Air Quality Specialist Scoping Report for the proposed H2 Energy Power Station, near KwaMhlanga, Mpumalanga Province

Project done on behalf of **Savannah Environmental (Pty) Ltd**

Report Compiled by:

T Bird

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Revision Record

Revision Number	Date	Reason for Revision
Draft Scoping	November 2016	For client review
Revised Scoping	December 2016	Site layout changes and text revisions requested by client

Terri Bird, PhD (Wits), Pr. Sci. Nat

Dr Terri Bird holds a PhD from the School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg. The focus of her doctoral research was on the impact of sulfur and nitrogen deposition on the soil and waters of the Mpumalanga Highveld. Since March 2012 she has been employed at Airshed Planning Professionals (Pty) Ltd. In this time, she has been involved in air quality impact assessments for various mining operations (including coal, mineral sand, diamond and platinum mines); coal-fired power stations and associated ash disposal facilities; refineries; landfills; and various other small industries. She has been a team member on the development of Air Quality Management Plans, both provincial and for specific industries. Recent projects include assessing the impact of Postponement and/or Exemption of Emission Standards for various Listed Activities.

EXECUTIVE SUMMARY

Airshed Planning Professionals (Pty) Ltd was appointed by Savannah Environmental (Pty) Ltd to undertake a scoping level assessment for the proposed H2 Energy Power station and associated infrastructure. The proposed location of the project is 9 km south of KwaMhlanga, 10 km south-east of Moloto, and approximately 1 km north of the existing Palesa Coal Mine. The facility will be located in the Thembisile Hani Local Municipality, in the Nkangala District of the Mpumalanga Province.

The aim of this investigation was to determine baseline air quality conditions, identify potential sensitive receptors and impacts to air quality that may arise from the proposed project; all of which will form the basis for the air quality impact assessment to be conducted for the project.

Determination of the baseline air quality characterisation included an assessment of:

- The regional climate and site-specific atmospheric dispersion potential;
- The identification of existing sources of emissions in the area;
- The preliminary identification of the potential sensitive receptors within the vicinity of the proposed site;
- The characterisation of ambient air quality in the region based on recent observational data;
- The legislative and regulatory context, including ambient air quality and dust-fall standards with specific reference to the new Air Quality Act of 2004; and,
- Identification of the potential impacts of the proposed project's operations on air quality that could affect environmental and/or human health.

The main findings from the scoping level assessment were as follows:

- The flow field is dominated by winds from the north-easterly sector.
- The closest residential area to the project area is KwaMhlanga, approximately 9 km north of the proposed site. Individual homesteads surround the proposed project location. No schools or clinics are located within a 7.5 km radius of the proposed project.
- Criteria pollutants emitted during operation of the power station will include sulfur dioxide (SO_2), oxides of nitrogen (NO_X), carbon monoxide (CO), and particulate matter (PM).

The following will be included in the impact assessment study:

- Homesteads within 5 km of the proposed project will be identified (using aerial photography) and included as discrete receptors in the dispersion modelling simulations;
- Compilation of an emissions inventory, comprising the identification and quantification of potential sources of emissions due to the proposed operations;
- Dispersion modelling simulations of all potential pollutants from the operational plant for applicable averaging periods;
- Evaluation of potential for human health and environmental impacts;
- Determination of environmental risk according to a stipulated Impact Assessment methodology and,
- Recommendation of mitigation and management measures.

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LIST OF ACRONYMS AND SYMBOLS

ADF	Ash disposal facility
Airshed	Airshed Planning Professionals (Pty) Ltd
AQSRs	Air quality sensitive receptors
°C	Degrees Celsius
CFB	Circulating fluidised bed
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CEPA	Canadian Environmental Protection Agency
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
EMPR	Environmental Management Programme
H_2S	Hydrogen sulfide
km	Kilometre
m^3	Cubic metre
m^2	Square metre
m/s	Metre per second
MM5	Fifth-Generation NCAR/Penn State Mesoscale Model
Mtpa	Million tonnes per annum
NAAQS	National Ambient Air Quality Standards
NDCR	National Dust Control Regulations
NEM:AQA	National Environmental Management: Air Quality Act
NO_x	Oxides of nitrogen
NO_2	Nitrogen dioxide
O_3	Ozone
PAHs	Polycyclic aromatic hydrocarbons
Pb	Lead
PM	Particulate matter
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 μm
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5 μm
SABS	South African Bureau of Standards
SO_2	Sulfur Dioxide [1]
TSP	Total Suspended Particles
tpd	Tonnes per day
US-EPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds

Note:

The spelling of “sulfur” has been standardised to the American spelling throughout the report. "The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, published, in 1990, a list of standard names for all chemical elements. It was decided that element 16 should be spelled “sulfur”. This compromise was to ensure that in future searchable data bases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook)"

Air Quality Specialist Scoping Report for the proposed H2 Energy Power Station, near KwaMhlanga, Mpumalanga Province

1 INTRODUCTION

Airshed Planning Professionals (Pty) Ltd was appointed by Savannah Environmental (Pty) Ltd to undertake a scoping level assessment for the proposed H2 Energy Power Station and associated infrastructure, near KwaMhlanga, Mpumalanga Province. The project entails the development of a 600MW coal-fired power station and associated infrastructure (including an ash dump and coal stockpile within the site boundary, access roads and overhead power line).

The main objective of this investigation is to determine the baseline receiving environment including general and local climate to identify air quality features; identify sensitive receptors in the area; identify potential air quality impacts that may arise and require further assessment, as well as provide a plan of study for the detailed Environmental Impact Assessment (EIA) phase investigation, which is to follow. This will form the basis for determining the potential impacts associated with the proposed project as well as the effects it might have on the environment and human health.

1.1 Terms of Reference

The scoping level air quality characterisation includes:

- The assessment of the regional and local (site-specific) climate and atmospheric dispersion potential;
- Description of air quality features that may be affected;
- The identification of existing sources of emissions in the area;
- The identification and rating of the sensitive receptors within the vicinity of the proposed operation (e.g. a school will have a higher sensitivity rating than a neighbouring mine);
- The identification and justification of impacts requiring further investigation during the EIA phase;
- The identification of gaps in knowledge, data and information that could hamper the impact identification and evaluation process; and,
- Providing a detailed plan of study for the EIA phase of assessment.

1.2 Methodology

An understanding of the atmospheric dispersion potential of the area, based on site specific weather data, is essential to an air quality impact assessment. Due to no on-site or near-site weather station being available, simulated (MM5) meteorological data for the site during the period January 2013 – December 2015 were used to describe local meteorological conditions. The data include hourly average wind speed, wind direction and temperature. For the purposes of establishing the local climatology, it is necessary to analyse at least one year of on-site data; and at least three years of off-site data (DEA, 2014). The pollutants of concern associated with coal-fired power stations include: sulfur dioxide (SO_2); oxides of nitrogen (NO_X); and particulate matter (PM). Particulates are divided into different particle size categories with total suspended particulates (TSP) associated with nuisance impacts and the finer fractions of PM_{10} (particulates with a diameter less than 10 µm) and $PM_{2.5}$ (diameter less than 2.5 µm) linked with potential health impacts.

The scoping phase assessment has also included a preliminary identification of air quality sensitive receptors (AQSRs). No schools or clinics are located within a 7.5 km radius of the proposed project; however several individual homesteads occur within 7.5 km of the project. These homesteads will be identified (using aerial photography, and information derived from the

Socio-Economic Impact Assessment) and included as discrete receptors in the dispersion modelling simulations during the EIA phase.

1.3 Outline of Report

The basic site description and identification of possible environmental aspects is discussed in Section 2. This is followed by the consideration of related and significant aspect management plans for the region in Section 3. The potential impacts are described in Section 4. Section 5 comprises a detailed plan of study for the EIA.

2 REGULATORY REQUIREMENTS AND ASSESSMENT CRITERIA

The environmental regulations and guidelines governing the emissions and impact of the proposed power station and associated infrastructure need to be considered prior to potential impacts and sensitive receptors being identified.

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

2.1 National Ambient Air Quality Standards

The South African Bureau of Standards (SABS) assisted the Department of Environmental Affairs (DEA) in the development of ambient air quality standards. National Ambient Air Quality Standards (NAAQS) were determined based on international best practice for $PM_{2.5}$ PM_{10}, SO_2, NO_2, ozone (O_3), carbon monoxide (CO), lead (Pb) and benzene. The NAAQS were published in the Government Gazette (no. 32816) on 24 December 2009 (Table 2-1).

Table 2-1: South African National Ambient Air Quality Standards (Government Gazette 32816, 2009).

Substance	Molecular formula / notation	Averaging period	Concentration limit (µg m^{-3})	Frequency of exceedance[1]	Compliance date[2]
Sulfur dioxide	SO_2	10 minutes	500	526	Immediate
		1 hour	350	88	Immediate
		24 hours	125	4	Immediate
		1 year	50	-	Immediate
Nitrogen dioxide	NO_2	1 hour	200	88	Immediate
		1 year	40	-	Immediate
Particulate matter	PM_{10}	24 hour	75	4	Immediate
		1 year	40	-	Immediate
Fine particulate matter	$PM_{2.5}$	24 hour	40		1 Jan 2016 – 31 Dec 2029
			25		1 Jan 2030
		1 year	20		1 Jan 2016 – 31 Dec 2029
			15		1 Jan 2030
Ozone	O_3	8 hours (running)	120	11	Immediate
Benzene	C_6H_6	1 year	5	-	1 Jan 2015
Lead	Pb	1 year	0.5	-	Immediate
Carbon monoxide	CO	1 hour	30 000	88	Immediate
		8 hour (calculated on 1 hour averages)	10 000	11	Immediate

[1] The number of averaging periods where exceedance of limit is acceptable.

[2] Date after which concentration limits become enforceable.

2.2 National Regulations for Dust Deposition

South Africa's Draft National Dust Control Regulations were published on 27 May 2011 with the dust fallout standards passed and subsequently published on 1 November 2013 (Government Gazette No. 36974). These are called the National Dust Control Regulations (NDCR). The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and light commercial areas. Acceptable dustfall rates according to the regulations are summarised in Table 2-2.

Table 2-2: Acceptable dustfall rates

Restriction areas	Dustfall rate (D) in mg/m^2-day over a 30 day average	Permitted frequency of exceedance
Residential areas	D < 600	Two within a year, not sequential months.
Non-residential areas	600 < D < 1 200	Two within a year, not sequential months.

The regulations also specify that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact.

2.3 Listed Activities and Minimum Emission Standards

Solid fuels combusted with the purpose of steam raising for electricity generation is a Listed Activity under Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA) and will require an Atmospheric Emissions License (AEL) to operate. The proposed power station, will be required to comply with the new plant Minimum Emission Standards (MES). The applicable listed activities categories will include: Sub-category 1.1 (Solid Fuel Combustion Installations) (Table 2-3). The storage and handling of coal qualifies as a listed activity, due to the stockpile size (225 440 tonnes), and will be required to comply with the special conditions stipulated for Subcategory 5.1 (Table 2-4).

Table 2-3: Listed Activity Category 1.1

<table>
<tr><th colspan="4">Sub-category 1.1 – Solid Fuel Combustion Installations</th></tr>
<tr><th>Description:</th><td colspan="3">Solid fuel combustion installations used primarily for steam raising or electricity generation.</td></tr>
<tr><th>Application:</th><td colspan="3">All installations with design capacity equal to or greater than 50 MW heat input per unit, based on the lower calorific value of the fuel used.</td></tr>
<tr><th colspan="2">Substance or Mixture of Substances</th><th rowspan="2">Plant Status</th><th rowspan="2">mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa</th></tr>
<tr><th>Common Name</th><th>Chemical Symbol</th></tr>
<tr><td>Particulate matter</td><td>N/A</td><td rowspan="3">New</td><td>50</td></tr>
<tr><td>Sulfur dioxide</td><td>SO_2</td><td>500</td></tr>
<tr><td>Oxides of nitrogen</td><td>NO_X, expressed as NO_2</td><td>750</td></tr>
<tr><td colspan="4">(a) The following special arrangements shall apply –
(i) Continuous emission monitoring of PM, SO_2, NO_X is required, however, installations less than 100 MW heat input per unit must adhere to periodic emission monitoring as stipulated in Part 2 of the Notice which stipulates the manner, method and equivalency of measurement methods.
(ii) Where co-feeding with waste materials with a calorific value allowed in terms of the Waste Disposal Standards published in terms of the Waste Act, 2008 (Act No. 59 of 2008) occurs, additional requirements under subcategory 1.6 shall apply.</td></tr>
</table>

Table 2-4: Listed Activity Category 5.1

<table>
<tr><th colspan="4">Sub-category 5.1 – Storage and Handling of Ore and Coal</th></tr>
<tr><td>Description:</td><td colspan="3">Storage and handling of ore and coal not situated on the premises of a mine or works as defined in the Mines Health and Safety Act 29/1996.</td></tr>
<tr><td>Application:</td><td colspan="3">Locations designed to hold more than 100 000 tons.</td></tr>
<tr><th colspan="2">Substance or Mixture of Substances</th><th rowspan="2">Plant Status</th><th rowspan="2">mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa</th></tr>
<tr><th>Common Name</th><th>Chemical Symbol</th></tr>
<tr><td>Dustfall</td><td>N/A</td><td>New</td><td>(a)</td></tr>
<tr><td colspan="4">(a) Three month running average no to exceed limit value for adjacent land use according to the NCDR promulgated in terms of Section 32 of the NEM:AQA, 2004 (Act No. 39 of 2004), in eight principle wind directions.</td></tr>
</table>

2.4 Regulations regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014, (DEA, 2014) and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations regarding Air Dispersion Modelling are applicable –

(a) in the development of an air quality management plan, as contemplated in Chapter 3 of the National Environmental Management: Air Quality Act (NEM:AQA);
(b) in the development of a priority area air quality management plan, as contemplated in section 19 of the AQA;
(c) in the development of an atmospheric impact report, as contemplated in section 30 of the AQA; and,
(d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the AQA.

The Regulations have been applied to the development of this report. The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives direction to the choice of the dispersion model most suited for the purpose. Chapter 2 of the Regulations present the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken for modelling applications. The proposed project falls under a Level 2 assessment – described as follows;

- The distribution of pollutants concentrations and depositions are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in the air quality impact assessment of the proposed project is AERMOD.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Regulations prescribe the source data input to be used in the models. Dispersion modelling can typically be used in the:

- Apportionment of individual sources for installations with multiple sources. In this way, the individual contribution of each source to the maximum ambient predicted concentration can be determined. This may be extended to the study of cumulative impact assessments where modelling can be used to model numerous installations and to investigate the impact of individual installations and sources on the maximum ambient pollutant concentrations.

- Analysis of ground level concentration changes as a result of different release conditions (e.g. by changing stack heights, diameters and operating conditions such as exit gas velocity and temperatures).
- Assessment of variable emissions as a result of process variations, start-up, shut-down or abnormal operations.
- Specification and planning of ambient air monitoring programs which, in addition to the location of sensitive receptors, are often based on the prediction of air quality hotspots.

The above options can be used to determine the most cost-effective strategy for compliance with the NAAQS. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required including:

- Stack height increases;
- Reduction in pollutant emissions through the use of air pollution control systems (APCS) or process variations;
- Switching from continuous to non-continuous process operations or from full to partial load.

Chapter 4 of the Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling.

Topography is also an important geophysical parameter. The presence of terrain can lead to significantly higher ambient concentrations than would occur in the absence of the terrain feature. In particular, where there is a significant relative difference in elevation between the source and off-site receptors large ground level concentrations can result. Thus the accurate determination of terrain elevations in air dispersion models is very important.

The modelling domain would normally be decided on the expected zone of influence; the latter extent being defined by the predicted ground level concentrations from initial model runs. The modelling domain must include all areas where the ground level concentration is significant when compared to the air quality limit value (or other guideline). Air dispersion models require a receptor grid at which ground-level concentrations can be calculated. The receptor grid size should include the entire modelling domain to ensure that the maximum ground-level concentration is captured and the grid resolution (distance between grid points) sufficiently small to ensure that areas of maximum impact are adequately covered. No receptors however should be located within the property line as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

Chapter 5 provides general guidance on geophysical data, model domain and coordinate systems required in dispersion modelling, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air concentration data. The chapter also provides guidance on the treatment of NO_2 formation from NO_X emissions, chemical transformation of SO_2 and NO_X into sulfates, nitrates and deposition processes.

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to authorities.

3 RECEIVING ENVIRONMENT

3.1 Site Description

The proposed project will be located approximately 9 km south of KwaMhlanga, 10 km south-east of Moloto, and approximately 1 km north of the existing Palesa Coal Mine. The facility will be located in the Thembisile Hani Local Municipality, in the Nkangala District of the Mpumalanga Province. The closest large residential areas to the project area are KwaMhlanga and Motolo. There are several individual homesteads within 5 km of the proposed location. No schools or clinics are located within 5 km of the proposed location.

3.2 Climate and atmospheric dispersion potential

Meteorological mechanisms direct the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. This dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. 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 wind speed, in combination with surface roughness. The wind direction, and variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. The pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Tiwary and Colls, 2010).

The spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). The atmospheric processes at macro- and meso-scales need therefore be taken into account in order to accurately parameterise the atmospheric dispersion potential of a particular area. A qualitative description of the synoptic systems determining the macro-ventilation potential of the region may be provided based on the review of pertinent literature. These meso-scale systems may be investigated through the analysis of meteorological data observed for the region.

Since no weather measurements are available from the proposed site, simulated MM5 meteorological data for the proposed location for the 1 January 2013 to 31 December 2015 period was used to generate the following summaries.

3.2.1 Local wind field

The vertical dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of wind speed, in combination with surface roughness (Tiwary and Colls, 2010).

The wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing winds between 5 and 7 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The period wind field and diurnal variability in the wind field are shown in Figure 3-1, while the seasonal variations are shown in Figure 3-2. The wind flow is dominated by north-easterly winds, followed by winds from the south-east. Calm conditions occurred 12% of the period summarised. During day-time conditions, the typical north-easterly and south-easterly winds are supplemented by winds from the north-west. Day-time conditions typically show calmer conditions than night-time. The north-easterly component shows greater dominance during the night with fewer calm conditions after dark.

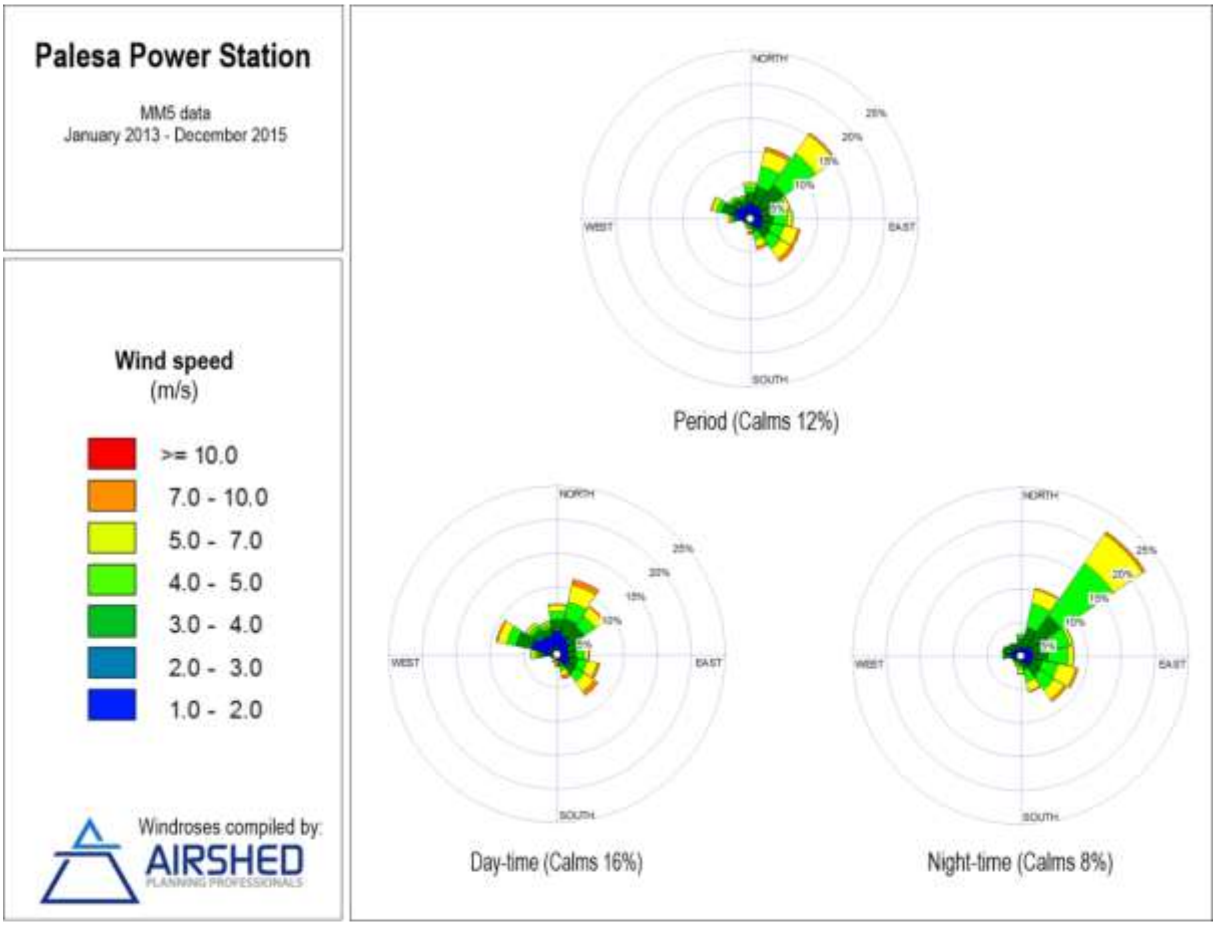

Figure 3-1: Period, day-, and night-time wind roses (MM5 data, January 2013 to December 2015)

Seasonally, the wind flow pattern conforms to the period average wind flow pattern with north-easterly dominance; however, some seasonal variability exists in the wind fields (Figure 3-2). During summer north-easterly winds dominant in the range between 4 and 5 m/s, while winds from the south-east occur more frequently in winter with the highest frequency of calm periods, while spring shows a north-easterly dominance with increased frequency of winds of speeds greater than 5 m/s and the fewest calm conditions.

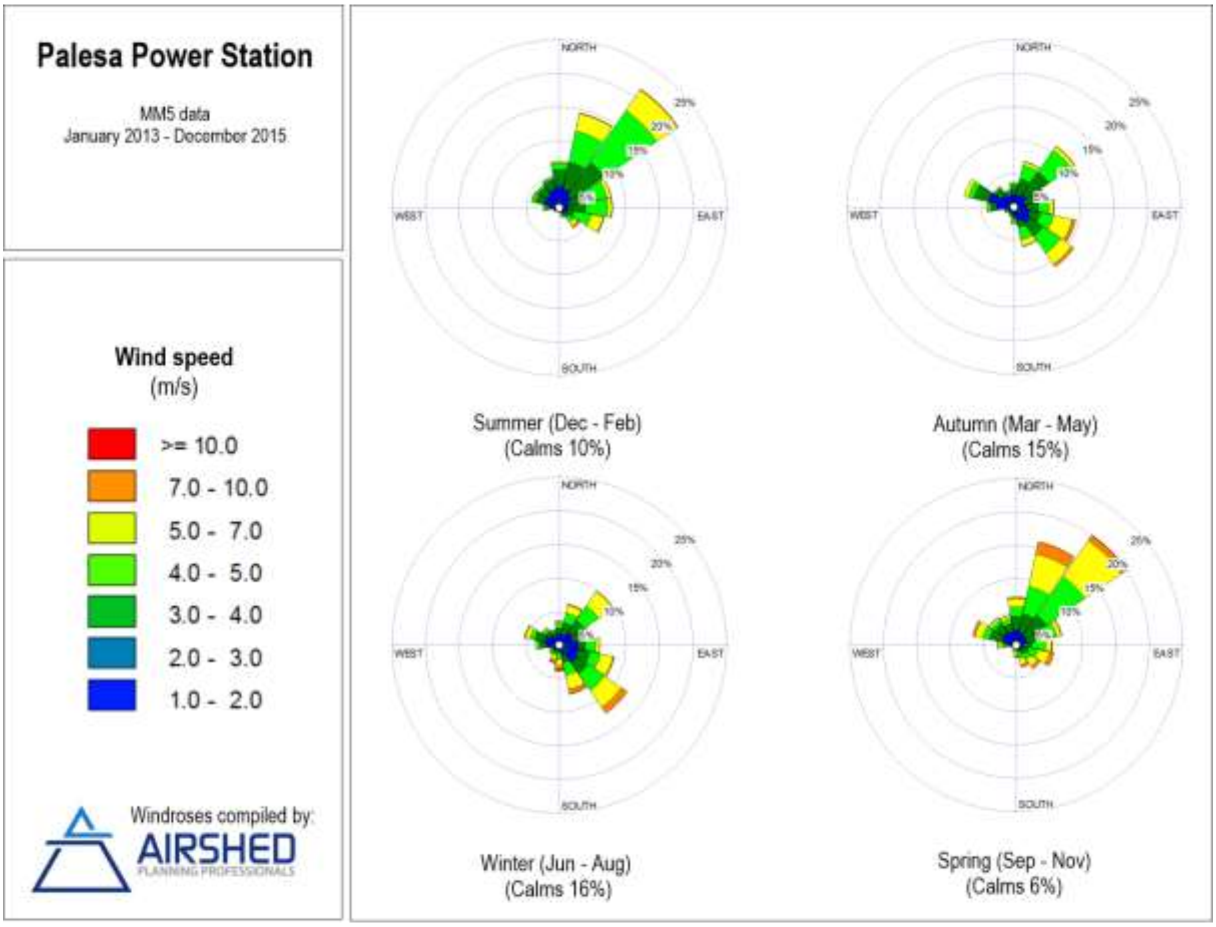

Figure 3-2: Seasonal wind roses (MM5 data, January 2013 to December 2015)

3.2.2 *Ambient Temperature*

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

Monthly mean, maximum and minimum temperatures are given in Table 3-1. Diurnal temperature variability is presented in Figure 3-3. Temperatures ranged between -0.2°C and 31.1°C. During the day, temperatures increase to reach maximum between 14:00 and 21:00 in the evening. Ambient air temperature decreases to reach a minimum at between 01:00 and 08:00 in the morning.

Table 3-1: Monthly temperature summary (MM5 data, January 2013 to December 2015)

Monthly Minimum, Maximum and Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	12.6	12.8	10.1	6.6	3.4	1.1	-0.2	1.2	2.6	5.0	7.0	12.5
Average	21.4	21.5	19.5	16.3	13.6	10.4	10.0	12.7	16.3	18.0	20.0	21.5
Maximum	29.9	30.2	28.2	26.0	22.6	20.1	19.2	25.0	26.0	29.1	29.6	31.1

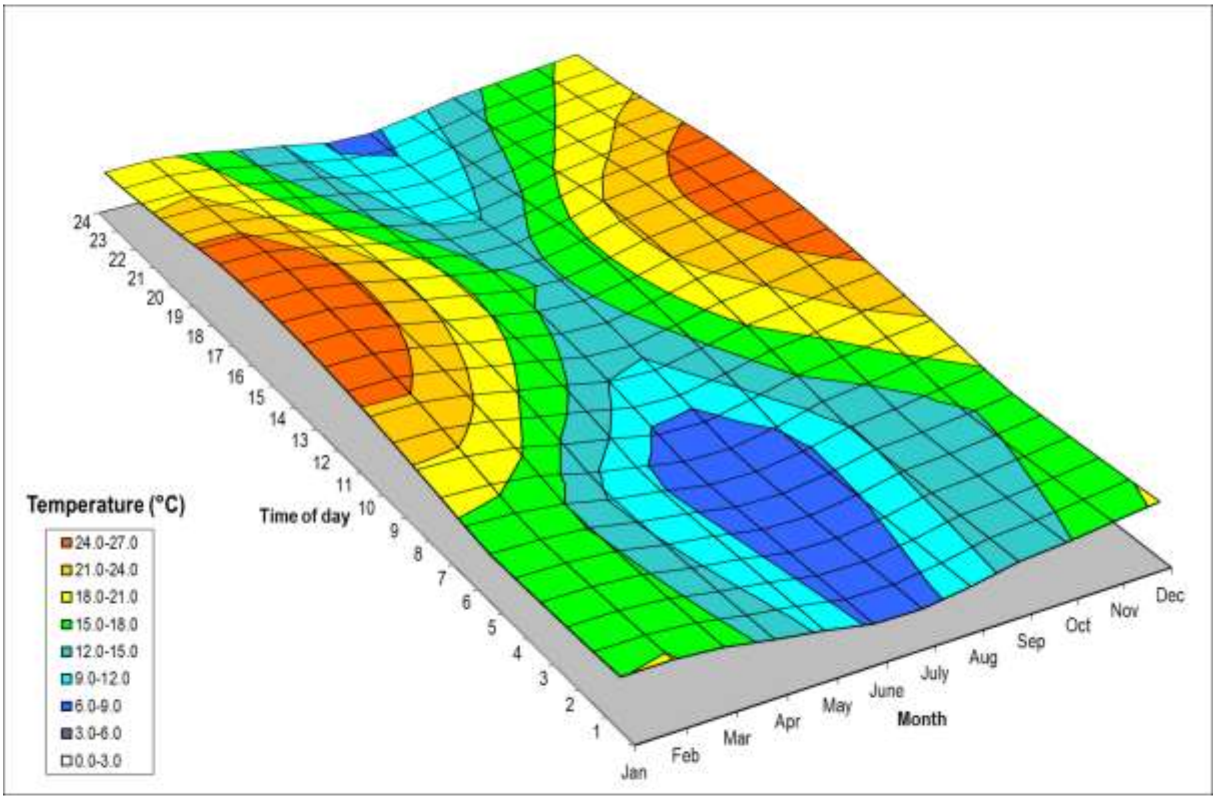

Figure 3-3: Diurnal temperature profile (MM5 data, January 2013 to December 2015)

3.3 Measured Baseline Ambient Air Quality

On-site or near-site ambient air quality monitoring data was not available during the scoping phase assessment. However, ambient air quality monitoring is monitored at the Ekandustria station, approximately 19.5 km south of the proposed project site. The station records surrounding sources including: residential, traffic, industrial and mining. The ambient records for the period 2013 to 2015 were accessed from the South African Air Quality Information System (www.saaqis.org.za) for SO_2, NO_X, and PM_{10} (Figure 3-4, Figure 3-5, and Figure 3-6; respectively).

During the period assessed, SO_2 concentrations were below the hourly NAAQS limit concentrations, however data availability after the end of February 2014 is poor (Figure 3-4). Measured NO_X concentrations (Figure 3-5) are also below the hourly NAAQS limit concentration; however the more recent portion of the dataset includes potentially spurious negative concentrations in the validated dataset. PM_{10} concentrations measured at the Ekandustria site also include some potentially spurious negative concentrations in the validated dataset. Several exceedances of the daily NAAQS PM_{10} limit concentration occurred after April 2014.

Full datasets will be requested from the City of Tshwane during the EIA phase for further screening and processing.

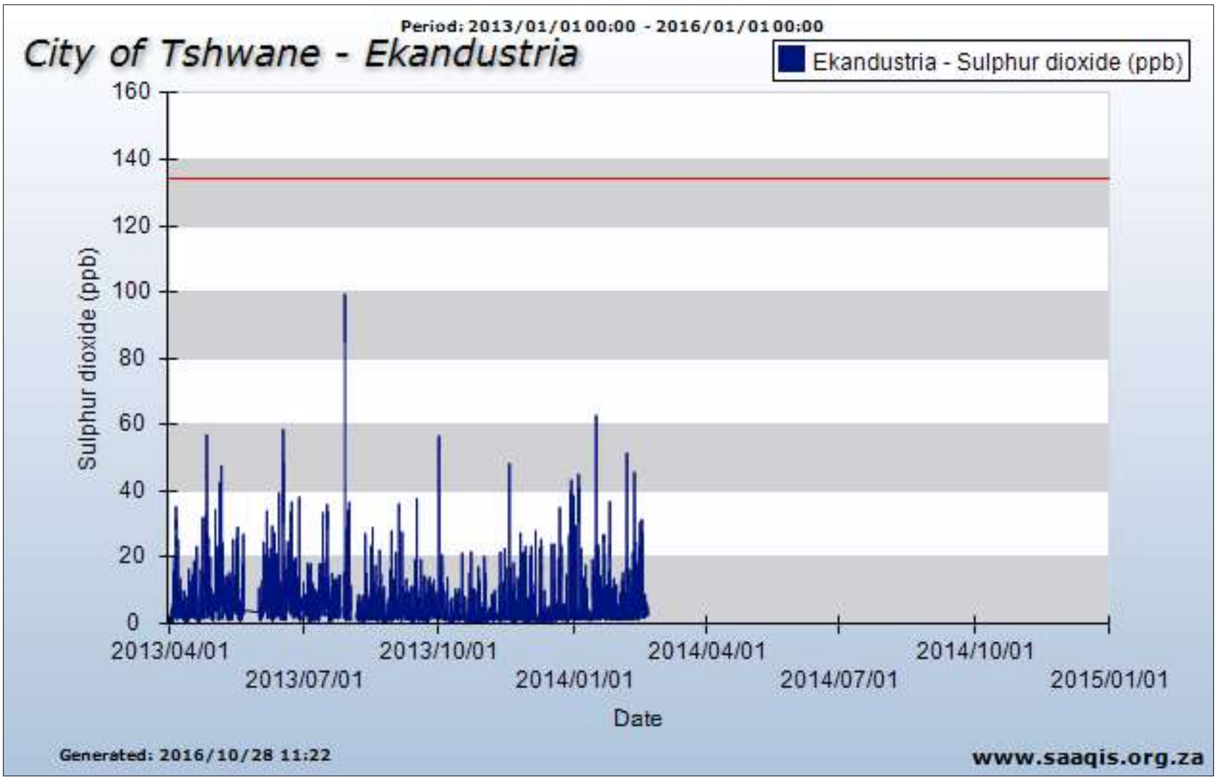

Figure 3-4: Ambient SO_2 concentrations recorded at the City of Tshwane, Ekandustria station between 1 January 2013 and 31 December 2016

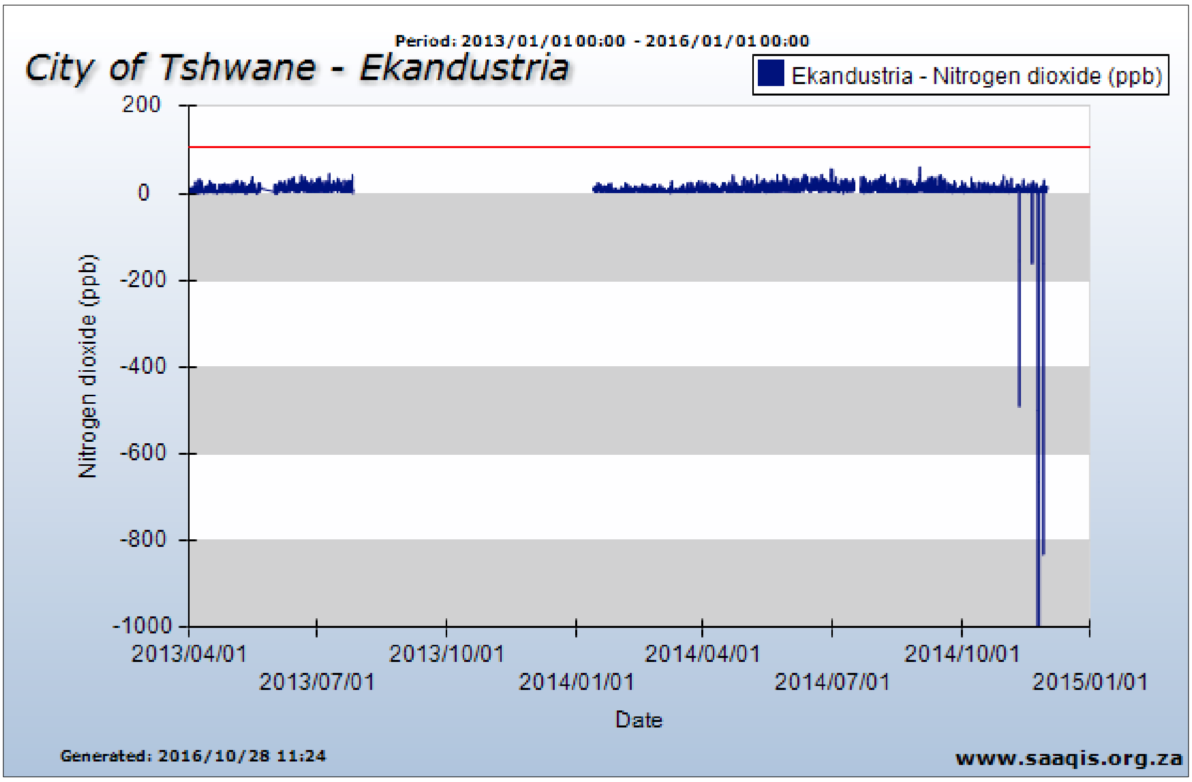

Figure 3-5: Ambient NO_X concentrations recorded at the City of Tshwane, Ekandustria station between 1 January 2013 and 31 December 2016

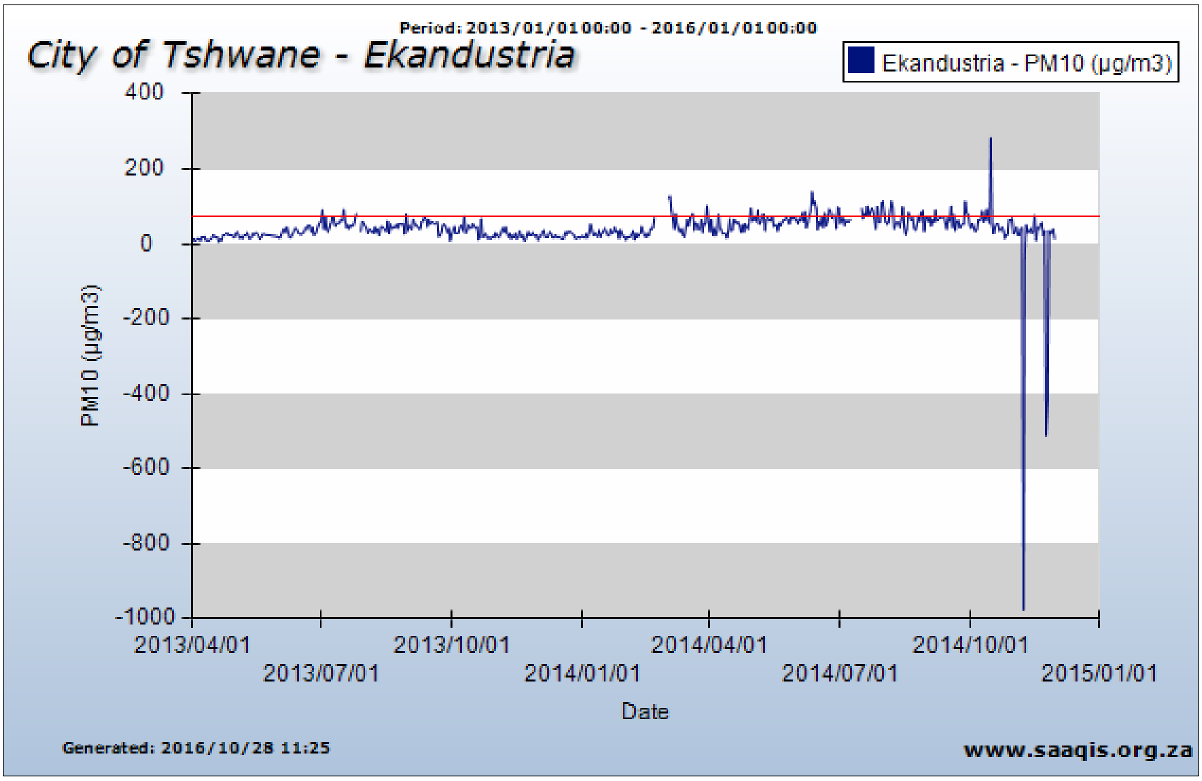

Figure 3-6: Ambient PM_{10} concentrations recorded at the City of Tshwane, Ekandustria station between 1 January 2013 and 31 December 2016

3.4 Existing Sources of Emissions near the Proposed Power station site

3.4.1 Mining Emission Sources

The opencast Palesa Coal Mine is located 1 km south of the proposed project site. Fugitive dust sources associated with mining activities include drilling and blasting operations, materials handling activities, vehicle-entrainment by haul vehicles and wind-blown dust from waste and product stockpiles. Mining operations represent potentially the most significant sources of fugitive dust emissions ($PM_{2.5}$, PM_{10} and TSP) with small amounts of NO_X, CO, SO_2, methane (CH_4), and carbon dioxide (CO_2) being released during blasting operations and from mine truck exhaust emissions.

3.4.2 Industrial Emission Sources

The proposed project location is approximately 20 km north of the industrial area of Ekandustria. Activities in this area are likely to include several continuous point sources of atmospheric pollutants. The industrial activities within this area are varied, resulting in a diversity of potential atmospheric pollutants from the sources, however SO_2, NO_X, CO, PM, and volatile organic compounds (VOCs) are likely to be common pollutants across most processes.

3.4.3 Vehicle Tailpipe Emissions

Emissions resulting from motor vehicles can be grouped into primary and secondary pollutants. While primary pollutants are emitted directly into the atmosphere, secondary pollutants form in the atmosphere as a result of chemical reactions. Significant primary pollutants emitted by internal combustion engines include CO_2, CO, carbon (C), SO_2, NO_X (mainly NO) and PM. Secondary pollutants include NO_2, photochemical oxidants such as ozone, sulfur acid, sulfates, nitric acid, and nitrate aerosols (particulate matter). Vehicle (i.e. model-year, fuel delivery system), fuel (i.e. type, oxygen content), operating (i.e. vehicle speed, load), and environmental parameters (i.e. altitude, humidity) influence vehicle emission rates (Onursal and Gautam, 1997). The release of VOCs via vehicle emissions is likely to have localised impacts and be within ambient air quality standards and are considered to be a minor contributor to an emissions inventory.

The main roads in the region are regional secondary and unpaved minor routes. Traffic volumes within the 5 km radius of the facility are unlikely to carry heavy traffic, other than that currently associated with the Palesa coal mine.

3.4.4 Domestic Fuel Combustion

Domestic households are known to have the potential to be one of the most important sources contributing to poor air quality within residential areas. Individual households are low volume emitters, but their cumulative impact can be significant. It is likely that some households within the surrounding settlements utilise coal, paraffin and/or wood for cooking and/or space heating (mainly during winter) purposes. Pollutants arising from the combustion of these fuel sources include respirable particulates, CO and SO_2 with trace amounts of polycyclic aromatic hydrocarbons (PAHs), in particular benzo(a)pyrene and formaldehyde.

3.4.5 Agricultural Sources

Agricultural activities including crop and stock farming appear, from aerial photography, to dominate the area surrounding the proposed project site.

Crop farming activities that may result in atmospheric emissions include land tilling operations, fertiliser and pesticide applications, and harvesting. By applying fertiliser and pesticides use is typically made of vehicles (tractors) driving on unpaved roads and exposed soil. Land tilling include dust entrainment on exposed surfaces, wind-blown dust and scraping and grading type activities resulting in fugitive dust releases. Both particulate matter (PM) and gaseous air emissions (mainly NO, NO_2, ammonia, SO_2 and VOCs) are generated from the application of nutrients as fertilizers or manures. There are primarily three harvesting operations resulting in particulate emissions: (1) crop handling by the harvest machine, (2) loading of the harvested crop into trucks, and (3) transport by trucks in the field. Particulate matter, composed of soil dust and plant tissue fragments (chaff), may be entrained by wind (US-EPA, 1995).

Livestock farms, especially cattle, are also significant sources of fugitive dust especially when feedlots are used and the cattle trample in confined areas. Pollutants associated with dairy production for instance include ammonia, hydrogen sulfide (H_2S), CH_4, CO_2, NO_X and odour related trace gasses. According to the US-EPA, cattle emit methane through a digestive process that is unique to ruminant animals called enteric fermentation. The calf-cow sector of the beef industry was found to be the largest emitter of methane emissions. Where animals are densely confined the main pollutants of concern include dust from the animal movements, their feed and their manure, ammonia from the animal urine and manure, and H_2S from manure pits.

Organic dust includes dandruff, dried manure, urine, feed, fungi, bacteria and endotoxins (produced by bacteria, and viruses). Inorganic dust is composed of numerous aerosols from building, materials and the environment. Since the dust is biological it may react with the defence system of the respiratory tract. Odours and VOCs associated with animal manure is also a concern when cattle are kept in feedlots. The main impact from methane is on the dietary energy due to the reduction of carbon from the rumen. Dust and gasses levels are higher in winter or whenever animals are fed, handled or moved (http://www.cdc.gov/nasd/docs).

3.4.6 Fugitive Dust Sources

These sources are termed fugitive because they are not discharged to the atmosphere in a confined flow stream. Sources of fugitive dust identified to potentially occur in the study area include paved and unpaved roads; agricultural tilling operations; and wind erosion of sparsely vegetated surfaces.

Unpaved and paved roads

Emissions from unpaved roads can constitute a substantial source of emissions to the atmosphere in the South African context. The force of the wheels of a vehicle traveling on an unpaved road, results in the pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong turbulent air shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust emissions from unpaved roads vary in relation to the vehicle traffic (including average vehicle speed, mean vehicle weight, average number of wheels per vehicle) and the silt loading on the roads.

Emissions from paved roads are significantly less than those originating from unpaved roads; however, they do contribute to the particulate load of the atmosphere. Particulate emissions occur whenever vehicles travel over a paved surface. The fugitive dust emissions are due to the re-suspension of loose material on the road surface.

Roads in the vicinity of the proposed project are mostly unpaved roads.

Wind erosion of open areas

Emissions generated by wind erosion are dependent on the frequency of disturbance of the erodible surface. Every time a surface is disturbed, its erosion potential is restored. Erodible surfaces may occur as a result of industrial processes (for example tailings storage facilities at the nearby Palesa Coal Mine), agriculture and/or grazing activities. The surrounding agricultural properties could also be a source of wind-blown particulates after harvesting when fields are fallow.

3.4.7 Biomass Burning

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity, crop-residue burning and wild fires (locally known as veld fires) may represent significant sources of combustion-related emissions (Maenhaut *et al.*, 1996; Galpin and Turner, 1999). The frequency of wildfires in the Highveld grasslands varies between annual and triennial (Tainton and Mentis, 1984).

Biomass burning is an incomplete combustion process (Cachier, 1992), with carbon monoxide, methane and nitrogen dioxide gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% is left in the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds (Held *et al.*, 1996). The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the proposed project, long-range transported emissions from this source can be expected to impact on the air quality between the months August to October. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

3.5 Identification of Possible Sensitive Receptors in the Area

The National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR) (detailed in Section 2.1) are based on human exposure to specific criteria pollutants and as such, possible sensitive receptors were identified where the public is likely to be unwittingly exposed. The scoping phase assessment included a preliminary identification of AQSRs. No schools or clinics are located within a 7.5 km radius of the proposed project site; however several individual homesteads occur within 7.5 km of the proposed project site. These homesteads will be identified (using aerial photography) and included as discrete receptors in the dispersion modelling simulations during the EIA phase.

4 DESCRIPTION OF PROPOSED PROJECT AND POTENTIAL IMPACTS

The proposed activity is the establishment of a 600 MW coal-fired power station using either Supercritical (SC) or Ultra-supercritical (USC) Circulating Fluidised Bed (CFB) boiler technology, or alternatively Pulverised Coal (PC), with direct or indirect dry cooling and dry ashing methods. Up to four boiler units are proposed in a single or multiple phased approach for the combined generation capacity up to 600 MW, where emissions will be vented to the atmosphere via up to two stacks 80 m in height (**Figure 4-1**). Limestone injection (with CFB) or Flue Gas Desulfurisation (FGD) technology (with PC), in combination with either baghouses or electrostatic precipitators, are proposed to reduce pollutant emissions before release to the atmosphere. Pollutants emitted via the flue-gas stacks will include: SO_2, NO_X, and PM which pose potential impacts to human health (Appendix A) at concentrations exceeding the NAAQS (Table 2-1). Impacts to the environment include the biotic components of vegetation and fauna.

The proposed power station design is based on the availability of 3 Mtpa coal. The Palesa Coal Mine (1 km south of the proposed facility) will provide coal for the power station via overland coal conveyor. The coal will be off loaded at the designated handling facility for stockpiling. A coal crusher is also planned prior to feed into the boiler feed bins. For start-up diesel is planned, with an on-site storage facility of 40 000 litres (**Figure 4-1**). The coal conveyor, handling facility; stockpile; and crusher will be sources of particulate emissions.

Primary mitigation of SO_2 emissions will be through the use of limestone, which will be trucked onto site and stockpiled in a covered area prior to use (**Figure 4-1**). The limestone handling and stockpile will be sources of particulate emissions, although to a lesser extent if covered.

Waste ash and gypsum will be deposited onto the proposed ash dump at a rate of approximately 112 t/h, currently proposed to cover an area of 110 ha (**Figure 4-1**). The ash conveyor; stacker and ash handling equipment; and the exposed ash dump are potential sources of fugitive particulate emissions.

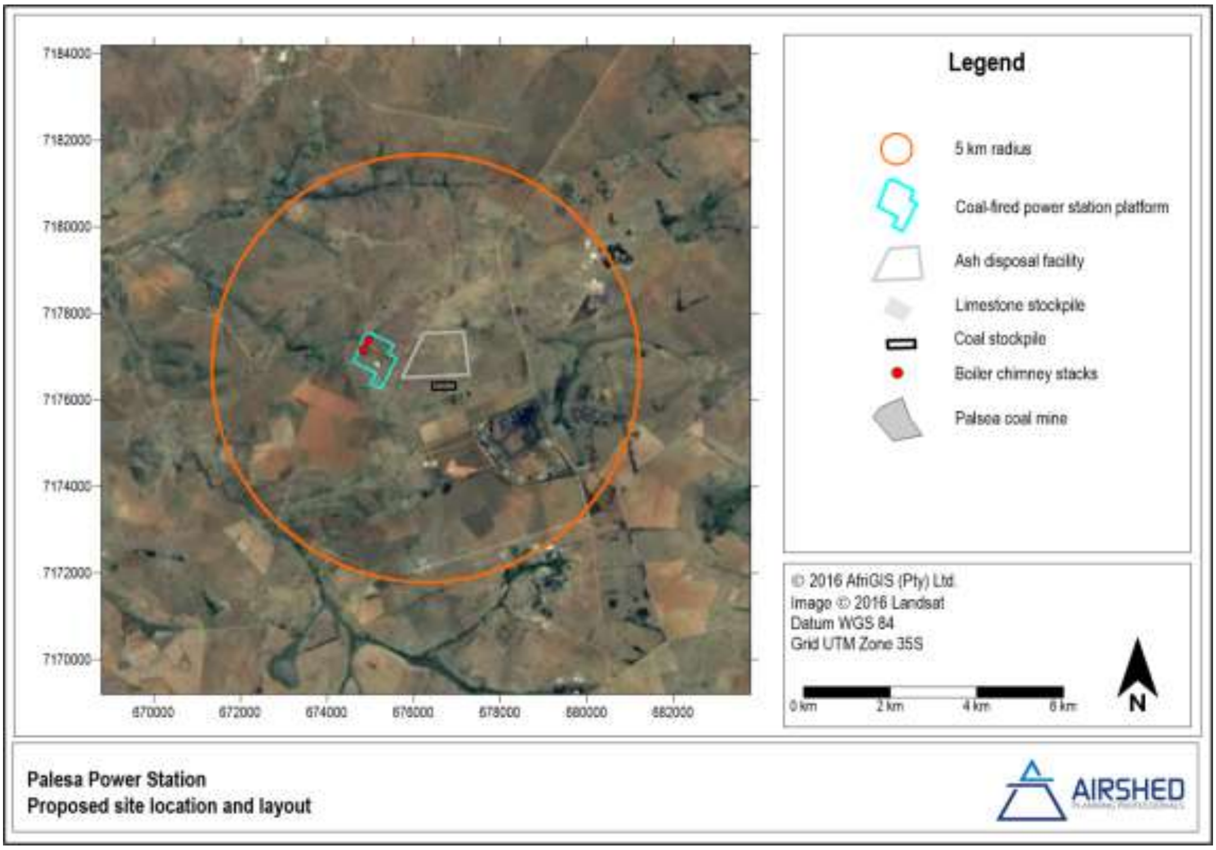

Figure 4-1: Location and layout of the proposed H2 Energy Power Station

5 SCOPING LEVEL IMPACT STATEMENT

Based on the desktop scoping level study the following impact statement is applicable to the air quality impacts as a result of the proposed project:

Impact:

The project is likely to have a negative impact by increasing ambient concentrations of criteria air pollutants (SO_2, NO_2, and PM). Increased nuisance dustfall is likely as a result of wind-blown dust emissions from the ash dump and raw material stockpiles (usually less than 2 km). Areas to the south-west of the project site are more likely to be affected, especially in the short-term, due to the predominantly north-easterly winds.

Desktop Sensitivity analysis of the Site:

No large residential areas, schools, or clinics occur within 5 km of the proposed facility. Individual homesteads within 5 km are likely to be affected. The full extent of impact to be assessed during EIA phase, but impacts may extend a few kilometres away from site. Areas of concern are homesteads within 5 km radius of the site, especially those to the south-west of the site.

Issue	Nature of impact	Extent of Impact	No-go Areas
Increased ambient concentrations of gaseous pollutants (SO_2, NO_2, possibly VOCs and others)	Negative human health impacts	Regional	None
Increased ambient concentrations of fine (inhalable) particulates	Negative human health impacts	Regional	None
Increased nuisance dustfall rates	Negative impact on dustfall at nearby homesteads. Dustfall on crop plants.	Local / Near-site	None

Description of expected significance of impact: *(based on experience with similar projects, but site specific details may change these values)*

Duration: Long-term (Power station) & Permanent (ash dump)
Consequence: 2 to 8
Probability: 3
Significance: Medium to High

Gaps in knowledge & recommendations for further study:

- Surrounding homesteads will be identified and included in dispersion modelling as sensitive receptors during the EIA phase.
- Impact of the Palesa coal mine on ambient air quality and dustfall is unknown at this stage. The project will have a cumulative impact with the mine, and following good general practice the mine operations will be included in cumulative impact assessment simulations.

6 DETAILED PLAN OF STUDY FOR EIA AND EMPR

The main findings from the scoping level assessment were as follows:

- The flow field is dominated by winds from the north-easterly sector.
- The closest residential area to the project area is KwaMhlanga, located approximately 9 km north of the proposed project. Individual homesteads surround the proposed project location.
- Criteria pollutants emitted during operation of the power station will include SO_2, NO_X, CO, and PM.

The main aim of this investigation was to provide the basis for the air quality impact assessment plan to be conducted for the proposed project. The following will be included in the impact assessment study:

- Compilation of an emissions inventory, comprising the identification and quantification of potential sources of emissions due to the proposed project;
- Dispersion modelling simulations of all potential pollutants from the operational plant and associated infrastructure for applicable averaging periods;
- Evaluation of potential for human health and environmental impacts;
- Determination of environmental risk according to a stipulated impact assessment methodology and,
- Recommendation of mitigation and management measures.

The modelling of air quality impacts requires information regarding the operation of the project, including: the daily coal consumption rates; engineering design; physical parameters for stack emissions; on-site equipment details; import and waste production rates; and waste disposal process details. The identification and evaluation of impacts may be hampered should default values be applied, or assumptions made, during the modelling process. Recent ambient air quality data from stations in the vicinity, will help verify the model projected air quality for baseline conditions. Ambient pollutant concentrations measured at the Ekandustria station will be requested from the City of Tshwane during the EIA phase for further screening and processing.

6.1 Assumptions, uncertainties and gaps in knowledge

The following assumptions apply to the scoping assessment conducted;

- No on-site meteorological data are available and simulated (MM5) meteorological data for the site was used.
- An identification of AQSRs included the location of larger residential areas, schools and clinics in the vicinity of the proposed project. Individual homesteads near the project will be identified (using aerial photography) and included as discrete receptors in the dispersion modelling simulations during the EIA phase.

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8 APPENDIX A - EFFECT OF DUST ON VEGETATION, ANIMALS AND SUSCEPTIBLE HUMAN RECEPTORS

8.1 Effects of particular matter on vegetation

Suspended particulate matter can produce a wide variety of effects on the physiology of vegetation that in many cases depend on the chemical composition of the particle. Heavy metals and other toxic particles have been shown to cause damage and death of some species as a result of both the phytotoxicity and the abrasive action during turbulent deposition (Harmens *et al.*, 2005). Heavy particle loads can also result in reduced light transmission to the chloroplasts and the occlusion of stomata (Ricks and Williams, 1974, Hirano *et al.*, 1995; Naidoo and Chirkoot; 2004; Harmens *et al.*, 2005), decreasing the efficiency of gaseous exchange (Ernst, 1981; Naidoo and Chirkoot, 2004; Harmens *et al.*, 2005) and hence water loss (Harmens *et al.*, 2005). Disruption of other physiological processes such as budbreak, pollination and light absorption/reflectance may also result under heavy particulate loads (Harmens *et al.*, 2005). The chemical composition of the dust particles can also affect exposed plant tissue and have indirect effects on the soil pH (Spencer, 2001).

To determine the impact of dust deposition on vegetation, two factors are of importance: (i) Does dust accumulate on vegetation surfaces and if it does, what are the factors influencing the rate of deposition (ii) Once the dust has been deposited, what is the impact of the dust on the vegetation? Regarding the first question, there is adequate evidence that dust does accumulate on all types of vegetation. Any type of vegetation causes a change in the local wind fields, increasing turbulence and enhancing the collection efficiency. Vegetation structure alters the rate of dust deposition such that the larger the "collecting elements" (branches and leaves), the lower the impaction efficiency per element. Therefore, for the same volume of tree/shrub canopy, finer leaves will have better collection efficiencies. However, the roughness of the leaves themselves, in particularly the presence of hairs on the leaves and stems, plays a significant role, with venous surfaces increasing deposition of 1-5 µm particles by up to seven-times compared to smooth surfaces. Collection efficiency rises rapidly with particle size; wind tunnel studies show a relationship of deposition velocity on the fourth power of particle size for moderate wind speeds (Tiwary and Colls, 2010). Wind tunnel studies also show that windbreaks or "shelter belts" of three rows of trees have a decrease of between 35 and 56% of the downwind mass transport of inorganic particles.

After deposition onto vegetation, the effect of particulate matter depends on the composition of the dust. South African ambient standards are set in terms of $PM_{2.5}$ and PM_{10} (particulate matter smaller than 2.5 µm and 10 µm aerodynamic diameter) but internationally it is recognised that there are major differences in the chemical composition of the fine PM (the fraction between 0 and 2.5 µm in aerodynamic diameter) and coarse PM (the fraction between 2.5 µm and 10 µm in aerodynamic diameter). The former is often the result of chemical reactions in the atmosphere and may have a high proportion of black carbon, sulfate and nitrate; whereas the latter often consists of primary particles as a result of abrasion, crushing, soil disturbances and wind erosion (Grantz *et al.*, 2003). Sulfate is however often hygroscopic and may exist in significant fractions in coarse PM. This has been shown at the Elandsfontein Eskom air quality monitoring station where the PM_{10} has been shown to vary between 15% (winter) and 49% (spring) sulfate (Alade, 2010). Grantz *et al.* (op. cit.) however indicate that sulfate is much less phototoxic than gaseous sulfur dioxide and that "it is unusual for injurious levels of particular sulfate to be deposited upon vegetation".

Naidoo and Chirkoot (2004) conducted a study to investigate the effects of coal dust on mangrove trees at two sites in the Richards Bay harbour. Mature fully-exposed sun leaves of 10 trees (*Avicennia marina)* were tagged as being covered or uncovered with coal dust and photosynthetic rates were measured. It was concluded that coal dust significantly reduced photosynthesis of upper and lower leaf surfaces and reduction in growth and productivity was expected. In addition, trees in close proximity to the coal stockpiles were in poorer health than those further away. Coal dust particles, which are composed predominantly of carbon, were not toxic to the leaves; neither did they occlude stomata as they were larger than fully open stomatal apertures (Naidoo and Chirkoot, 2004).

According to the Canadian Environmental Protection Agency (CEPA), generally air pollution adversely affects plants in one of two ways. Either the quantity of output or yield is reduced or the quality of the product is lowered. The former (invisible) injury results from pollutant impacts on plant physiological or biochemical processes and can lead to significant loss of growth or yield in nutritional quality (e.g. protein content). The latter (visible) may take the form of discolouration of the leaf surface caused by internal cellular damage. Such injury can reduce the market value of agricultural crops for which visual appearance is important (e.g. lettuce and spinach). Visible injury tends to be associated with acute exposures at high pollutant concentrations whilst invisible injury is generally a consequence of chronic exposures to moderately elevated pollutant concentrations. However given the limited information available, specifically the lack of quantitative dose-effect information, it is not possible to define a reference level for vegetation and particulate matter (CEPA, 1998).

Exposure to a given concentration of airborne PM may therefore lead to widely differing phytotoxic responses, depending on the mix of the deposited particles. The majority of documented toxic effects indicate responses to the chemical composition of the particles. Direct effects have most often been observed around heavily industrialised point sources, but even there, effects are often associated with the chemistry of the particulate rather than with the mass of particulate. A review of European studies has shown the potential for reduced growth and photosynthetic activity in sunflower and cotton plants exposed to dust fall rates greater than 400 mg m^{-2} day. Little direct evidence of the effects of dust-fall on South African vegetation, including crops, exists.

8.2 Effects of particulate matter on animals

As presented by the Canadian Environmental Protection Agency (CEPA, 1998) studies using experimental animals have not provided convincing evidence of particle toxicity at ambient levels. Acute exposures (4-6 hour single exposures) of laboratory animals to a variety of types of particles, almost always at concentrations well above those occurring in the environment have been shown to cause:

- decreases in ventilatory lung function;
- changes in mucociliary clearance of particles from the lower respiratory tract (front line of defence in the conducting airways);
- increased number of alveolar macrophages and polymorphonuclear leukocytes in the alveoli (primary line of defence of the alveolar region against inhaled particles);
- alterations in immunologic responses (particle composition a factor, since particles with known cytotoxic properties, such as metals, affect the immune system to a significantly greater degree);
- changes in airway defence mechanisms against microbial infections (appears to be related to particle composition and not strictly a particle effect);
- increase or decrease in the ability of macrophages to phagocytize particles (also related to particle composition);
- a range of histologic, cellular and biochemical disturbances, including the production of proinflammatory cytokines and other mediators by the lungs alveolar macrophages (may be related to particle size, with greater effects occurring with ultrafine particles);
- increased electrocardiographic abnormalities (an indication of cardiovascular disturbance); and
- increased mortality.

Bronchial hypersensitivity to non-specific stimuli, and increased morbidity and mortality from cardio-respiratory symptoms, are most likely to occur in animals with pre-existing cardio-respiratory diseases. Sub-chronic and chronic exposure tests involved repeated exposures for at least half the lifetime of the test species. Particle mass concentrations to which test animals were exposed were very high (> 1 mg m^{-3}), greatly exceeding levels reported in the ambient environment. Exposure resulted in significant compromises in various lung functions similar to those seen in the acute studies, but including also:

- reductions in lung clearance;
- induction of histopathologic and cytologic changes (regardless of particle types, mass, concentration, duration of exposure or species examined);
- development of chronic alveolitis and fibrosis; and
- development of lung cancer (a particle and/or chemical effect).

The epidemiological finding of an association between 24-hour ambient particle levels below 100 µg m^{-3} and mortality has not been substantiated by animal studies as far as PM_{10} and $PM_{2.5}$ are concerned. At ambient concentrations, none of the other particle types and sizes used in animal inhalation studies result in acute effects, including high mortality, with exception of ultrafine particles (0.1 µm). The lowest concentration of $PM_{2.5}$ reported that caused acute death in rats with acute pulmonary inflammation or chronic bronchitis was 250 g m^{-3} (3 days, 6 hour day^{-1}), using continuous exposure to concentrated ambient particles.

Most of the literature regarding air quality impacts on cattle refers to the impacts from feedlots on the surrounding environment, hence where the feedlot is seen as the source of pollution. This mainly pertains to odours and dust generation. The US-EPA recently focussed on the control of air pollution from feed yards and dairies, primarily regulating coarse particulate matter. However, the link between particulates and public health is considered to be understudied (Sneeringer, 2009).

A study was conducted by the State University of Iowa on the effects of air contaminants and emissions on animal health in swine facilities. Air pollutants included gases, particulates, bioaerosols, and toxic microbial by-products. The main findings were that ammonia is associated with lowered average number of pigs weaned, arthritis, porcine stress syndrome, muscle lesions, abscesses, and liver ascarid scars. Particulates are associated with the reduction in growth and turbine pathology, and bioaerosols could lower feed efficiency, decrease growth, and increase morbidity and mortality. The authors highlighted the general lack of information on the health effects and productivity-problems of air contaminants on cattle and other livestock. Ammonia and hydrogen sulfide are regarded the two most important inorganic gases affecting the respiratory system of cattle raised in confinement facilities, affecting the mucociliary transport and alveolar macrophage functions. Holland *et al.,* (2002) found that the fine inhalable particulate fraction is mainly derived from dried faecal dust.

Inhalation of confinement-house dust and gases produces a complex set of respiratory responses. An individual's response depends on characteristics of the inhaled components (such as composition, particle size and antigenicity) and of the individual's susceptibility, which is tempered by extant respiratory conditions (Davidson *et al.*, 2005). Most studies concurred that the main implication of dusty environments is the stress caused to animals which is detrimental to their general health. However, no threshold levels exist to indicate at what levels these are having a negative effect. In this light it was decided to use the same screening criteria applied to human health, i.e. the South African Standards limit values.

8.3 Effect of particulate matter on susceptible human receptors

The impact of particles on human health is largely depended on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. These larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. The smaller particles (PM_{10}) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Then particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA, 1998; Dockery and Pope, 1994).

The air quality guidelines for particulates are given for various particle size fractions, including total suspended particulates (TSP), thoracic particulates or PM_{10} (i.e. particulates with an aerodynamic diameter of less than 10 µm), and respirable particulates or $PM_{2.5}$ (i.e. particulates with an aerodynamic diameter of less than 2.5 µm). Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm, and effective upper limit of 30 µm aerodynamic diameter is frequently assigned. The PM_{10} and $PM_{2.5}$ are of concern due to their health impact potentials. As indicated previously, such fine particles are able to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung.

The World Health Organization states that the evidence on airborne particulates and public health consistently shows adverse health effects at exposures experienced by urban populations throughout the world. The range of effects is broad, affecting the respiratory and cardiovascular systems and extending from children to adults including a number of large, susceptible groups within the general population. Long-term exposure to particulate matter has been found to have adverse effects on human respiratory health (Abbey *et al.*, 1995). Respiratory symptoms in children resident in an industrialised city were found not to be associated with long-term exposure to particulate matter; however non-asthmatic symptoms and hospitalizations did increase with increased total suspended particulate concentrations (Hruba *et al.*, 2001). The epidemiological evidence shows adverse effects of particles after both short-term and long-term exposures. However, current scientific evidence indicates that guidelines cannot be proposed that will lead to complete protection against adverse health effects as thresholds have not been identified.

Many scientific studies have linked inhaled particulate matter to a series of significant health problems, including:

- aggravated asthma;
- increases in respiratory symptoms like coughing and difficult or painful breathing;
- chronic bronchitis;
- decreased lung function; and,
- premature death.

PM_{10} is the standard measure of particulate air pollution used worldwide and studies suggest that asthma symptoms can be worsened by increases in the levels of PM_{10}, which is a complex mixture of particle types. PM_{10} has many components and there is no general agreement regarding which component(s) could exacerbate asthma. However, pro-inflammatory effects of transition metals, hydrocarbons, ultrafine particles (due to combustion processes) and endotoxins - all present to varying degrees in PM_{10} - could be important.

Exposure to motor traffic emissions can have a significant effect on respiratory function in children and adults. Studies show that children living near heavily travelled roadways have significantly higher rates of wheezing and diagnosed asthma. Epidemiologic studies suggest that children may be particularly susceptible to diesel exhaust. The adverse health effects from particulate matter exposure and susceptible populations is summarised in Table 8-1.

Table 8-1: Summary of adverse health effects from particulate matter exposure and susceptible populations

Health Effects	Susceptible Groups	Notes
Acute (short-term) exposure		
Mortality	Elderly, infants, persons with chronic cardiopulmonary disease, influenza or asthma	Uncertainty regarding how much life shortening is involved and how much is due to short-term mortality displacement.

Health Effects	Susceptible Groups	Notes
Hospitalisation / other health care visits	Elderly, infants, persons with chronic cardiopulmonary disease, pneumonia, influenza or asthma	Reflects substantive health impacts in terms of illness, discomfort, treatment costs, work or school time lost, etc.
Increased respiratory symptoms	Most consistently observed in people with asthma, and children	Mostly transient with minimal overall health consequences, although for a few there may be short-term absence from work or school due to illness.
Decreased lung function	Observed in both children and adults	For most, effects seem to be small and transient. For a few, lung function losses may be clinically relevant.
Chronic (long-term) exposure		
Increased mortality rates, reduced survival times, chronic cardiopulmonary disease, reduced lung function, lung cancer	Observed in broad-based cohorts or samples of adults and children (including infants). All chronically exposed are potentially affected.	Long-term repeated exposure appears to increase the risk of cardiopulmonary disease and mortality. May result in lower lung function. Average loss of life expectancy in highly polluted cities may be as much as a few years.

Source: Adopted from Pope (2000) and Pope et al. (2002)