic downwash due to nearby buildings on point source emissions;

- The model contains algorithms for modelling the effects of settling and removal (through dry deposition) of large particulates and for modelling the effects of precipitation scavenging from gases or particulates;
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system;
- Aermod View incorporates the COMPLEX1 screen model dispersion algorithms for receptors in complex terrain;
- Aermod View model uses real-time meteorological data to account for the atmospheric conditions that affect the distribution of air pollution impact on the modelling area; and
- Output results are provided for concentration, total deposition, dry deposition, and/or wet deposition flux.

Input data to the Aermod View model includes: source and receptor data, meteorological parameters, and terrain data. The meteorological data includes: wind velocity and direction, ambient temperature, mixing height and stability class, from surface and upper air stations.

The uncertainty of the Aermod View model predictions is considered to be equal to 2, thus it is possible for the results to be over predicting by double or under predicting by half, it is therefore recommended that monitoring be carried out at the proposed more during operation to confirm the modelled results, to ensure legal standards are maintained.

4.2.2 GIS Input Data

The plant is located in an area that is surrounded by gentle undulating terrain systems, therefore requiring the inclusion of a complex terrain file. The modelling domain selected for this campaign is 20km x 20km, covering an approximate area of 400km^2, with the plant at the centre of the domain (Table 13). The dispersion model was setup to model 882 points evenly distributed across the domain.

Table 13: GIS Domain input point – UTM zone 35J WGS84 projection

Domain Points	X Coordinate (m)	Y Coordinate (m)
Domain Centre point	532637.6	6703484.07

4.2.3 Topography

The general elevation in the region is shown in Figure 10

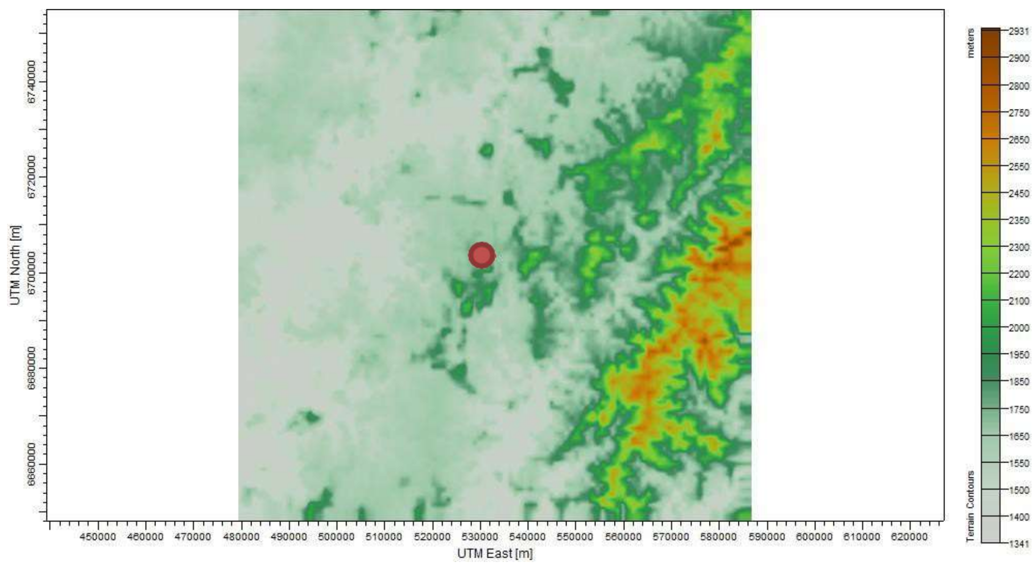

Figure 10: Topography of the region (site highlighted in red)

4.3 Dispersion Results and discussion

The Solar Power Plant project that is proposed is likely to only emit particulate matter. For the purpose of this impact assessment dispersion modelling was only done for PM10. The model calculated are the long-term (annual) concentrations for the region and also the daily averages were calculated for worst case and normal operations. Worst case operations are included to indicate where no dust suppression or mitigation of any time is implemented.

The results from the dispersion model runs are presented below

4.3.1 Construction Phase

Construction is commonly of a temporary nature with a definite beginning and end. Construction usually consists of a series of different operations, each with its own duration and potential for dust generation. Dust emission will vary from day to day depending on the phase of construction, the level of activity, and the prevailing meteorological conditions (USEPA, 1996).

The typical construction activity includes the removal of material, usually by bulldozer, the extracted topsoil is then stored in piles for later use during rehabilitation procedures. Construction sites are good candidates for dust control measures because land disturbance from clearing and excavation generates a large amount of soil disturbance and open space. The identified sources of dust during the construction phase is windblown dust and vehicle transportation and activity on the open and exposed ground surface. The use of long-term stockpiles on site should be avoided wherever possible. If necessary, the following measures should be in place. This can take the form of:

- Wind breaks
- Water sprays
- Revegetation of piles
- Material drop heights should be reduced and
- All stockpiles should be damped down, especially during dry weather.

It should be noted that emissions generated by wind are also dependent on the frequency of disturbance of the erodible surface. Each time material is added to or removed from a storage pile or surface, the potential for erosion by wind is restored. Any crusting of the surface binds the erodible material (USEPA, 1996).

The worst-case scenario is presented together with the mitigated (Normal) scenario, the dispersion model was ran on an hourly emissions rate file where the emission rate was only applied to when construction would occur at the construction site. The control efficiency of the mitigation measures were applied to each of the sources and a mitigated emission rate was calculated. It is presumed that under normal conditions, vegetation cover will be protected as much as possible.

4.3.2 Operational Phase

The dispersion modelled ran for both a worst-case scenario (unmitigated) and a mitigated (normal) scenario. The mitigation measures include the wetting of surfaces, general housekeeping (ensuring there isn't large amounts of dust), wetting the road surfaces, or applying chemical suppressants.

Figure 13 and Figure 14 indicate the daily maximum predicted emissions for the entire site (cumulative) with no mitigation and with mitigation, respectively. The current South African Standard for daily particulate matter is 75µg/m³ indicating that with even with no mitigation, it is unlikely that the standards will be exceeded for the cumulative impacts. These impacts are mostly from dust emissions from the road between the site and the substation, and therefore special focus needs to be made to manage these emissions. Figure 15 and Figure 16 show the impacts for the construction site for the proposed solar project, including stockpiles and site clearing. <u>The power line route has been highlighted in yellow on the maps for reference purposes to indicate road route to site.</u>

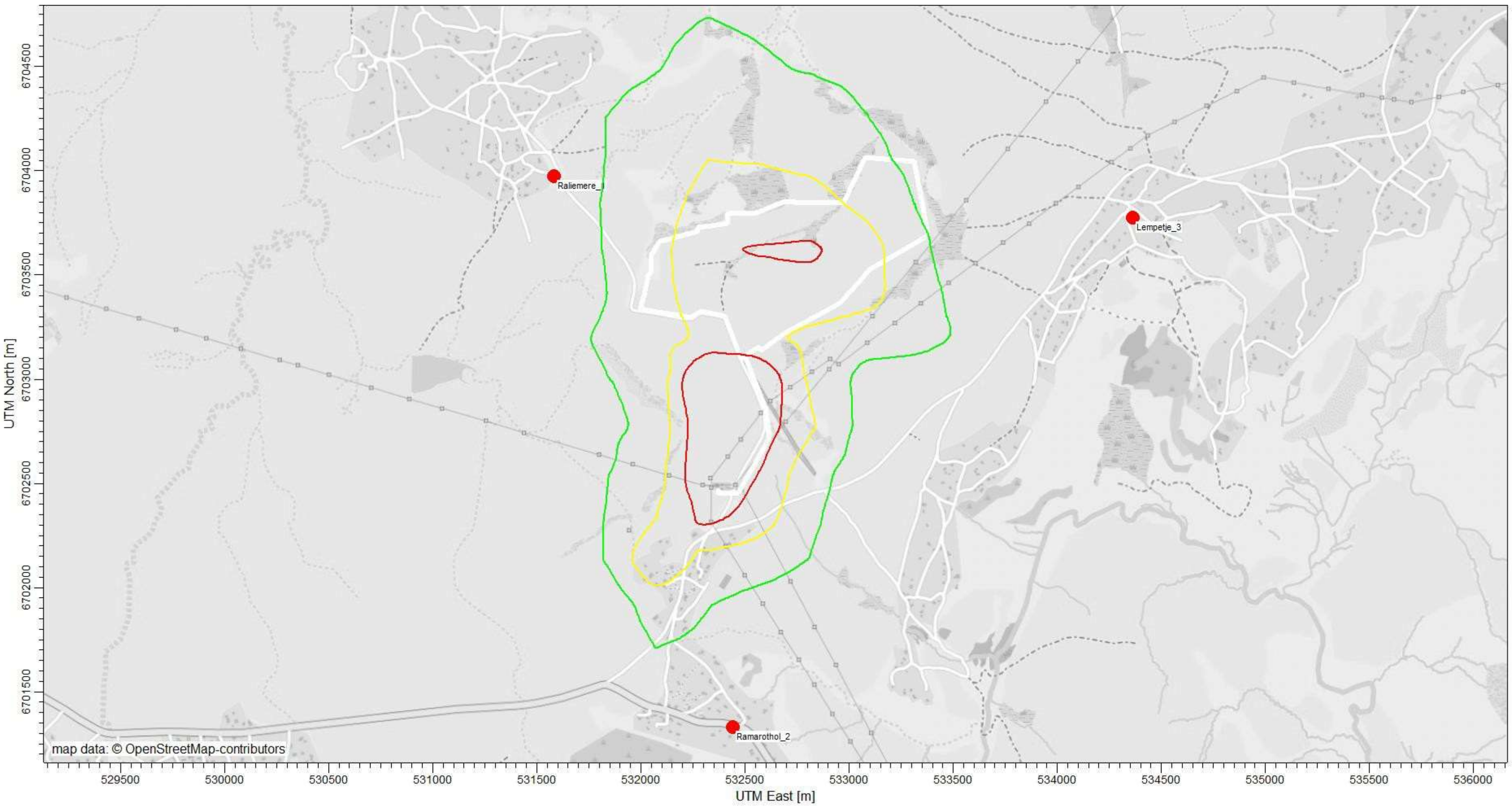

Figure 11: Dust fallout during construction without mitigation (Red - 1200mg/m²/day, Yellow - 600mg/m²/day, Green - 9mg/m²/day)

Figure 12: Dust fallout during construction with mitigation (Red - 1200mg/m²/day, Yellow - 600mg/m²/day, Green - 9mg/m²/day)

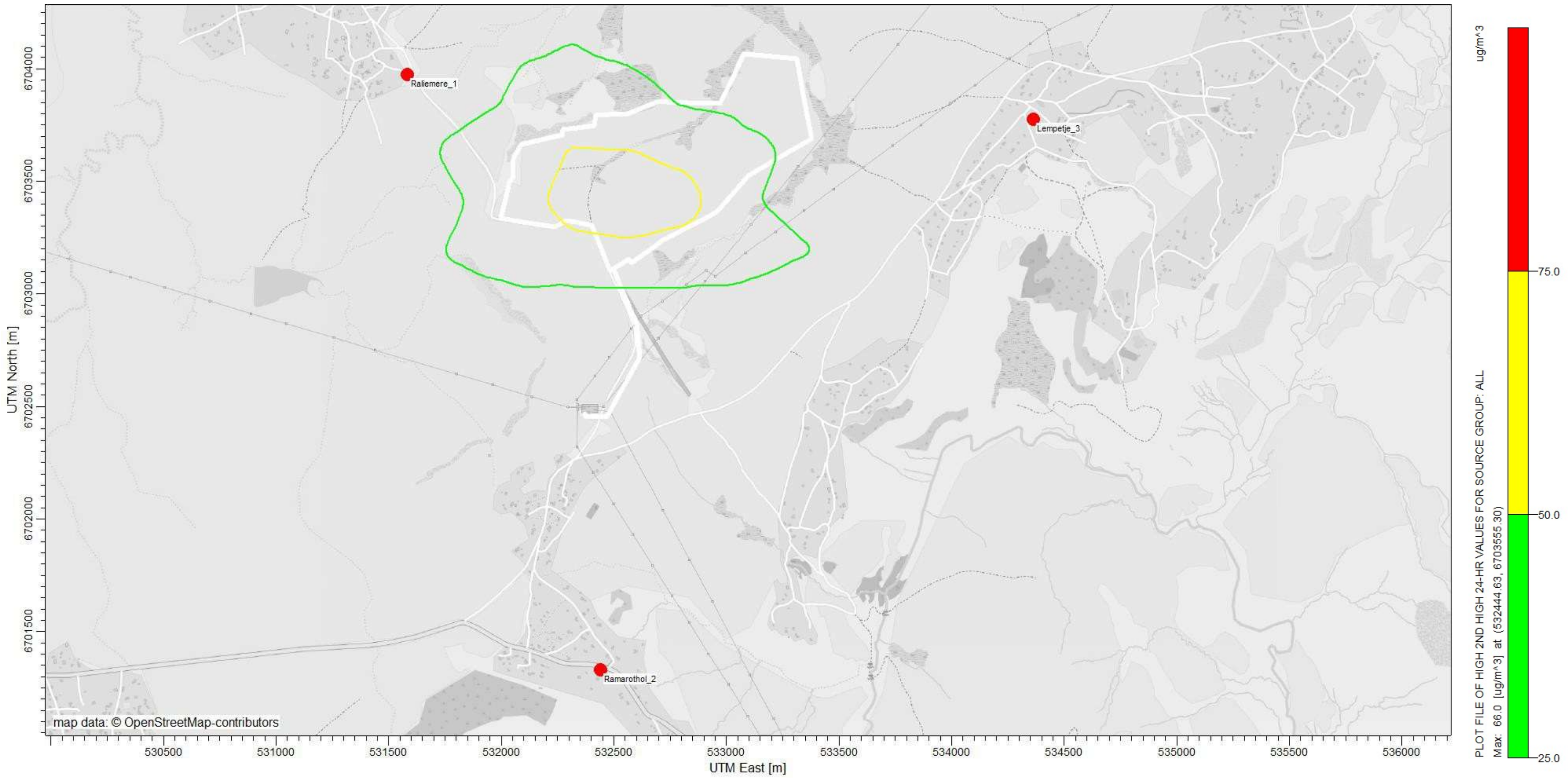

Figure 13 Cumulative daily PM10 impact during construction with no mitigation (South African Standard: 75µg/m³)

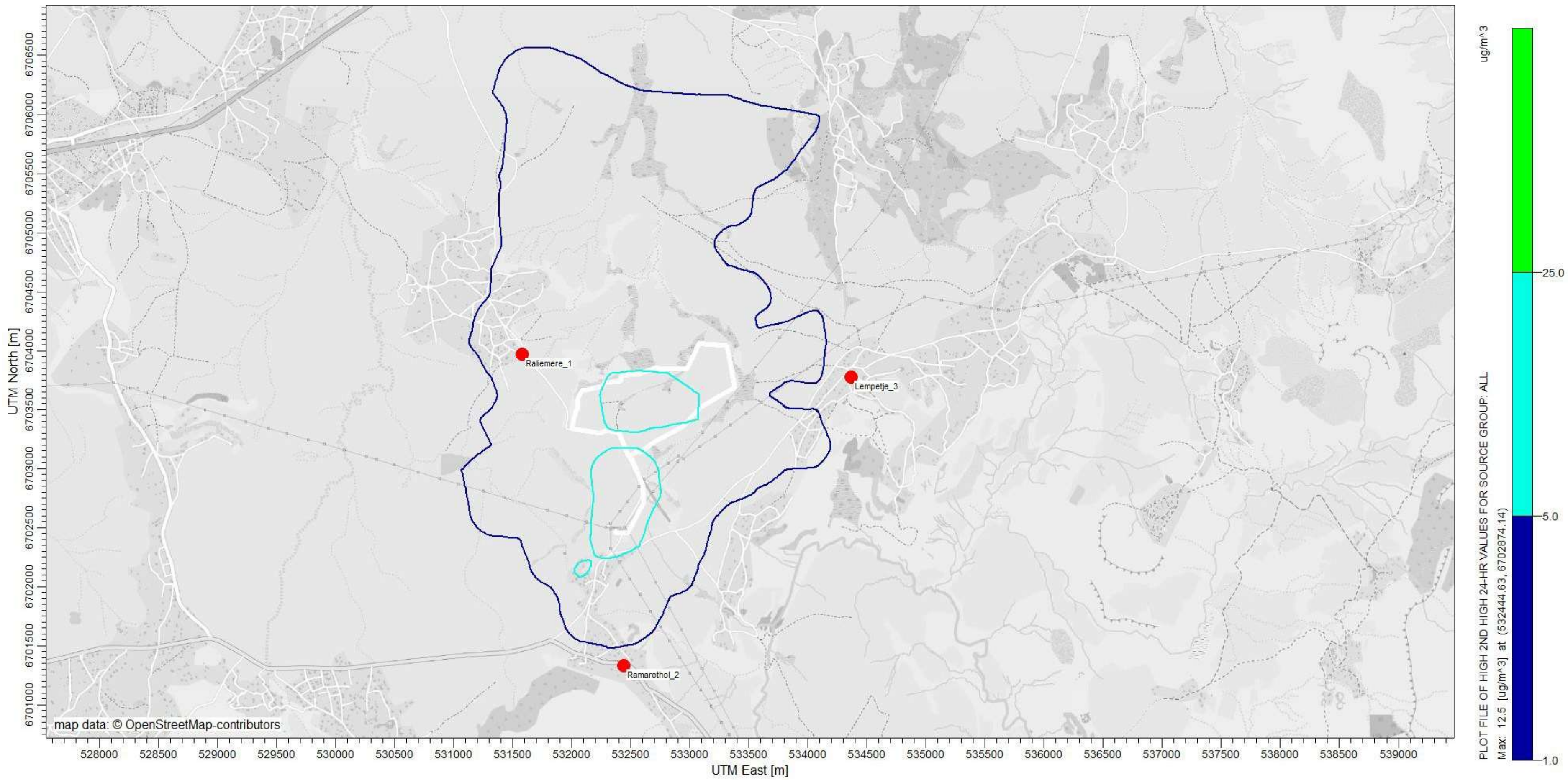

Figure 14: Cumulative daily PM10 impact during construction with mitigation

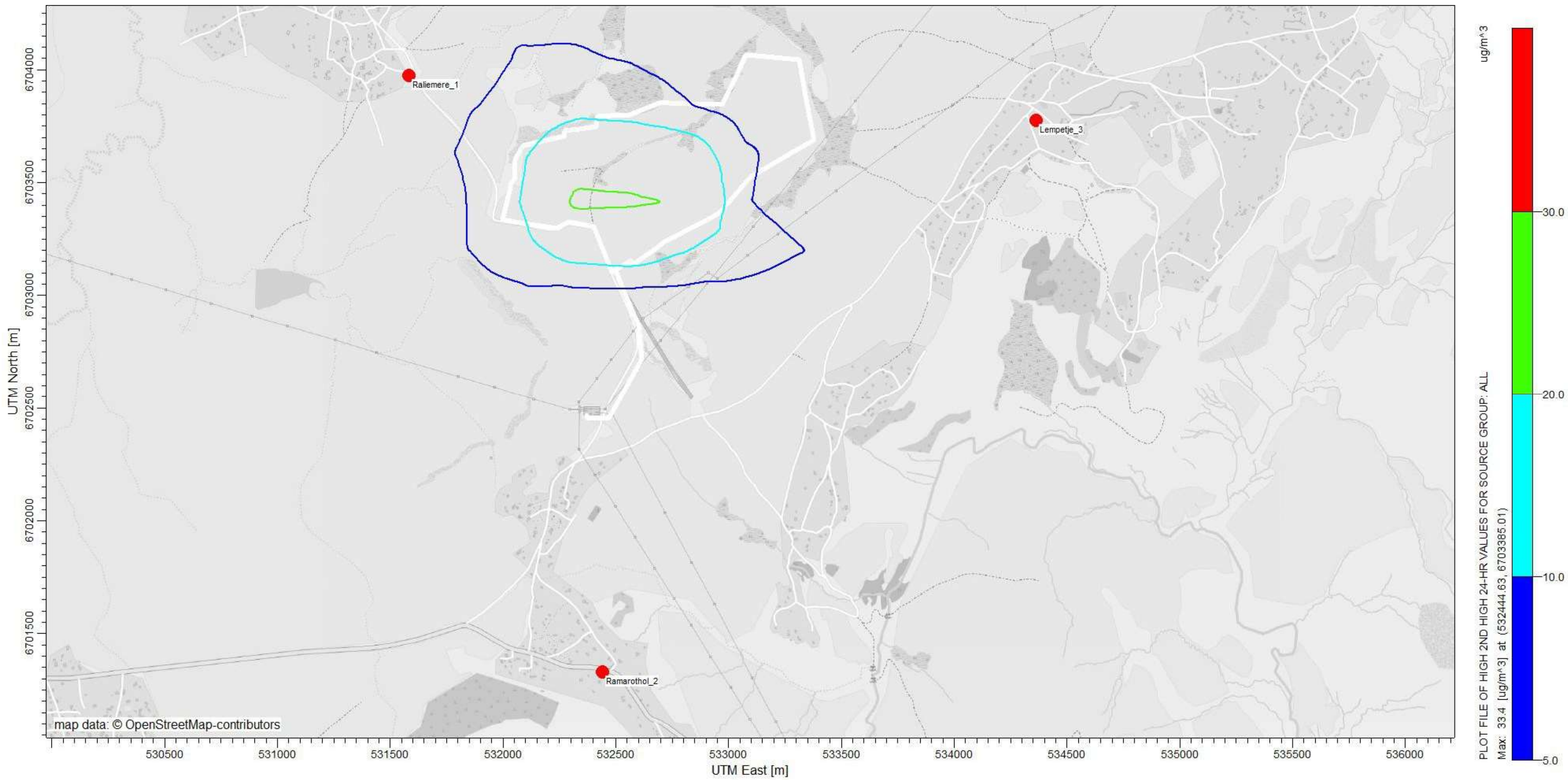

Figure 15: PM10 impact of the Solar project site activity during operations with no mitigation (South African Standard: 75µg/m³)

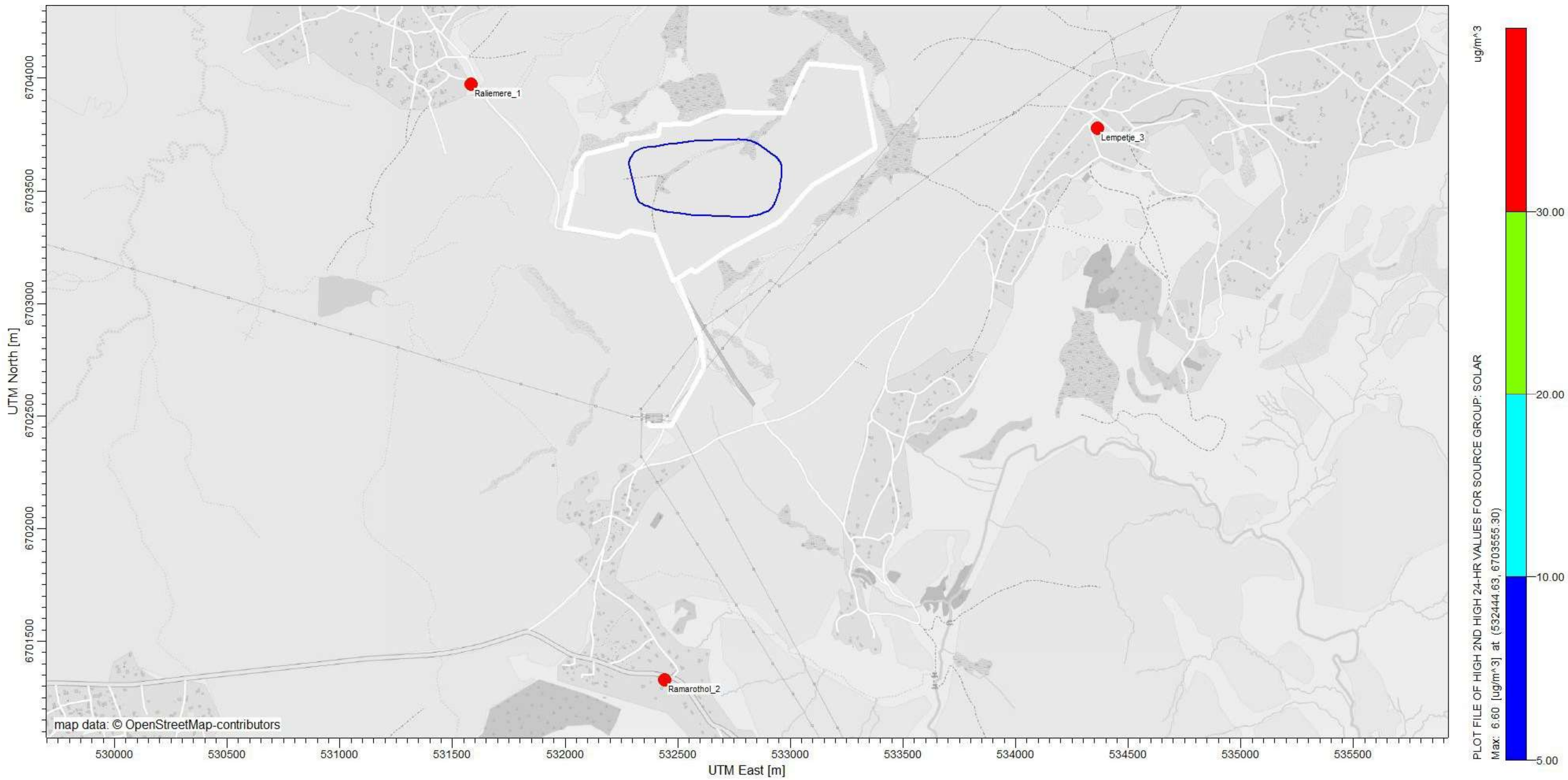

Figure 16: PM10 impact of the Solar project site activity during operations with Mitigation (South African Standard: 75µg/m³)

4.3.3 Decommissioning Phase

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 revegetated. 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 areas filled and levelled; and
- Land and permanent piles revegetated.

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 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 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.

4.4 Recommendations

4.4.1 Construction Phase

Due to the lack of quantitative dust emissions data for the site, it is recommended that the precautionary principle be followed, and dust control measures be implemented. Recommendations for the control of fugitive dust emissions are given in Table 14. Wet suppression with water is the least expensive of the possible control measures but is temporary in nature.

Table 14: Recommendations for the control of fugitive dust emissions during the construction phase (USEPA, 1996).

Emission Source	Recommended Control Methods
Debris handling and debris piles	Wind breaks
	Dust suppression [1]
Truck transport [2]	Wet suppression
	Paving
	Chemical stabilisation [3]
Bulldozers	Wet suppression
Pan scrapers	Wet suppression of travel routes
Cut/fill material handling	Wind breaks
	Wet suppression
Cut/fill haulage	Wet suppression
	Paving
	Chemical stabilisation
General construction	Wind breaks
	Wet suppression
	Early paving of permanent roads

Note: [1] Dust control plans should contain precautions against watering programs that compound trackout problems.

[2] Loads could be covered to avoid loss of material in transport, especially if material is transported offsite.

[3] Chemical stabilisation is usually cost-effective for relatively long-term or semi-permanent unpaved roads.

Water may be combined with a surfactant such 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. Products such as Dustex orDust-A-Side (DAS) represents an example of a chemical product, which is commercially available and widely used in the construction industry. The dust suppression product binds with the aggregate used to build on-site roads. It should be noted however, that the treatment with chemical stabilisers (depending on the chemical suppressant used) 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 construction 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).

Any temporary storage piles (e.g. cleared topsoil) should be maintained for as short a time as possible and should be enclosed by wind breaking enclosures of similar height to the storage pile. Storage piles should be situated away from the site boundary, water courses and nearby receptors and should take into account the predominant wind direction.

During the transfer of material to piles, drop heights should be minimised to control the dispersion of materials being transferred (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).

4.4.2 Operational Phase

Based on the results presented the following recommendations are outlined:

- Should an complaints or concerns be noted due to the dust generated on site, fallout monitoring should be undertaken to assess the level of nuisance dust associated with the site. Sampling of fallout is also undertaken within the neighbouring farming and community areas as well as on-site.

Due to dust emissions being generated from increased wind speeds, a water spray system should be operated at the site for stockpiles until re-vegetation has occurred, it is also recommended that wind breaks be used in order to reduce the potential erosive forces of the wind.

Water may be combined with a surfactant such as a wetting agent to increase the control efficiency for adequate control of dust. 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. Nozzles fitted on a spread bar behind trucks for a controlled spray opposed to a wide splash set-up shown in picture below.

Figure 17: Examples of water spray equipment

4.4.3 Decommissioning

Revegetation 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 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

4.5 Impact Rating

Significance ratings are provided by the Environmental Authorisation Practitioner for all specialists to evaluate their impacts in a standardised approach. For the Lesotho Solar PV project, the following have been provided:

DESCRIPTIVE CRITERIA		
Nature	**Category**	
Extent (E)	Categories 1 – 4	
	1	Footprint / site
	2	Local (within a radius of 2 kms of site)
	3	Regional
	4	National
Duration (D)	Categories 1 – 4	
	1	Short (less than five years)
	2	Medium term (5-15 years)
	3	Long term (15-30 years)
	4	Permanent
Intensity (I)	Categories 1 – 4	

DESCRIPTIVE CRITERIA		
	1	Low
	2	Moderate
	3	High
	4	Very High
	Categories 1 – 4	
Probability (P)	1	Improbable
	2	Probable
	3	Highly Probable
	4	Definite
IMPACT: Cumulative		
Extent (E)		
Duration (D)		
Intensity (I)		
Probability (P)		
	Significance = E + D + I + P	
	Minimum value of 1, maximum of 16	
	Status determines if positive / negative	
	Neg (13 - 16 points) **NEGATIVE VERY HIGH**	Permanent and important impacts. The design of the site may be affected. Intensive remediation is needed during construction and/or operational phases. Any activity which results in a "very high impact" is likely to be a fatal flaw.
Significance	**Neg (10 - 12 points)** **NEGATIVE HIGH**	These are impacts which individually or combined pose a significantly high negative risk to the environment. These impacts pose a high risk to the quality of the receiving environment. The design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. The effects of the impact may affect the broader environment.
	Neg (7 - 9 points) **NEGATIVE MODERATE**	These are impacts which individually or combined pose a moderate negative risk to the quality of health of the receiving environment. These systems would not generally require immediate action, but the deficiencies should be rectified to avoid future problems and associated cost to rectify once in HIGH risk. Aesthetically and/or physically non-compliance can be expected over a medium term. In this case the impact is medium term, moderate in extent,

DESCRIPTIVE CRITERIA		
		mildly intense in its effect and probable. Mitigation is possible with additional design and construction inputs.
	Neg (4 - 6 points) **NEGATIVE LOW**	These are impacts which individually or combined pose a deleterious or adverse impact and low negative risk to the quality of the receiving environment, and may lead to potential health, safety and environmental concerns. Aesthetically and/or physical non-compliance can be expected for short periods. In this case the impact is short term, local in extent, not intense in its effect and may not be likely to occur. A low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure.
	Pos (4 - 6 points) **POSITIVE LOW**	These are impacts which individually or combined pose a low positive impact to the quality of the receiving environment and health, and may lead to potential health, safety and environmental benefits. In this case the impact is short term, local in extent, not intense in its effect and may not be likely to occur. A low impact has no permanent impact of significance.
	Pos (7 - 9 points) **POSITIVE MODERATE**	These are impacts which individually or combined pose a moderate positive effect to the quality of health of the receiving environment. In this case the impact is medium term, moderate in extent, mildly intense in its effect and probable.
		These are impacts which individually or combined pose a significantly high positive impact on the environment. These impacts pose a high

DESCRIPTIVE CRITERIA		
	Pos (13 - 16 points) POSITIVE VERY HIGH	These are permanent and important beneficial impacts which may arise. Individually or combined, these pose a significantly high positive impact on the environment. These impacts pose a very high benefit to the quality of the receiving environment and health, and may lead to potential health, safety and environmental benefits. In this case the impact is long term, greater in extent, intense in its effect and highly likely or definite to occur. The effects of the impact may affect the broader environment.

With the air quality impacts expected as follows:

PHASE: CONSTRUCTION								
No.	**POTENTIAL IMPACT**	**MITIGATION**	**EXTENT**	**DURATION**	**INTENSITY**	**PROBABILITY**	**SIGNIFICANCE**	**STATUS CLASSIFICATION**
1	Dust emissions from Road construction	Without Mitigation	-2	-2	-2	-3	**-9**	**Negative Moderate**
		With Mitigation	-1	-1	-1	-2	**-5**	**Negative Low**
	Mitigation Options	**Wet / Dust suppression of unpaved roads and permanent roads as soon as possible, along with a maximum speed limit of 40km/h**						
2	Dust emissions from exposed stockpiles	Without Mitigation	-2	-1	-2	-1	**-6**	**Negative Low**
		With Mitigation	-1	-1	-1	-1	**-4**	**Negative Low**
	Mitigation Options	**Wet / Dust suppression, covering with bio textile, and installation of wind breaks**						

3	Dust emissions from Site Clearing	Without Mitigation	-2	-1	-2	-1	**-6**	**Negative Low**
		With Mitigation	-1	-1	-1	-1	**-4**	**Negative Low**
	Mitigation Options	**Wet suppression or stabilisation of storage piles. Minimum disturbance of land during construction**						
PHASE: OPERATIONAL								
4	Dust emissions from roads during normal operation	Without Mitigation	-2	-2	-2	-2	**-8**	**Negative Moderate**
		With Mitigation	-2	-1	-1	-1	**-5**	**Negative Low**
	Mitigation Options	**Wet / Dust suppression of unpaved roads and a maximum speed limit of 40km/h**						
	Dust emissions from exposed stockpiles	Without Mitigation	-2	-1	-1	-1	**-5**	**Negative Low**
		With Mitigation	-1	-1	-1	-1	**-4**	**Negative Low**
	Mitigation Options	**Wet / Dust suppression, covering with bio textile, and installation of wind breaks**						
6	Dust emissions from Site during normal operation	Without Mitigation	-2	-1	-1	-1	**-5**	**Negative Low**
		With Mitigation	-1	-1	-1	-1	**-4**	**Negative Low**
	Mitigation Options	**Minimum Disturbance and revegetation of site**						

PHASE: DECOMMISIONING							
7	Dust emissions from Roads	Without Mitigation	-2	-1	-1	-1	**-5**	**Negative Low**
		With Mitigation	-1	-1	-1	-1	**-4**	**Negative Low**
	Mitigation Options	**Wet / Dust suppression of unpaved roads and a maximum speed limit of 40km/h**						
8	Dust emissions from exposed stockpiles	Without Mitigation	-2	-1	-1	-1	**-5**	**Negative Low**
		With Mitigation	-1	-1	-1	-1	**-4**	**Negative Low**
	Mitigation Options	**Wet / Dust suppression, covering with bio textile, and installation of wind breaks**						
9	Dust emissions from Site Clearing and closure	Without Mitigation	-2	-1	-1	-1	**-5**	**Negative Low**
		With Mitigation	-1	-1	-1	-1	**-4**	**Negative Low**
	Mitigation Options	**Wet suppression or stabilisation of storage piles. Minimum disturbance of land during decommissioning**						

5. Conclusion

Based on the predicted model results and from the general condition of the area, it is recommended that mitigation measures be put in place to manage the dust emissions expected on site. With the management measures traditionally used in the construction industry, all emissions will fall well below the ambient standards that have been used, it is expected that the site will then adequately comply with environmental legislation.

6. References

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7. Glossary

Advection – The horizontal movement of air.

Aeolian erosion - the direct erosive action of wind.

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.

Atmospheric pressure - the pressure created by the mass of air above a point or level, the total force per unit is the pressure.

Baseline - the current and existing condition before any development or action.

Boundary layer - the layer directly influenced by a surface.

Climate - the integrated effect weather typical of a site or region.

Climatology - the study of the integrated effect weather typical of a site or region.

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 growth of water or ice by diffusion from contiguous water vapour.

Dispersion model - a mathematical model which can be used to assess pollutant concentrations and deposition rates from a wide variety of sources. Various dispersion modelling computer programs have been developed.

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.

Electrostatic Precipitator - a device that removes particles from a gas stream after combustion occurs. The ESP imparts an electrical charge to the particles, causing them to adhere to metal plates inside the precipitator. Rapping on the plates causes the particles to fall into a hopper for disposal.

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.

Erosion – the lowering of the land surface by agents such as gravity, river flow, waves, currents, wind, etc that involve the transport of rock debris.

Evaporation - the dissipation of water into invisible water vapour.

Hydro-seeding - The application of seed in water slurry that contains fertilizer, which is used as a soil binder and/or mulch of disturbed or unstable soils

Front - a synoptic-scale swath of cloud and precipitation associated with a significant horizontal zonal temperature gradient. A front is warm when warm air replaces cold on the passage of the front; with a cold front cold air replaces warm air.

Fugitive dust - dust generated from an open source and is not discharged to the atmosphere in a confined flow stream.

High pressure cells - regions of raised atmospheric pressure and air moving in anti-clockwise direction.

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

Low pressure cells – regions of lowered atmospheric pressure and air moving in a clockwise direction.

Mesoscale - a spatial scale intermediate between small and synoptic scales of weather systems.

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.

Nitrogen fixation – the process by which atmospheric nitrogen is converted to forms usable by organisms. It is carried out only by certain micro-organisms such as free-living soil bacteria and bacteria or microbes in symbiotic associations with fungi, ferns or in the roots of legume plants.

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.

Photosynthesis - the synthesis in green plants of carbohydrate from carbon dioxide as a carbon source and water as a hydrogen donor with the release of oxygen as a waste product, using light energy.

Pioneer plants – plants that are initial invaders of disturbed sites or the early seral stages of succession. Succession is the replacement of one plant community by another, often progressing to a stable terminal community called a climax.

PM10 - refers to particulate matter that is 10 µm or less in diameter. PM10 is generally subdivided into a fine fraction of particles 2.5 µm or less (PM2.5), and a coarse fraction of particles larger than
2.5 µm. Particles less than 10 µm in diameter are also termed inhalable particulates.

Productivity – in plants is the amount of organic matter fixed over a period of time and is related to rate of photosynthesis.

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.

Respiration - the process used by organisms to generate metabolically useable energy from the oxidative breakdown of foodstuffs.

Solar radiation - electromagnetic radiation from the sun.

Stomata - minute openings on the surface of aerial parts of plants through which air and water vapour enters the intercellular spaces, and through which water vapour and carbon dioxide from respiration are released.

Surface forcings – these forcings include frictional drag, evaporation, transpiration, heat transfer, pollutant emissions and terrain induced flow modification.

Synoptic scale - the minimum horizontal spatial scale of weather observations defined in a synoptic observation network. Synoptic observations are simultaneous observations taken at recognised weather stations.

Thermal – a buoyant rotating air parcel, usually about 100m in diameter or larger.

Total suspended particulates (TSP) -. all particulates which can become suspended and generally noted to be less than 75 µm in diameter (TSP).

Vehicle entrainment - the lifting of dust particles in the turbulent wake of a vehicle passing over an unpaved road or exposed area. The force of the wheels on the road causes pulverisation of the surface material and the particles are lifted and dropped by the rolling wheels.