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AIR QUALITY SCOPING ASSESSMENT FOR PROJECT LIMA - A PUMPED STORAGE POWER GENERATION FACILITY IN THE VICINITY OF THE STEELPOORT RIVER, LIMPOPO PROVINCE, SOUTH AFRICA

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SUMMARY

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1 BACKROUND

The Air Quality Unit of Stewart Scott International (Pty) Ltd was appointed by Bohlweki Environmental (Pty) Ltd to conduct a baseline assessment and scoping phase air quality impact assessment of the three site options stipulated for Project Lima. Eskom intends constructing a pumped storage power generation facility in the Steelpoort River area. The sites are located in the Limpopo Province in the two quarter- degree grids, with Site C situated in grid 2429DD, and Sites A and B in grid 2529BB respectively (Howard *et al.*, 2006). (Figure 1-1).

All of the sites are located on the eastern escarpment of the Nebo Plateau, to the west of the Steelpoort River, with altitudes varying between 800 and 2000 meters above mean sea level (mamsl). The sites are located within the Sekhukhuneland Cross Boundary District Municipality with Sites A and B situated within the Greater Groblersdal Local Municipality, and Site C located within the Makhudutamaga Local Municipality. Townships are situated on the escarpment near to the sites, with cultivation practices occurring on the level areas within the valleys and on the plateau.

1.1 Methodology

An overview of the methodological approach to be followed during the current assessment is outlined in the section which follows.

1.1.1 Baseline Assessment

During the baseline assessment hourly meteorological data sourced from the South African Weather Service will be used to determine the atmospheric dispersion potential of the area. Sensitive receptors in close proximity to the site will also be identified.

1.1.2 Scoping Phase Impact Assessment

During the scoping phase impact assessment, information gaps in the data provided will be identified (Section 1.3). This will be followed by a qualitative assessment of the possible air quality impacts resulting due to the construction, operational and decommissioning phases of the project. The emissions generated and air quality impacts resulting due to these stages will be evaluated where possible. As hydroelectric power generation is considered air quality friendly the main air quality impacts to be considered will occur during the construction and decommissioning phases. The pollutant of concern in this investigation is particulate matter.

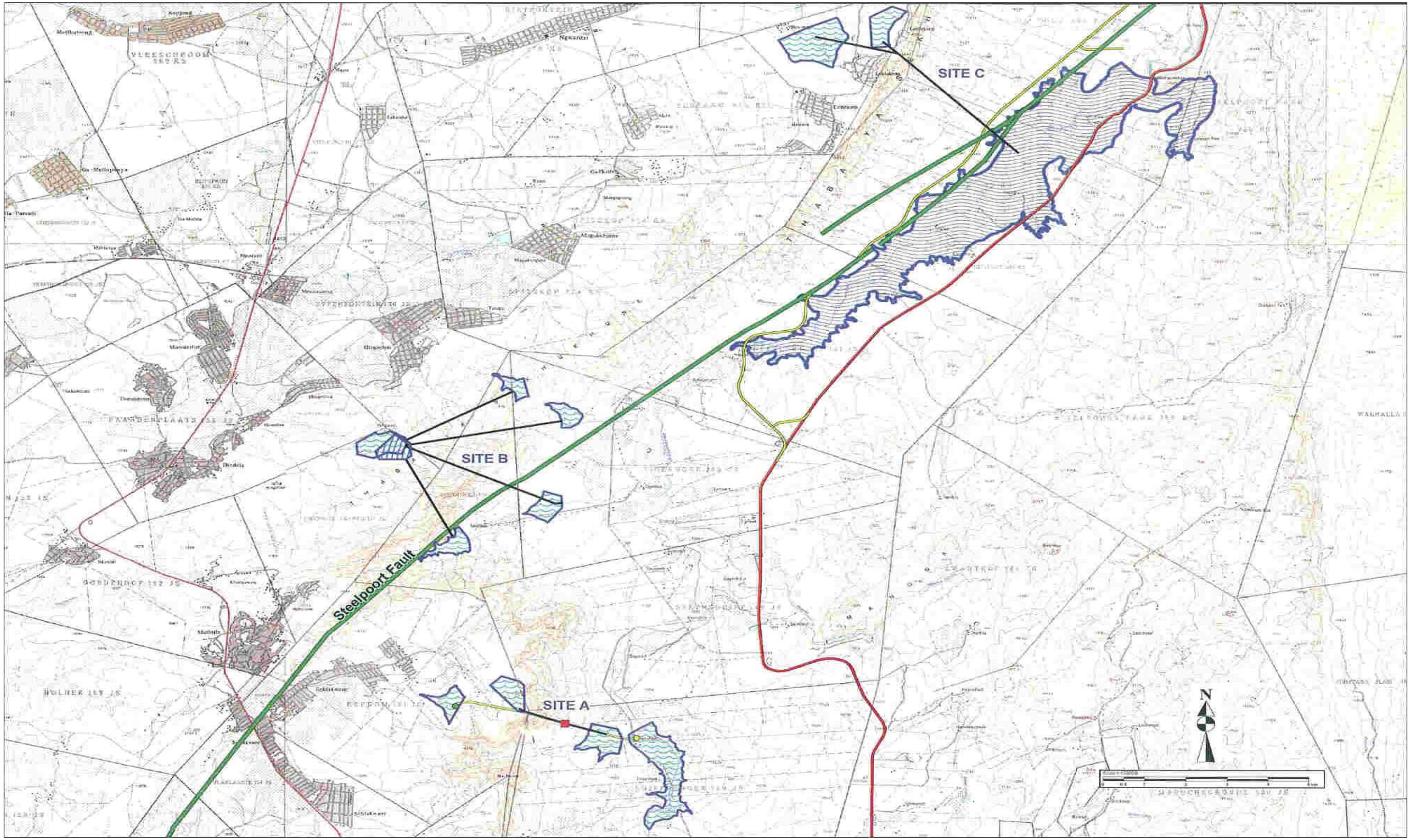

Figure 1-1: Project Lima locality map (from BKS (Pty) Ltd, 2006).

The Calpuff View dispersion model will be deployed in order to demonstrate the three-dimensional wind field of the area. Meteorological input data for the model will be sourced from the closest monitoring station(s) able to provide hourly average meteorological readings. Upper air data required to run the CALMET processor will be sourced from the Weather Services ETA model.

1.2 Overview of the CALPUFF View Dispersion Model

During both the baseline assessment and impact assessment phase the CALPUFF view dispersion model will be used to develop a three-dimensional wind field for the area under investigation.

CALPUFF View is a Windows user interface for the U.S. EPA recommended CALPUFF dispersion model (Thé *et al.* 2006). CALPUFF is suitable for modeling air dispersion over rough complex terrain (Thé *et al.* 2006).

CALPUFF consists of three main components, namely CALMET, CALPUFF and CALPOST. CALMET is a diagnostic three dimensional meteorological model, CALPUFF is the puff model that performs the air dispersion modelling, and CALPOST is the post-processing package which compiles the CALPUFF results.

To develop the three dimensional meteorological profile for the modelling domain CALMET requires meteorological data from multiple weather stations. In order to develop a regional three dimensional wind field for the study area, meteorological data were obtained from the South African Weather Service for 7 surface and one upper air weather station for a 100 x 100 km^2 area encompassing the study site, for the period 2001 to 2005 (Table 1-1). Scire *et al.* (2000a) recommends that 5 years of continuous data be used for modelling using CALMET. It should be noted however, that for air quality modelling purposes a data set which is less than 90% complete should not be used (Atkinson and Lee, 1992). Analysis of the 7 Weather Services stations data availability revealed, that only weather data from 2005 complies with the requirement of 90% data availability. This data was thus used as input into the CALMET model for the development of the 3 dimensional wind field for the study area. Tables 1-2 and 1-3 show the data availability for the weather stations and weather data used.

CALMET requires hourly surface observations for wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure and relative humidity; and twice-daily upper air observations of wind speed, wind direction, temperature, pressure and elevation (Thé *et al.* 2006). Hourly precipitation data is also included. Hourly cloud cover and ceiling height data was not recorded, thus an unlimited ceiling height and 0 % cloud cover was assumed for input into CALMET.

Table 1-1 lists the weather stations used to deliver hourly surface weather data (7 stations), hourly precipitation data (7 stations) and twice-daily upper air data (1 station) to CALMET. Figure 1-2 to Figure 1-4 outline the position of the Surface, precipitation and upper air station in relation to the current projects modelling domain (computational grid). It should be noted here that the scale bars used represent the UTM co-ordinate system required by the model. The distances measured when using this scale is in meters.

Table 1-1: SA Weather Service weather stations used to deliver hourly surface weather, precipitation and twice-daily upper air observations.

Station Name	Station Number	Latitude (degrees)	Longitude (degrees)	Surface	Precipi-tation	Upper Air
Ermelo	0479870 X	26.5	29.98	x	x	-
Graskop	0594626B9	24.93	30.85	x	x	-
Lydenburg	0554816A7	25.1	30.47	x	x	-
Nelspruit	0555750 9	25.5	30.92	X	x	-
Pietersburg	0677802BX	23.87	29.45	x	x	-
Pretoria UNISA	0513346 0	25.77	28.20	x	x	-
Witbank	0515320 8	25.83	29.18	x	x	-
Vereeniging	0438784 3	26.57	27.95	-	-	x

x indicates data used

- indicates data not used

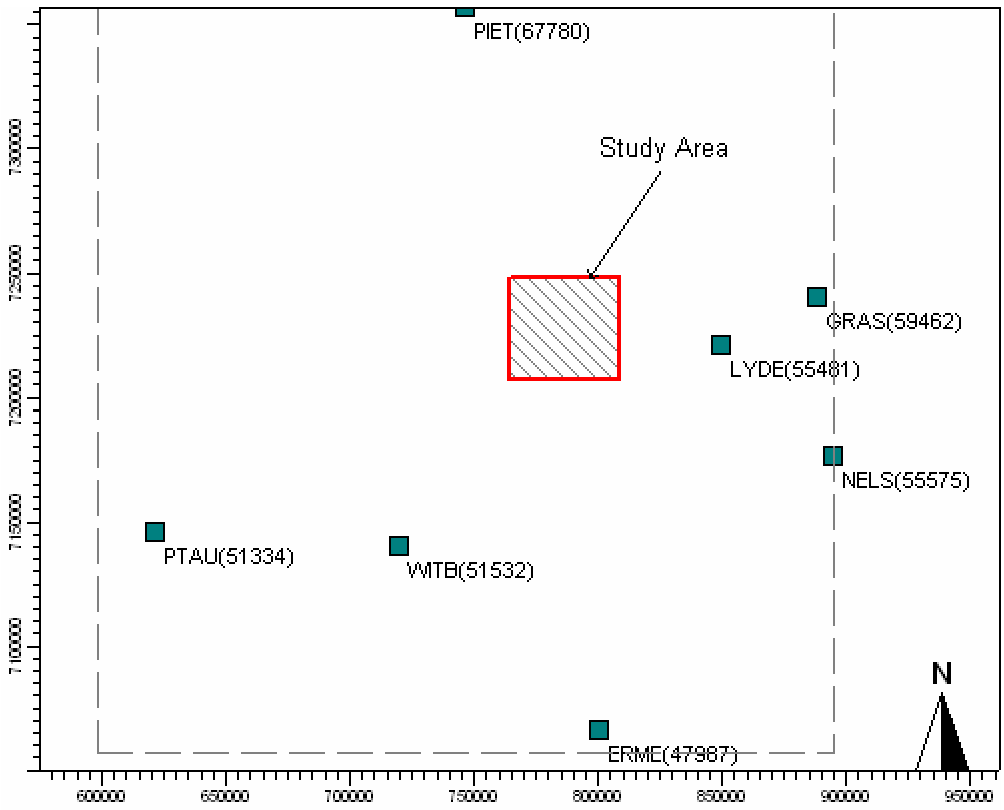

Figure 1-1: Position of the surface stations in relation to the modeling domain (computational Grid).

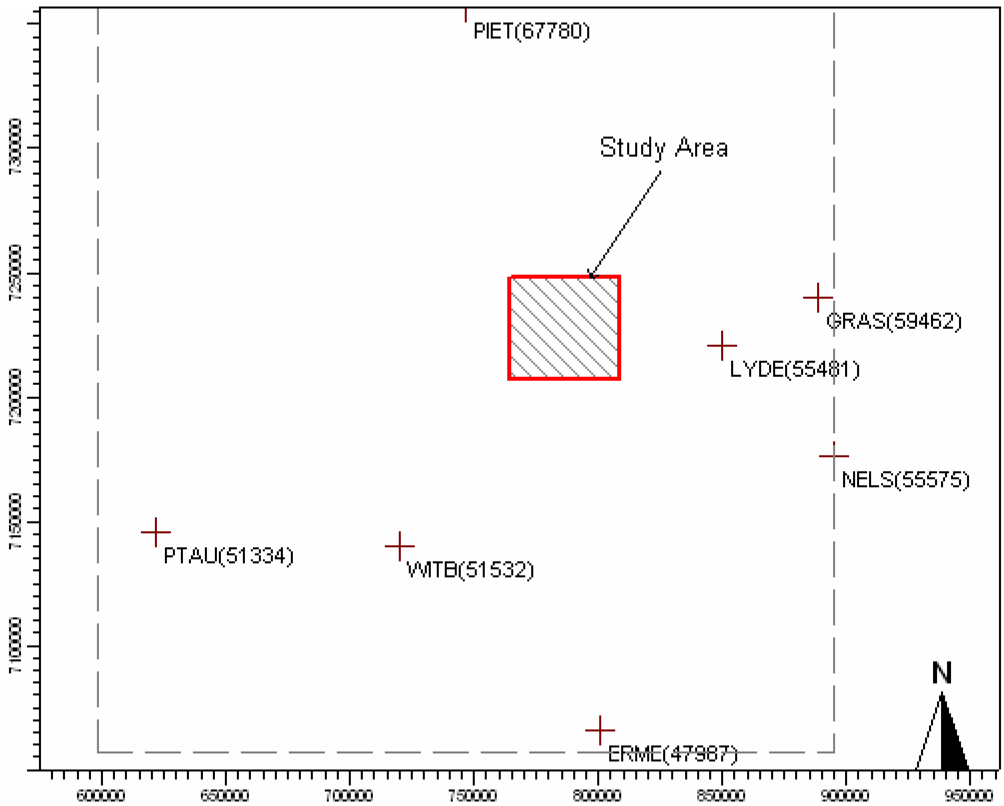

Figure 1-2: Position of the precipitation stations in relation to the modeling domain (computational Grid).

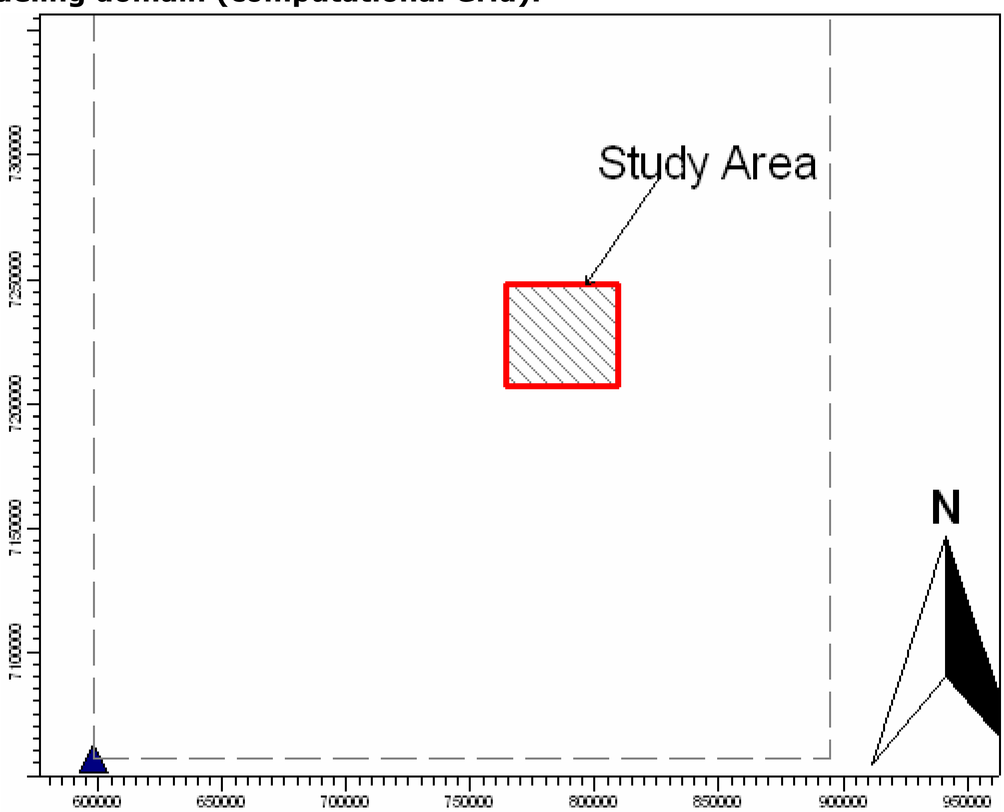

Figure 1-3: Position of the upper air stations in relation to the modeling domain (computational Grid).

CALMET also requires geophysical data in the form of terrain elevations, land use categories, surface roughness length, albedo, bowen ratio, soil heat flux, anthropogenic heat flux and vegetative leaf area index (Thé *et al.* 2006). Terrain elevations were obtained as digital elevation model (DEM) files in GTOP030 format (WEBGIS, 2002) and land use categories were obtained the from the USGS Africa Land cover characteristics database (Lambert Azimuthal Equal Area projection) (USGS, 2005). The defaults provided by CALMET were used for surface roughness length, albedo, bowen ratio, soil heat flux, anthropogenic heat flux and vegetative leaf area index.

Figure 1-5 provides a diagrammatic representation of the terrain elevations input into CALMET View. Similarly Figure 1-6 presents the land use categories applied by the model. The land use codes as outlined in the scale bar in Figure 1-6 are described in Table 1-5. Table 1-6 details the default variables used by the CALMET model for surface roughness length, albedo, bowen ratio, soil heat flux, anthropogenic heat flux and vegetative leaf area index.

1.3 Study Limitations

This section aims to highlight the shortfalls with respect to establishing the baseline conditions of the study area or in determining the predicted impacts due to the proposed operations. One aspect has been identified as part of the current investigation, and is detailed as follows:

* Due to poor data availability only 1 year of meteorological data could be modelled using the CALMET model.

1.4 Report Structure

The current report is divided into to seven sections. Section 1 of the report provides the background to the project, with Section 2 detailing a baseline description of the study area, also included in this section is an overview of both local and international guidelines and standards stipulated for the evaluation of exposure to particulate matter. Sections 3 outlines the scoping phase impact assessment. Section 4 provides a summary of the general conclusions and recommendations presented in the report. Section 6 presents a glossary of terms with Section 7 outlining the references cited in the report.

Table 1-2: Percentage data availability for hourly surface and precipitation data as provided by the weather stations listed in Table 1.1 for the period January to December 2005.

	Month	Rainfall	Temperature	Wind Speed	Wind Direction	Relative Humidity	Atmospheric Pressure
Ermelo	January	100	100	100	100	100	100
	February	100	100	100	100	100	100
	March	100	100	100	100	100	100
	April	100	100	100	100	100	100
	May	100	100	100	100	100	100
	June	100	100	100	100	100	100
	July	100	100	100	100	100	100
	August	100	100	100	100	100	100
	September	100	100	*78*	*78*	100	100
	October	100	100	100	100	100	100
	November	100	100	100	100	100	100
	December	100	100	100	100	100	100
	Average	**100**	**100**	**100**	**100**	**100**	**100**
Graskop	January	100	100	100	100	100	100
	February	100	100	100	100	100	100
	March	100	100	100	100	100	100
	April	100	100	100	100	100	100
	May	100	100	100	100	100	100
	June	100	100	100	100	100	100
	July	98	98	98	98	98	98
	August	100	100	100	100	100	100
	September	100	100	100	100	100	100
	October	100	100	100	100	100	100
	November	100	100	100	100	100	100
	December	100	100	100	100	100	100
	Average	**100**	**100**	**100**	**100**	**100**	**100**
Lydenburg	January	100	100	100	100	100	100
	February	*83*	*83*	*83*	*83*	*83*	*83*
	March	100	100	100	100	100	100
	April	100	100	100	100	100	100
	May	100	100	100	100	100	100
	June	100	100	100	100	100	100
	July	98	98	98	98	98	98
	August	100	100	*75*	*75*	100	100
	September	100	100	100	100	100	100
	October	100	100	100	100	100	100
	November	100	100	100	100	100	100
	December	100	100	100	100	100	100
	Average	**99**	**99**	**99**	**99**	**99**	**99**

Table 1-2 continued: Percentage data availability for <u>hourly surface and precipitation data</u> as provided by the weather stations listed in Table 1.1 for the period January to December 2005.

	Month	Rainfall	Temperature	Wind Speed	Wind Direction	Relative Humidity	Atmospheric Pressure
Nelspruit	January	100	100	100	100	100	100
	February	100	100	100	100	100	100
	March	100	100	100	100	100	*78*
	April	100	100	100	100	100	100
	May	100	100	100	100	100	100
	June	*78*	*79*	*78*	*78*	*79*	*78*
	July	100	100	100	100	100	100
	August	100	100	100	100	100	100
	September	100	100	100	100	100	100
	October	100	100	100	100	100	100
	November	100	100	100	100	100	100
	December	100	100	100	100	100	100
	Average	**97**	**97**	**97**	**97**	**97**	**96**
Pietersburg	January	100	100	100	100	100	100
	February	98	100	98	98	100	100
	March	100	100	100	100	100	100
	April	100	100	100	100	100	100
	May	100	100	100	100	100	100
	June	100	100	100	100	100	100
	July	100	100	100	100	100	100
	August	100	100	100	100	100	100
	September	97	96	93	93	96	96
	October	100	100	100	100	100	100
	November	100	100	100	100	100	100
	December	100	100	100	100	100	100
	Average	**100**	**100**	**99**	**99**	**100**	**100**
Pretoria UNISA	January	100	100	100	100	100	100
	February	100	100	100	100	100	100
	March	100	100	100	100	100	99
	April	100	100	100	100	100	*60*
	May	100	100	100	100	100	100
	June	100	100	100	100	100	100
	July	100	100	100	100	100	100
	August	100	100	100	100	100	100
	September	100	100	100	100	100	100
	October	100	100	100	100	100	100
	November	100	100	100	100	100	100
	December	100	100	100	100	100	100
	Average	**100**	**100**	**100**	**100**	**100**	**97**

Table 1-2 continued: Percentage data availability for hourly surface and precipitation data as provided by the weather stations listed in Table 1.1 for the period January to December 2005.

Station	Month	Rainfall	Temperature	Wind Speed	Wind Direction	Relative Humidity	Atmospheric Pressure
Witbank	January	100	100	100	100	100	100
	February	100	100	100	100	100	100
	March	100	100	100	100	100	100
	April	100	100	100	100	100	100
	May	100	100	100	100	100	100
	June	100	100	100	100	100	100
	July	100	100	100	100	100	100
	August	100	100	100	100	100	100
	September	100	100	100	100	100	100
	October	100	100	100	100	100	100
	November	100	100	100	100	100	100
	December	100	100	100	100	100	100
	Average	**100**	**100**	**100**	**100**	**100**	**100**

Table 1-3: Percentage data availability for upper air weather data as provided by the weather stations listed in Table 1.1 for the period January to December 2005.

Station	Month	Pressure	Wind Direction	Wind Speed	Potential Temperature	Geo - Potential Height
Vereeniging	January	100	100	100	100	100
	February	100	100	100	100	100
	March	100	100	100	100	100
	April	100	100	100	100	100
	May	100	100	100	100	100
	June	100	100	100	100	100
	July	100	100	100	100	100
	August	100	100	100	100	100
	September	100	100	100	100	100
	October	100	100	100	100	100
	November	100	100	100	100	100
	December	100	100	100	100	100
	Average	100	100	100	100	**100**

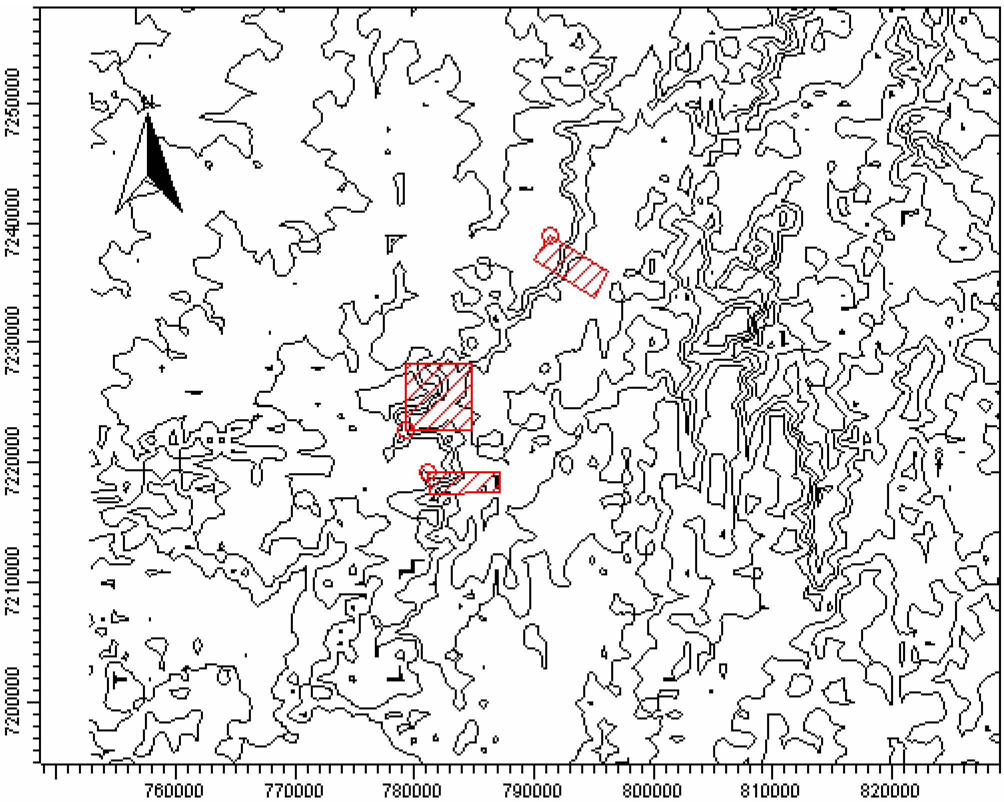

Figure 1-4: Terrain elevation as extracted from the GTOP030 DEM files (WEBGIS, 2002) for the CALMET modeling domain.

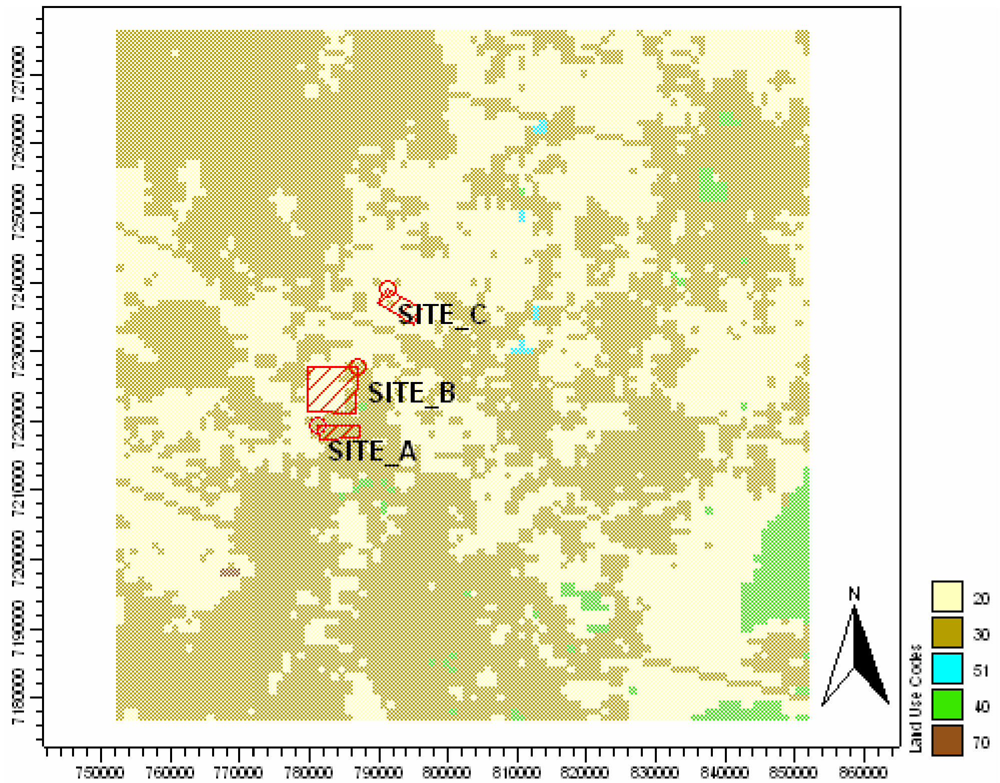

Figure 1-5: Land use categories as extracted from the USGS Africa Land Cover Characteristics Database (USGS, 2005).

Table 1-4: Land use codes as used in the CALMET model

Code	Explanation	Sub-code	Explanation
20	Cropland and Pasture	21	Cropland and Pasture
30	Rangeland	33	Mixed rangeland
40	Forest land	43	Mixed forest land
50	Water	51	Water
70	Barren land	75	Strip mines, quarries and gravel pits

Table 1-5: Default variables used in the CALMET model for surface roughness length, albedo, bowen-ratio, soil heat flux, anthropogenic heat flux and vegetative leaf area index

Land use sub- code	Surface Roughness Length (m)	Albedo	Bowen-Ratio	Soil heat flux (W/m^2)	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index
16	1.0	0.18	1.5	0.25	0.0	0.2
31	0.05	0.25	1.0	0.15	0.0	0.5
43	1.0	0.1	1.0	0.15	0.0	7.0,
51	0.001	0.1	0.0	1.0	0.0	0.0
75	0.05	0.3	1.0	0.15	0.0	0.05

2 BASELINE DESCRIPTION OF THE AREA

The impact of anthropogenic emissions released to the atmosphere is controlled by prevailing metereological conditions and topographical features in the region. Air movement reduces air pollution by diluting or dispersing it. Air movement can also transport air pollutants over long distances, sometimes over hundreds of kilometers. Air movement and mixing is dependant on differences in low and high pressures and the presence of temperature inversions. The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during unstable atmospheric conditions when the mixing layer is deep. These conditions occur most frequently in summer during the daytime. The dilution effect can however be inhibited under stable atmospheric conditions when the mixing layer is shallow. These conditions occur frequently in the winter.

2.1.1 Regional-Climatology and Atmospheric Dispersion Potential

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 & Preston-Whyte, 2000).

Seasonal variations in the positions of the high pressure cells have an effect on atmospheric conditions over the region (Tyson & Preston-Whyte, 2000). 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.

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 & Preston-Whyte, 2000).

2.1.2 Meso-scale meteorology and site-specific dispersion potential

The information presented in the subsections which follow detail the dispersion potential of the area under investigation. As discussed earlier in Section 1.2, the CALMET model was used to develop a three dimensional wind field for the area under investigation.

2.1.2.1 Wind

Period wind roses for the 7 weather services stations used in the development of the three dimensional wind field are presented in Figure 2-1. Wind roses comprise 16 spokes which represent the directions from which winds blew during the period. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The resultant vector represents the mean wind direction.

The closest weather station to the study site is the Weather Service’s Lydenburg station ~59 km east of the study area. It is clearly evident from Figure 2-1 that in Lydenburg the wind blows almost exclusively from the north-eastern and north-north-eastern sectors with very little wind from the west. Calms are relatively common (36.12 %) and wind speed is mostly below 3.6 $m.s^{-1}$.

The prevailing wind field vectors predicted by CALMET are shown in Figure 2-2. It can be seen that the predicted wind field more-or-less corresponds to the prevailing wind for Lydenburg as shown in Figure 2-1. Some variation in wind direction caused by the complex terrain is found in the Steelpoort River valley.

2.1.2.2 Atmospheric Stability

Atmospheric stability is commonly categorised into one of six stability classes. These are briefly described in Table 2-1. 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 a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Table 2-1: Atmospheric stability classes

A	Very unstable	calm wind, clear skies, hot daytime conditions
B	Moderately unstable	clear skies, daytime conditions
C	Unstable	moderate wind, slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Stable	moderate wind, slightly overcast night-time conditions
F	Very stable	low winds, clear skies, cold night-time conditions

At the Lydenburg weather station very stable conditions are associated mostly with winds from the north-westerly and the northerly sectors (Figure 2-5). Poor atmospheric dispersion potentials are associated with such stable conditions. Winds from the north-west are, however, rare (Figure 2-1). Unstable conditions

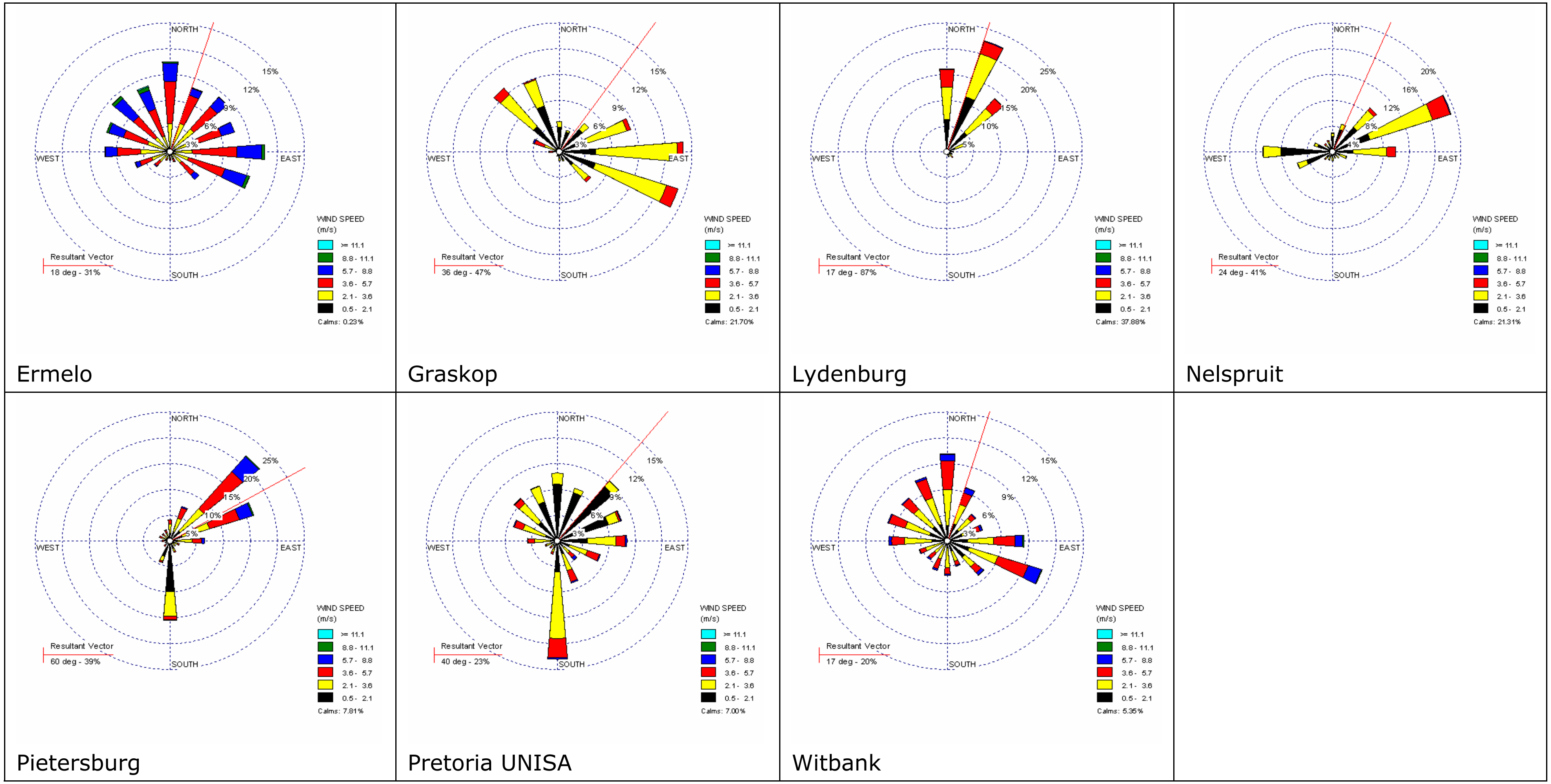

Figure 2-1: Period wind roses (January to December 2005) for the 7 Weather Services stations used in the development of a three dimensional wind field for the modelling domain. The resultant vector represents the mean wind direction.

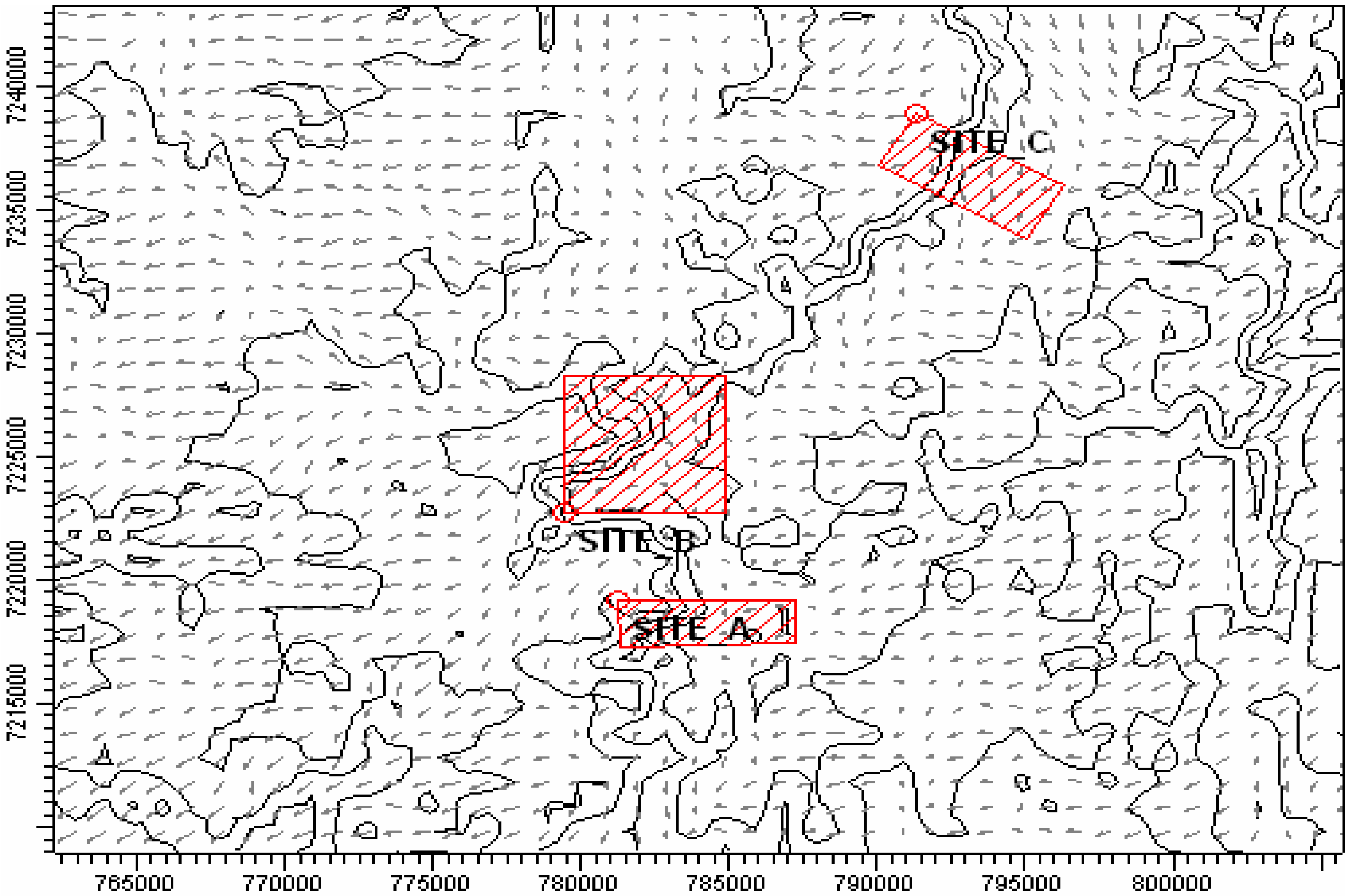

Figure 2-2: Prevailing wind field vectors predicted by CALMET at Site A, Site B and Site C.

are associated with winds blowing from various sectors. Turbulent conditions prevalent during unstable conditions disperse pollutants.

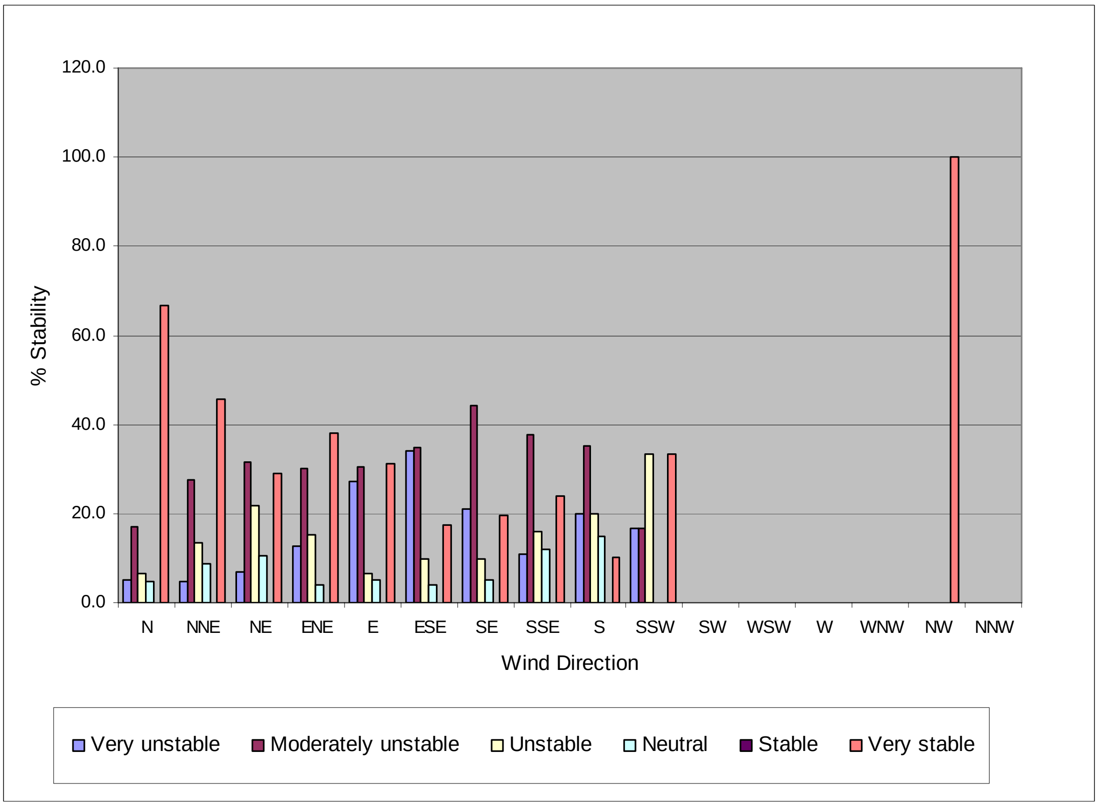

Figure 2-5: Stability class frequency distribution associated with the Lydenburg weather station for the period January 2005 to December 2005.

2.1.2.3 Precipitation and Evaporation

Precipitation cleanses the air by washing out particles suspended in the atmosphere (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).

Average monthly rainfall for the Lydenburg weather station for the period January 2004 to December 2005 is shown in Figure 2-6. The rainfall is typical of the summer rainfall region of South Africa. The annual average of 132.2 mm recorded at Lydenburg is considered to be low for the Lydenburg-Witbank area. This is probably due to the data availabilty of 83% recorded for the Lydenburg station during February (Table 1-2). The average monthly rainfall for the Witbank weather station (Figure 2-7) is included here for the purpose of comparison. The annual average rainfall of 540.4 mm received at Witbank is considered to be more representative of rainfall in the Lydenburg-Witbank area.

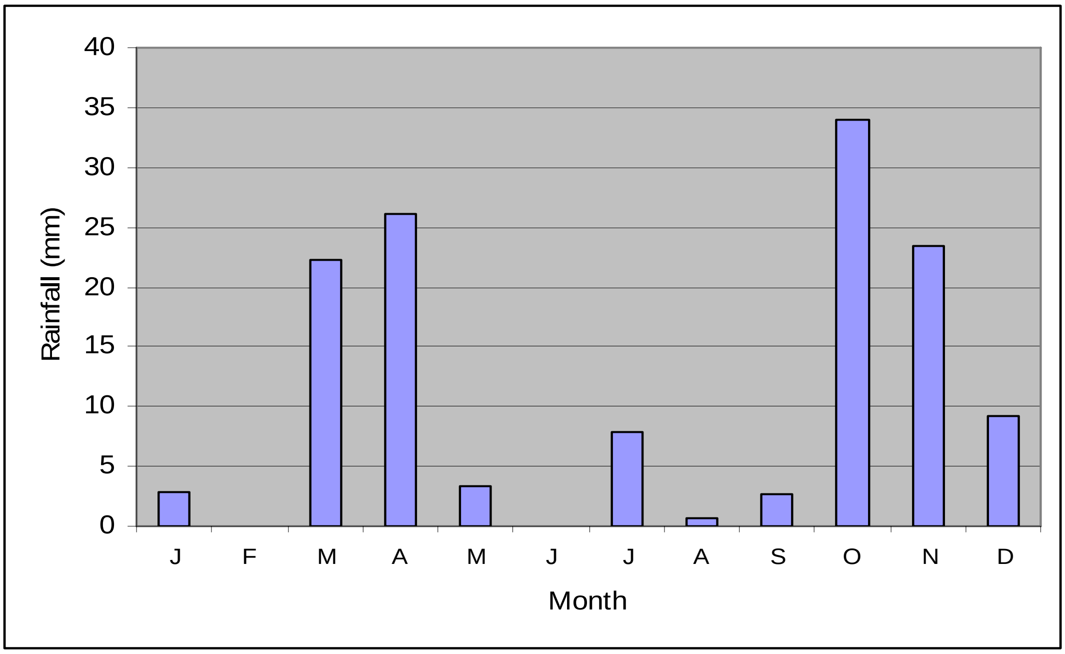

Figure 2-6: Average monthly rainfall at the Lydenburg weather station for 2004 to 2005. Mean annual rainfall 132.2 mm.

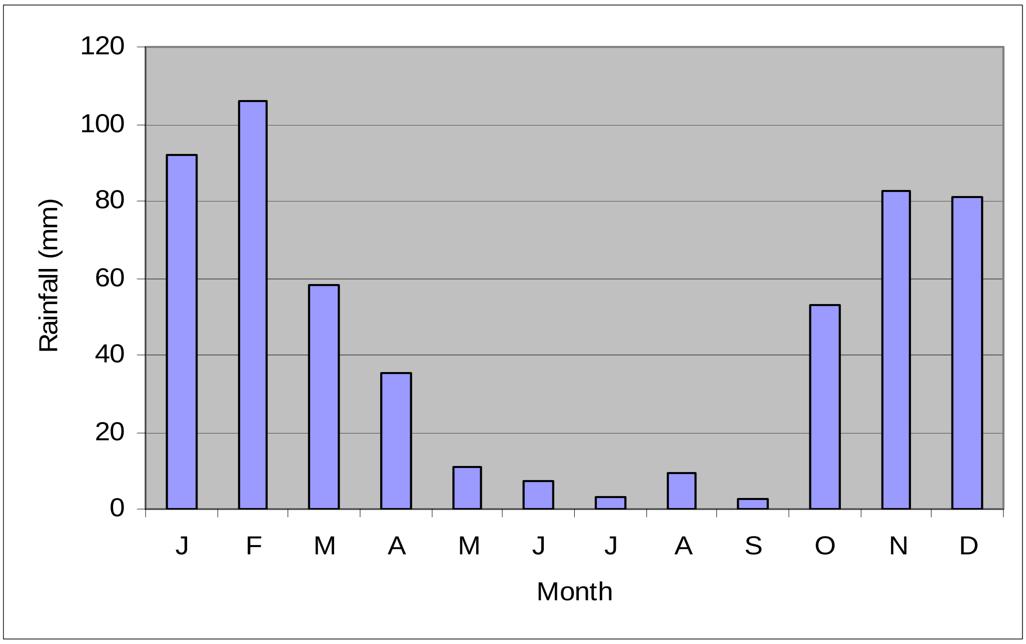

Figure 2-7: Average monthly rainfall at the Witbank weather station for 2001 to 2005. Mean annual rainfall 540.4 mm.

2.1.2.4 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. 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. 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.

Average monthly minimum and maximum temperatures for the period 2004 to 2005 for the Lydenburg weather station are given in Figure 2-8. Daily summer temperatures at the Lydenburg weather station range between ~10 °C and ~32 °C, while winter temperatures range between ~0 °C and ~25 °C respectively.

Figure 2-9 depicts monthly relative humidity figures for the Lydenburg weather station. From Figure 2-9 it is evident that relative humidity is lowest during winter and early spring.

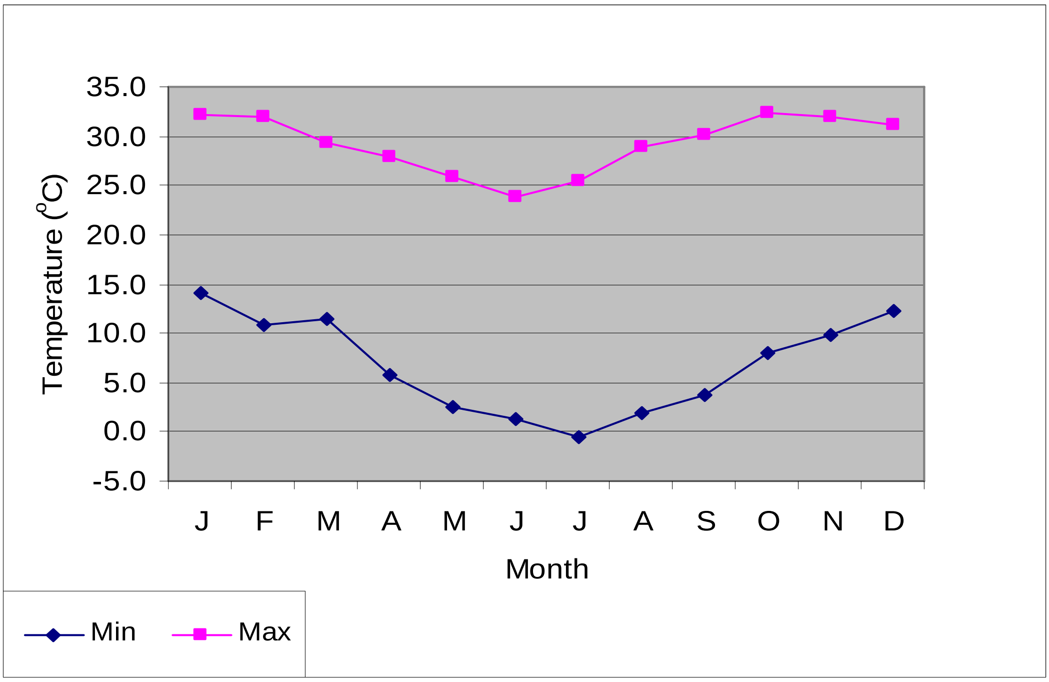

Figure 2-8: Average monthly minimum, maximum and mean temperatures for the Lydenburg weather station for 2004 to 2005. Average minimum monthly temperature is 6.8 oC and the average maximum monthly temperature is 29.2°C, while the average annual temperature is 17°C.

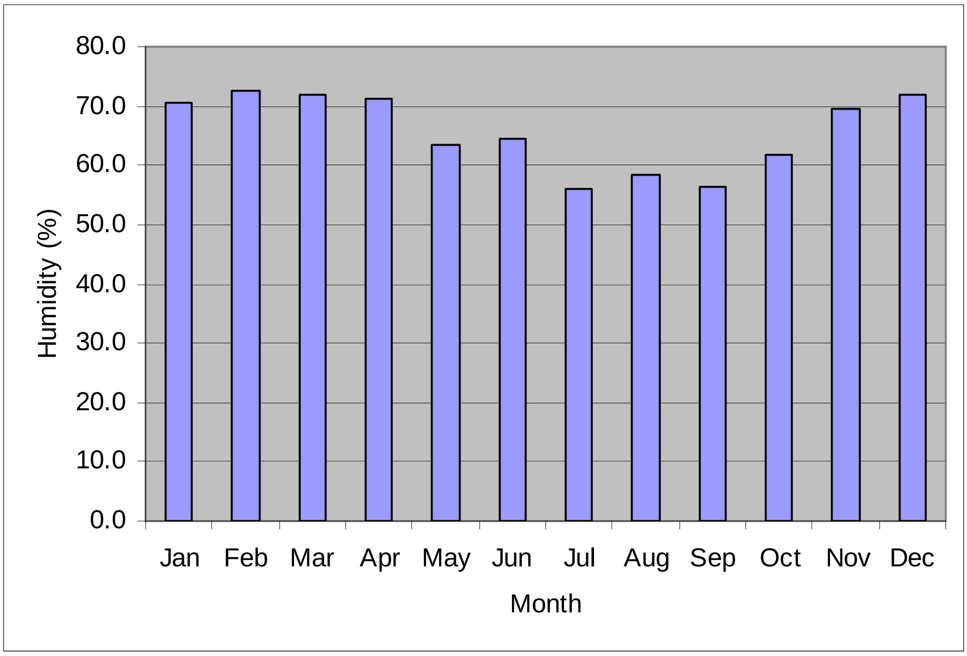

Figure 2-9: Monthly average relative humidity for the Lydenburg Weather Station for 2004 to 2005. Average annual relative humidity is 65.6 %.

2.2 Identified Sensitive Receptors

The following sensitive receptors were identified from 1:50 000 topographical maps:

- Sehlakwane – 2-3 km west of Site A and 3-4 km south and south-south-west of Site B
- Sovolo – 5-8km south and south-west of Site A
- Roossenekaal – 11 km south-east of Site A
- Mathula – 4-5 km south and south-east of Site B
- Thabaneng – ~1 km north of Site B
- Dindela - ~3 km west of Site B
- Eenzaam - ~1km south of Site C
- Maré - ~4-5 km west-south-west of Site C
- Patantswane - ~1km north of Site C
- Matlakatle - ~5km north-west of Site C
- Lehlakong – directly east of Site C
- Ngwaritsi - ~4-5 km west of Site C

2.3 Other Polluting Sources in the Area

The pollutant of concern during this investigation is particulate matter. Currently a detailed emissions inventory for the study area is not available. Based on 1:50 000 topographical maps; the following sources of air pollution have been identified:

* Agricultural activities
* Mining Activities

* Vehicle dust entrainment and exhaust gas emissions
* Domestic fuel burning
* Veld Fires

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

2.3.1 Agriculture

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 animal. The types of livestock assessed included pigs, sheep, goats and chickens. Emissions assessed include ammonia and hydrogen sulphide (USEPA, 1996).

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

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

2.3.2 Mining Operations

The Mapochs iron ore mine, situated east of Site A and north-north-east of Roossenekal, contributes to fugitive dust emissions in the area. Land clearing operations, materials handling, vehicle entrainment from haul roads, wind erosion from open areas and storage piles, and drilling and blasting give rise to fugitive dust (U.S Environmental Protection Agency, 1996).

2.3.3 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 both mining and agricultural activity, road networks can often be of a temporary nature, and are thus unpaved. An extensive unpaved road network exists in the area. The impacts due to the unpaved roads, as a result of proposed operations, will be assessed during the impact assessment component of the study.

2.3.4 Domestic Fuel Burning

It is anticipated that certain low income households in the area are likely to use coal and wood for space heating and/ or cooking purpose. The problems facing South Africa around the impact of air pollution generated indoors as a result of the use of coal and wood are not unique. Similar problems are reported around the world in poor communities which either lack access to electricity or lack the means to fully utilise the available supply of electricity (Van Horen et al. 1992).

Globally, almost 3 billion people rely on biomass (wood, charcoal, crop residues, and dung) and coal as their primary source of domestic energy. Exposure to indoor air pollution (IAP) from the combustion of solid fuels is an important cause of morbidity and mortality in developing countries. Biomass and coal smoke contain a large number of pollutants and known health hazards, including particulate matter, carbon monoxide, nitrogen dioxide, sulphur oxides (mainly from coal), formaldehyde, and polycyclic organic matter, including carcinogens such as benzo[*a*]pyrene (Ezzati and Kammen, 2002).

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).

Monitoring of pollution and personal exposures in biomass-burning households has shown concentrations are many times higher than those in industrialized countries. The latest South African National Ambient Air Quality Standards, for instance, required the daily average concentration of PM_{10} (particulate matter < 10 μm in diameter) to be < 180 $\mu g/m^3$ (annual average < 60 $\mu g/m^3$). In contrast, a typical 24-hr average concentration of PM_{10} in homes using biofuels may range from 200 to 5000 $\mu g/m^3$ or more throughout the year, depending on the type of fuel, stove, and housing. Concentration levels, of course, depend on where and when monitoring takes place, because significant temporal and spatial variations may occur within a house. Field measurements, for example, recorded peak concentrations of ≥ 50000 $\mu g/m^3$ in the immediate vicinity of the fire, with concentrations falling significantly with increasing distance from the fire. Overall, it has been estimated that approximately 80% of total global exposure to airborne particulate matter occurs indoors in developing nations. Levels of CO and other pollutants also often exceed international guidelines (Ezzati and Kammen, 2002).

2.3.5 Veld Fires

A veld fire is 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).

Once a fire begins, the dry combustible material is consumed first. If the energy released is large and of sufficient duration, the drying of green, live material occurs, with subsequent burning of this material as well. Under suitable environmental and fuel conditions, this process may initiate a chain reaction that results in a widespread conflagration. It has been hypothesized, but not proven, that the nature and amounts of air pollutant emissions are directly related to the intensity and direction (relative to the wind) of the veld fire, and are indirectly related to the rate at which the fire spreads. The factors that affect the rate of spread are (1) weather (wind velocity, ambient temperature, relative humidity); (2) fuels (fuel type, fuel bed array, moisture content, fuel size); and (3) topography (slope and profile). However, logistical problems (such as size of the burning area) and difficulties in safely situating personnel and equipment close to the fire have prevented the collection of any reliable emissions data on actual veld fires, so that it is not possible to verify or disprove the hypothesis.

The major pollutants from veld burning are particulate matter, carbon monoxide, and volatile organics. Nitrogen oxides are emitted at rates of from 1 to 4 g/kg burned, depending on combustion temperatures. Emissions of sulphur oxides are negligible (USEPA, 1996). A study of biomass burning in the African savanna 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).

2.4 The Impact of Particulate Matter

The pollutant of concern 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). Particulate matter is classified as criteria pollutant thus national air quality standards have been developed in order to protect the public from exposure to the inhalable fractions. Similarly the South African Bureau of Standards has developed guidelines for the assessment of nuisance dust impacts. In subsection 2-4-1 and subsection 2-4-2 an overview is provided of the available local and international guidelines and standards prescribed for inhalable particulate and nuisance dust exposure.

2.4.1 Inhalable Particulates

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 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).

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.

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

2.4.2 Nuisance Dust

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. Dustfall may also impact negatively on sensitive industries, e.g. bakeries or textile industries. Certain elements in dust may damage materials. For instance it was found that sulphur and chlorine if present in dust may cause damage to copper (Maeda *et al.*, 2001).

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). A review of the effects of cement dust on trees showed that the dust caused physical damage to the leaves, reduced fruit setting and generally reduced growth (Farmer, 1993). Several studies in Europe and the United States have indicated that a decline in species diversity may be linked to declining air quality around urban and industrial areas (Gunnarsson, 1988; Hallingbäck, 1992; Váňa, 1992; Van Zanten, 1992; Finizio *et al.*, 1998; Jones & Paine, 2006; Motiejūnaitė, in press; Otnyukova, in press).

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.

3 SCOPING PHASE IMPACT ASSESSMENT

The scoping phase impact assessment will deal qualitatively with the air quality impacts associated with the construction, operational and decomissioning phases of the pumped storage power generation facility.

The criteria used to evaluate these impacts and the significance ratings are presented in Tables 1 to 6 in Appendix A.

3.1 Construction Phase

Dust created during heavy construction is a source of air pollution that could impact substantially on the local air quality. Construction is temporary in nature and consists of a series of actions of known duration and extent (U.S Environmental Protection Agency, 1996). Thus dust emissions generated at a construction site have a definite beginning and end and will vary substantially over the period of construction. The quantity of dust emissions from construction activities is proportional to the area of land being worked, the level of construction activity and the prevailling metereological conditions (U.S Environmental Protection Agency, 1996).

The following possible sources of fugitive dust and particulate emissions were identified as activities which could potentially generate air pollution during construction operations (U.S Environmental Protection Agency, 1996):

1. Demolition and debris removal
    a. Demolition of obstacles such as boulders, trees, etc;
    b. Loading of debris into trucks;
    c. Truck transport of debris;
    d. Truck unloading of debris;
2. Site preparation (earthworks)
    a. Bulldozing;
    b. Scrapers unloading topsoil;
    c. Scrapers in travel;
    d. Scrapers removing topsoil;
    e. Loading of excavated material into trucks;
    f. Truck dumping of fill material, road base, or other materials;
    g. Compacting;
    h. Motor grading;
    i. Excavating;
    j. Embanking;
3. General Construction
    a. Vehicular traffic;
    b. Portable plants – aggregrate processing; and
    c. Concrete Mixing,

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

1. ambient air quality;
2. local residents and neighbouring communities;
3. the aesthetic environment; and
4. 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 industries and aesthetics. The inhalable particulate fraction could however adversely affect human health.

Short-term impacts on the local air quality of a negative nature will occur as a result of construction activities at the pumped storage facilty. Impacts will be more of a nuisance value than a potential health risk. Construction traffic, excavation and earthmoving, and aggregate processing facilities will generate dust. Short-term increases in sulfur oxides, nitrogen oxides, and hydrocarbons from vehicle exhaust will occur, but air quality is not expected to deteriorate significantly over the long-term as a result of construction activities. It is expected that air quality will be poorer during the winter months as a result of temperature inversions common over the region in the colder months and the cumulative effects of pollution caused by the burning of coal and wood in households, and from veld fires common in winter.

Sensitive receptors were identified in close proximity to all three sites (Section 2.2). Considering the prevailing wind direction (Section 2.1), it is predicted that construction activites could potentially impact particularly on these residential areas (although all receptors identified in Section 2.2 could be impacted upon):

Site A

1. Sehlakwane
2. Sovolo

Site B

1. Sehlakwane
2. Mathula
3. Dindela
4. Thabaneng

Site C

1. Eenzaam
2. Lehlakong
3. Maré

4. Ngwaritsi
5. Matlakatle

Site A and B were identified as being ecologically sensitive (Howard *et al.*, 2006). Due to the short duration of construction activities, the impacts on fauna and flora of particulate matter are expected to be of low significance.

The resultant haze caused by suspended particulate matter could potentially impact on the aesthetics of the area. Tourism depends on natural beauty and poor air quality could impact negatively on tourism in the area. Impacts on aesthetics and tourism due to poor air quality is expected to be of short duration, of a localised nature and therefore of low significance.

Impacts will be of a temporary nature and weather conditions are mostly stable with low wind speeds; dust should not be dispersed very widely and should be scavenged from the air by rains during the summer months. Provided that mitigation methods such as dust supression are employed, overall the negative air quality impacts from construction activities are not expected to be significant during the construction phase.

Based on these provided definitions the significance of the air quality impacts related to the construction operations are outlined as follows (Table 3-3).

Table 3-3: Scoping Assessment: Construction Phase

Environmental Component	Air Quality
Nature of Impact	Reduction in the ambient air quality
Activities causing Impact	Construction and related activities
Duration of Impact	Short Term
Extent of Impact	Localised
Severity of impact	Slight
Significance of Impact	Low
Likelihood of Impact	May occur
Degree of certainty	Probable

3.2 Operational Phase

Hydroelectric power generation is generally regarded as being environmentally friendly. However, recent studies have shown that decaying vegetation in dams may emit greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) (Fearnside, 2002). Trees left standing above water in flooded reservoirs begin to decay aerobically while submerged vegetation decays anaerobically. Several recent studies in reservoirs indicate that methane emissions show a large peak in the first years after filling (Fearnside, 2002).

Once this initial pulse has subsided, emissions seem to vary from year to year with no clearly established pattern of decline over time. However, water levels in reservoirs fluctuate seasonally and exposed areas are quickly invaded by vegetation. Sub-sequent flooding once again results in submergence of this vegetation and decay. Water entering dam turbines and, depending on their design, spillways is under high pressure from the water above and can contain large amounts of dissolved methane. When this water is discharged the pressure instantly drops to atmospheric pressure and the dissolved methane is suddenly released (Fearnside, 2002).

The amount of greenhouse gas emitted from dams also depends on the climate. It has been found that dams in tropical regions emit 5 and 20 times more greenhouse gases than those in boreal and temperate regions (Duchemin *et al.*, 2002). There is however, considerable uncertainty and controversy around the methodology for estimating emissions and also whether dams are significant sources of greenhouse gases; a lot more research is required (Fearnside, 2002).

Due to this uncertainty and in line with the precautionary approach it is assumed here that dams do emit greenhouse gases. Any new emissions of methane in an area could cause an upset in the ecological nutrient and gaseous cycles. However, permanent alteration to such ecological cycles is dependent on the amount of disruption that the ecosystem can withstand. Since the area to be flooded is small, any methane emissions are predicted to be of low to medium significance, although methane emissions could add cumulatively to those from the proposed De Hoop Dam near Site C.

The extent of the impact is regarded as being international due to the contribution of greenhouse gases to the atmosphere. However, there is a large amount of uncertainty in the prediction due to general uncertainty in the literature as to the amount of greenhouse gases emitted by dams. It is recommended that this aspect be investigated in more detail during the full environmental impact assessment phase.

Based on the provided definitions the significance of the air quality impacts related to the operational phase are outlined in Table 3-4.

Table 3-4: Environmental Impact Assessment: Operational Phase

Environmental Component	Air Quality
Nature of Impact	Increase in levels of greenhouse gases
Activities causing Impact	Submergence of vegetation resulting in methane emissions
Duration of Impact	Long Term
Extent of Impact	International – global warming is of international concern
Severity of impact	Severe
Significance of Impact	Don't know
Likelihood of Impact	May occur
Degree of certainty	Unsure

3.3 Decomissioning Phase

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

1. Existing buildings and structures demolished, rubble removed and the area levelled;
2. Remaining exposed excavated areas filled and levelled using overburden recovered from stockpiles;
3. Stockpiles smoothed and contoured;
4. Topsoil replaced using topsoil recovered from stockpiles; and
5. Land prepared for revegetation.

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

1. Smoothing of stockpiles by bulldozer;
2. Grading of sites;
3. Transport and dumping of overburden for filling;
4. Infrastructure demolition;
5. Infrastructure rubble piles;
6. Transport and dumping of building rubble;
7. Transport and dumping of topsoil; and
8. Preparation of soil for revegetation – ploughing and addition of fertiliser, compost etc.

Impacts for this phase will depend on the extent of rehabilitation efforts and are similar to those identified for the construction phase (section 3.1).
Based on these provided definitions the significance of the air quality impacts related to the decomissioning phase are outlined in Table 3-5.

Table 3-5: Scoping Assessment: Decomissioning Phase

Environmental Component	Air Quality
Nature of Impact	Reduction in the ambient air quality
Activities causing Impact	Demolition of Infrastructure and rehabilitation of disturbed areas.
Duration of Impact	Short Term
Extent of Impact	Localised
Severity of impact	Slight
Significance of Impact	Low
Likelihood of Impact	May occur
Degree of certainty	Probable

4 CONCLUSIONS AND RECOMMENDATIONS

The proposed pumped storage power generation facility in the Steelpoort River valley area is regarded as being a more favourable option than fossil fuel-based power plants. However the construction and future decomissioning of the facility and associated structures could impact on the local air quality over the short-term. The implementation of best management practices during construction activities, will ensure that any negative impacts will be mitigated so that their effects on the neighbouring residential areas and ecological components are minimised.

Some schools of thought do not regard hydroelectrical power as being as "clean" as has been made out. It has been shown that dams could potentially emit significant amounts of greenhouse gases, maybe more so than fossil fuel-based power plants of similar generating capacity (Fearnside, 2002). However, there is great uncertainty and controversy as to whether the amounts of greenhouse gases emitted are more significant than those emitted from fossil fuel-based power plants. The science of the estimation of greenhouse gases from dams is young and much research is required. However, due to this uncertainty and in accordance with the precautionary principle it is recommended that this subject be dealt with in more detail in the environmental impact assessment phase.

5 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.

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.

Boreal Region – a cbiogeographic region ocurring as a broad band across northern North America and northern Eurasia and also extends southward at higher elevations in the mountains. The climate is characterised by cold winters and short, mild summers.

Boundary layer - the layer directly influenced by a surface.

Climatology - the study of weather.

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.

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

Evaporation - the opposite of condensation.

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.

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

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.

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.

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.

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.

Temperate Region – the biogeoghraphic region occupying eastern and western North America, western and eastern Europe, western Asia, Japan, Eastern China, Argentinia, New Zealand and Chile. The region has a well-defined warm summer and cool to cold winter.

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

Tropical Region - the biogeoghraphic region occupying the equatorial zone and the sub-tropical and adjacent areas alongside the equator. The largest areas occupying the equatorial region are in the Amazon Basin of South America, western Africa and Indonesia. Annual precipitation is very high in the equatorial areas and seasonal variation in temperature is slight. The largest part of the sub-tropical region is found in Africa, with other areas in souther Asia, Australia, Venezuela and Brazil. There is a pronounced rainy and dry season, summers are usually hot while winters are mild to cool.

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.

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APPENDIX A

Table 1: Temporal scale criteria used to define an impact (from Bohlweki Environmental)

Short Term	Less than 5 years
Medium Term	Between 5 and 15 years
Long Term	Between 15 and 30 years
Permanent	Over 30 years and resulting in permanent change that will always be there
Short Term	Less than 5 years

Table 2: Spatial scale criteria used to define an impact (from Bohlweki Environmental)

International	Across international boundaries
National	South Africa
Regional	Provincial
Localised	Small scale impacts – from a few hectares in extent to e.g. the local district area
Household	Applies to households in the area
Individual	Applies to person or person/s in the area

Table 3: Severity/beneficial scale criteria used to define an impact (from Bohlweki Environmental)

Very severe	Irreversible and permanent change to the affected system(s) or party (ies) which cannot be mitigated.
Severe	Long term impacts on the affected system(s) or party (ies) that could be mitigated. However, this mitigation would be dificult, expensive or time consuming or some combination of these.
Moderately severe	Medium to long term impacts on the affected system(s) or party (ies) that could be mitigated.
Slight	Medium or short term impacts on the affected system(s) or party (ies). Mitigation is very easy, cheap, less time consuming or not necessary.
No effect	The system(s) or party (ies) is not affected by the proposed development.
Very beneficial	A permanent and very substantial benefit to the affected system(s) or party (ies), with no real alternative to achieving this benefit.
Beneficial	A long term impact and substantial benefi to the affected system(s) or party (ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming or some combination of these.
Moderately beneficial	Medium to long term impact of real benefit to the affected system(s) or party (ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way.
Slightly beneficial	A short to medium term impact and negliglible benefit to the affected system(s) or party (ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker or some combination of these.
Don’t know/Can’t know	In certain cases it may not be possible to determine the severity of an impact

Table 4: Definition of significance ratings (from Bohlweki Environmental)

Very high	These impacts would eb considered by society as constituting a major and nusually permanent change to the environment, and usually result in **severe** or **very severe** effects, or **beneficial** or **very beneficial** effects.
High	These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as high will need to be considered by society as constituting an important and usually long term change to the environment. Society would probably view these impacts in a serious light,
Moderate	These impacts will usually result in medium- to long-term effects on the enviroment. Impacts rated as moderate will need to be considered by society as constituting a fairly important and usually medium term change to the environment. These impacts are real but are not substantial.
Low	These impacts will usually result in medium to short term effects on the environment. Impacts rates as low will need to be considered by the public and/or the specialist as constituting a fairly unimportant and usually short term change to the environment. These impacts are not substantial and are likely to have little real effect
No significance	There are no primary or secondary effects at all that are important to scientists or the public.

Table 5: Risk/likelihood scale criteria used to define an impact (from Bohlweki Environmental)

Very unlikely to occur	The chance of these impacts occurring is extremely slim
Unlikely to occur	The risk of these impacts occurring is slight.
May occur	The risk of these impacts is more likely, although it is not definite.
Will definitely occur	There is no chance that the impact will not occur.

Table 6: The degree of certainty or confidebce used to define an impact (from Bohlweki Environmental)

Definite	More than 90% sure of a particular fact. Requires substantial supportive data.
Probable	Over 70% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Only over 40% sure of a particular fact or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact or of the likelihood of an impact occurring.